Designing the Future: Exploring the Dynamics of Anticipatory Design in AI-Driven User Experiences

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Resumo

O design antecipatório representa uma mudança de paradigma na interação humano-computador, enfatizando experiências de utilizador proativas que preveem e satisfazem necessidades antes mesmo de serem articuladas. Esta tese propõe um novo modelo conceptual de design antecipatório, que integra metodologias de previsão, análises preditivas e princípios de design centrado no utilizador. Desenvolvido a partir de uma revisão exploratória de sistemas e tecnologias antecipatórias, esta investigação identifica lacunas significativas nas práticas atuais, nomeadamente em personalização, confiança e transparência. O modelo é estruturado em três fases interdependentes — Antecipar Direções de Mudança, Imaginar Cenários Alternativos e Modelar as Nossas Escolhas — oferecendo uma metodologia abrangente para projetar sistemas adaptativos, éticos e alinhados com os valores e expectativas dos utilizadores.

Esta investigação contribui para o discurso sobre design antecipatório ao sintetizar insights teóricos, princípios das ciências comportamentais e análises de estudos de caso, demonstrando uma base sólida para o avanço na área. O modelo proposto aborda diretamente lacunas críticas em personalização, confiança e transparência identificadas nas práticas atuais, proporcionando uma metodologia estruturada inovadora e aplicável. Embora a validação empírica com parceiros da indústria seja um próximo passo necessário, o alicerce interdisciplinar e os princípios de design práticos reforçam o seu potencial significativo.

Ao integrar metodologias de previsão e modelos das ciências comportamentais com princípios centrados no utilizador, este trabalho oferece uma abordagem escalável e ética para o design de sistemas adaptativos baseados em inteligência artificial. Além disso, o modelo proposto apresenta-se singularmente posicionado para influenciar aplicações diversas, promovendo o envolvimento, reduzindo a carga cognitiva e fomentando a confiança em experiências baseadas em inteligência artificial. A sua metodologia estruturada e abrangente assegura o alinhamento com as complexidades do mundo real e com os valores sociais, refletindo uma forte confiança na sua capacidade de informar práticas futuras de design antecipatório.

Abstract

Anticipatory design represents a paradigm shift in human-computer interaction, emphasizing proactive user experiences that predict and fulfill needs before articulation. This thesis proposes a novel anticipatory design framework integrating foresight methodologies, predictive analytics, and user-centered design principles. Developed through a scoping review of anticipatory systems and technologies, this research identifies significant gaps in personalization, trust, and transparency in current practices. The framework is structured into three interdependent phases—Anticipate Directions of Change, Imagine Alternative Scenarios, and Shape Our Choices—offering a comprehensive methodology for designing adaptive, ethical, and user-aligned systems.

This research contributes to the anticipatory design discourse by synthesizing theoretical insights, behavioral science principles, and case study analyses, demonstrating a robust foundation for advancing the field. The proposed framework directly addresses critical gaps in personalization, trust, and transparency identified in current practices, providing an innovative and actionable structured methodology for design artificial intelligent system. While empirical validation with industry partners is a necessary next step, the framework's grounding in interdisciplinary research and practical design principles underscores its substantial promise.

By integrating foresight methodologies, and behavioral science frameworks with user-centered principles, this work offers a scalable and ethical approach to designing adaptive artificial intelligent systems. Moreover, the framework is uniquely positioned to influence diverse applications by fostering engagement, reducing cognitive load, and promoting trust in AI-driven experiences. Its structured and comprehensive methodology ensures alignment with real-world complexities and societal values, reflecting high confidence in its ability to inform future anticipatory design practices.

Prologue

List of academic publications

Cerejo, Joana, and Miguel Carvalhais. 2024. "Anticipation as a Tool for Designing the Future." In: *Advances in Design and Digital Communication IV*. Edited by Nuno Martins and Daniel Brandão, 37-52. Cham: Springer Series in Design and Innovation. https://doi.org/10.1007/978-3-031-47281-7_4

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Cerejo, Joana. 2025. "Statistically Right, Humanly Wrong: The Limits of Data in AI-Driven Experiences." *UX Matters*, September, 2025. https://www.uxmatters.com/mt/archives/2025/09/statistically-right-humanly-wrong-the-limits-of-data-in-ai-driven-experiences-1.php

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“Everything should be made as simple as possible, but not simpler.”

Albert Einstein

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Glossary

Anticipatory Concepts

- **Anticipation** - Capacity to act in preparation for a potential future reality, enabling individuals and systems to proactively respond to anticipated outcomes (Zamenopoulos and Alexiou 2020).
- **Anticipatory Systems** – Systems that determine present behavior based on an internal predictive model of future states, integrating past, present, and potential future contexts for decision-making (A. H. Louie 2009; Dubois 2008).
- **Anticipatory Thinking** - The cognitive foresight that designers utilize to craft solutions thriving in future-oriented contexts by integrating potential future scenarios and preparing accordingly (Geden et al. 2019).
- **Anticipatory Behavior –** Behavior driven by predictions, expectations, or beliefs about future states rather than solely by past or present conditions, shaping proactive actions and decision-making (Butz, Sigaud, and Gérard 2003).

Methodologies and Approaches

- **Anticipatory Design** – A method that simplifies processes by predicting and addressing user needs one step ahead of their decisions, enabling a seamless and efficient user experience (Shapiro 2015).
- **Strategic Foresight –** A discipline that identifies and analyzes emerging trends to construct potential future scenarios, enabling informed decision-making in the present (Poli 2017).
- **Future Thinking –** A future-oriented design approach that explores diverse possibilities to ideate and develop solutions for potential futures, extending beyond traditional design thinking (Poli 2017).
- **Backcasting –** A design methodology that starts with defining a desirable future state and then works backward to identify steps and strategies to achieve that state. It is often used alongside forecasting to ensure alignment between present actions and long-term goals (Poli 2017).
- **Forecasting –** A method of predicting future events or trends based on the analysis of past and present data. It is widely used in anticipatory systems to provide insights for proactive decision-making (Poli 2017).

- **Speculative Design –** A design methodology envisioning future possibilities through prototypes and scenarios, facilitating more ethical and responsible pathways for technological and societal progress[1].

Data and Technology

- **Predictive Systems –** Systems leveraging historical data to generate personalized predictions and recommendations, aimed at producing relevant and effective outcomes for users (Dubois 2008).
- **Artificial Intelligence –** A domain of computer science focused on creating systems capable of human-like reasoning, decision-making, and adaptability (Sadiku and Musa 2021).
- **Machine learning –** A subset of AI where systems improve their performance on tasks through data-driven learning without explicit programming, enabling predictive insights and adaptive behavior (Samuel 1959).
- **Big Data -** Extensive, complex datasets characterized by high volume, variety, and velocity, requiring advanced processing methods to extract actionable insights for diverse applications (Sadiku and Musa 2021).

Disciplines and Studies

- **Future Studies –** A systematic field that investigates possible, probable, and preferable futures through logic and evidence, employing tools to analyze and validate assertions about future scenarios (Bell 2003).
- **Foresight –** A forward-looking process of exploring potential future scenarios by considering multiple possibilities and their implications. Foresight is essential for strategic planning and managing uncertainty in anticipatory design (Poli 2017; Voros 2017).

[1] https://morespaceforlight.com.au/tag/speculative-design/

1 Introduction

This chapter establishes the foundation for the research project by situating the emergence of anticipatory design within the current artificial intelligence (AI) landscape and identifying the key problems it aims to address. The chapter introduces the research questions that guide the study, shaping the overall strategy and structure of the thesis.

1.1 Defining Core Concepts

To ensure conceptual clarity, it is essential to define the fundamental terms that underpin this study:

Anticipatory Systems: For this research, anticipatory systems are defined as context-aware predictive systems that leverage contextual and historical data to make forecasts and predictions for clearly defined and measurable goals. These systems differ fundamentally from traditional reactive systems through their proactive nature and integration of multiple data streams. (Rosen 1985; Dubois 2008)

By anticipatory systems, we mean those that can gather information from:

- **User inputs:** Anticipatory systems enhance user interactions by not only reacting to explicit commands but also predicting what they might want to do next. For instance, a fitness tracker such as Fitbit not only tracks users' activity but also prompts them to log activities like running or cycling based on their usual habits at specific times.
- **Background applications:** Anticipatory systems integrate with other tools to provide proactive support. A navigation app, such as Google Maps, might sync with users' calendars and, upon noticing an upcoming meeting, notify them of the best route to take. If there's heavy traffic, it might even suggest an earlier departure time to ensure punctuality, demonstrating the ability to combine calendar, traffic, and location data for an anticipatory experience.
- **Network information:** A news app, such as Flipboard, might detect users' geographical location through their network and offer tailored updates on local events, weather warnings, or nearby activities. This personalized delivery ensures that the information is both timely and pertinent to the user's immediate environment.
- **Sensor technology:** Modern anticipatory systems leverage sensor data to adapt dynamically to environmental changes. For example, Nest Thermostats use built-in sensors to detect room occupancy and adjust the temperature accordingly, optimizing

energy efficiency and comfort. Similarly, wearable devices like Oura Rings monitor body temperature, sleep patterns, and activity levels to recommend lifestyle adjustments for improved health and well-being.

Human-Computer Interaction (HCI): The interdisciplinary study of the design, evaluation, and implementation of interactive computing systems for human use, emphasizing usability, accessibility, and user satisfaction (Carroll and Rosson 2003).

Human-Computer Interaction Context: Within HCI, anticipatory systems represent a paradigm shift from user-initiated interactions to system-initiated support, fundamentally altering the focus of agency in digital experiences (Shneiderman 2020).

Experience: In the context of this research, an experience is understood as the totality of user interactions with a system over time, including cognitive, emotional, and behavioral responses to system-initiated actions. While in HCI contexts, Hassenzahl and Tractinsky (2006) expand this to include the complete range of user interactions with a system over time, covering cognitive, emotional, and behavioral responses to system-initiated actions.

Design Process: This research follows Cross's (2008) understanding of the design process as the systematic methodology for creating solutions that address user needs through iterative cycles of research, ideation, prototyping, and evaluation. This aligns with Brown's (2008) design thinking framework, emphasizing human-centricity, empathy, and iterative problem-solving.

Human-Centered Design: ISO 9241-210 (2019) defines human-centered design as an approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques. Norman (1986) further emphasizes this as a design philosophy that prioritizes human needs, capabilities, and limitations throughout the design process, ensuring technology serves human goals rather than imposing technological constraints.

Design Process Implications: Traditional user-centered design processes assume reactive system architectures. Anticipatory systems require new design methodologies that account for temporal prediction, behavioral modeling, and proactive intervention strategies.

Anticipatory systems gather information from four primary sources:

1. **User Inputs**: Direct behavioral data and explicit preferences
2. **Background Applications**: Cross-platform integration and contextual synthesis
3. **Network Information**: Environmental and location-based contextual data

4. **Sensor Technology**: Real-time environmental and physiological monitoring

1.2 Theoretical Framework: The PICo Approach

The research adopts the PICo framework (Population/Problem, Interest, Context) to structure the investigation systematically (Aromataris and Munn 2017).

- **Population/Problem:** The chapter defines the primary challenge as cognitive overload and burnout within today's digital landscape, affecting a broad user population, with particular emphasis on tech-savvy millennials and Generation Z who engage heavily with digital platforms.
- **Interest:** The research explores anticipatory systems as an enabler, focusing on their ability to leverage AI, ML, forecasting, and backcasting techniques to predict and meet user needs proactively. Forecasting enables these systems to analyze past data and trends to make predictions about user behaviors and preferences. To address the dynamic nature of human behavior, backcasting allows designers to plan from desired future outcomes, ensuring that anticipatory systems remain flexible and adaptable. These approaches emphasize creating systems that evolve with user needs, providing proactive and relevant experiences that guide users toward achieving their goals.
- **Context:** While the primary emphasis is on anticipatory systems, the study implicitly contrasts them with traditional reactive systems that rely on user-driven inputs, highlighting the limitations of such approaches in addressing modern digital challenges. Recognizing that human behavior is dynamic, anticipatory systems must incorporate strategies to guide users toward meaningful, long-term engagement. While the specifics of these strategies will be explored later, this research positions behavior change as a crucial outcome, with anticipatory systems serving as tools to support users in achieving their goals over time.

Using the PICo framework, this section systematically examines these challenges. By focusing on the affected user groups (Population/Problem), the role of anticipatory systems in addressing these issues (Interest), and the digital environments in which these systems are deployed (Context), the framework guides a user-centered exploration of the problem and identifies gaps in current design practices, setting the stage for subsequent research questions. This approach enables a comprehensive investigation of anticipatory design and its potential to transform user experiences in the age of AI.

1.3 Background and Context

The rapid evolution of technology has transformed the way we interact with the digital world, providing unprecedented access to information, tools, and services. However, this constant connectivity has also introduced new challenges. Research in cognitive psychology demonstrates that the overwhelming volume of notifications, choices, and tasks that demand our attention at every turn contributes to measurable cognitive overload (Sweller 1988; Hirshleifer et al. 2019). Contemporary studies reveal that digital burnout affects over 50% individuals, with younger demographics experiencing disproportionately higher rates due to intensive technology engagement patterns (Reinecke et al. 2016).

Cognitive overload occurs when the brain is overwhelmed by the amount of information it must process, leading to decision fatigue, diminished productivity, and reduced satisfaction (Schwartz 2004; Hirshleifer et al. 2019). Burnout exacerbates these issues, leaving individuals feeling disengaged and emotionally exhausted. Burnout is on the rise, with over half of surveyed individuals reporting experiencing it in 2021 (Kelly 2021). Among these, younger, technology-dependent demographics are disproportionately affected.

The neuropsychological basis of this phenomenon is well-documented. Functional magnetic resonance imaging studies demonstrate decreased activity in the prefrontal cortex—the brain region responsible for executive decision-making—following extended periods of choice-making activity (Vohs et al. 2008). These neurological findings support behavioral research on ego depletion, where decision-making quality deteriorates following sustained cognitive effort (Baumeister et al. 1998).

For Schwartz (2004), while technology has increased convenience, it has also subjected individuals to a "tyranny of choice," leading to decision fatigue and suboptimal decisions. This, in turn, has been linked to burnout, particularly among highly engaged technology users such as millennials and Generation Z (Twenge 2017).

Empirical evidence demonstrates the potential of anticipatory design. Several real-world implementations demonstrate the potential of anticipatory approaches to reduce cognitive burden. Netflix's recommendation algorithm reduces content discovery time by approximately 80% compared to manual browsing, while simultaneously improving user satisfaction scores (Gomez-Uribe and Hunt 2016). Similarly, Google's autocomplete functionality decreases search query completion time by 25% while improving search result relevance (Mitra et al. 2014). These examples provide quantitative evidence for anticipatory design's capacity to enhance both efficiency and user experience quality.

Anticipatory design offers a promising solution to these challenges by simplifying decision-making processes through prediction and automation. Shapiro (2015) defines anticipatory design as a methodology that simplifies processes by predicting and responding to user needs before they are explicitly expressed.

By leveraging AI and ML, anticipatory systems can:

- **Reduce cognitive overload** by presenting only the most relevant information.
- **Mitigate decision fatigue** by automating routine decisions.
- **Promote better decision-making** by framing information to align with user needs and motivations.

Pezzulo and Butz (2008) understand prediction as assessments of uncertainty, involving methods like forecasting (predicting future states), backcasting (goal-oriented planning), and retrospective (examining past events to inform future decisions) to shape desirable futures. This indicates that anticipation encompasses more than just predicting the future. These methods facilitate temporal analysis (looking at different points in time) and projection (predicting or planning future outcomes), essential for supporting the anticipatory design process.

Therefore, this research emphasizes how design can integrate forecasting, backcasting, and retrospective methods to enhance its capability for projecting and designing anticipatory experiences to ensure that alternative perspectives are part of strategic decision-making. While both prediction and anticipation involve looking towards the future, they serve distinct purposes:

- **Prediction:** Predicting future events relies on present knowledge and reasoning to estimate potential outcomes, often incorporating uncertainty.
- **Anticipation:** Anticipation goes beyond mere prediction; It involves acting proactively to prepare for or prevent potential future events.

By analyzing the work of Geden et al. (2019), Rollier and Turner (1994), and Poli (2010; 2017) we identify three key forms of anticipation as illustrated below (Figure 1). Light gray circles represent the present, medium gray represents intermediate states, and dark gray represents states of interest. Arrows depict the direction in which the analyst is anticipating.

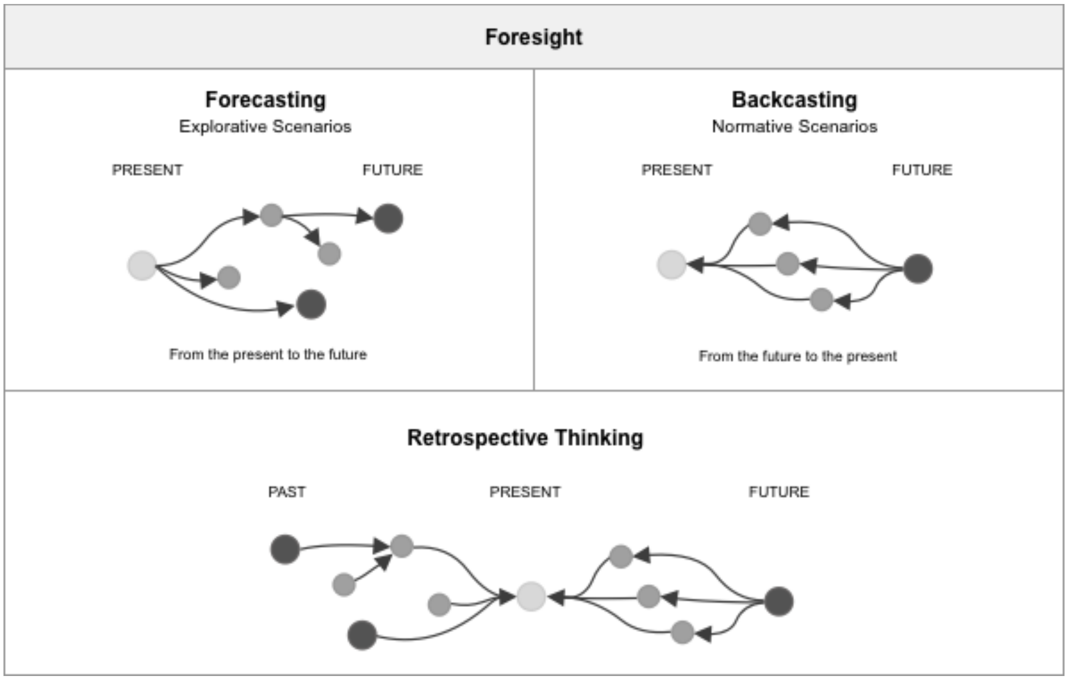

Figure 1: Foresight types, adapted from Geden et al. (2019), Rollier & Turner (1994), and Poli (2010).

Geden et al. (2019) discuss the different approaches to understanding the future - prediction, backcasting, and retrospective thinking. Their discussion highlights how anticipation goes beyond simply predicting the future and emphasizes exploring desirable future states and the pathways that could lead us there.

Anticipatory systems rely on temporal analysis and projection methods such as forecasting, backcasting, and retrospective thinking. These methodologies are instrumental in supporting anticipatory design by providing a structured approach to understanding and shaping future outcomes:

- **Forecasting** involves projecting future states based on historical data and trends. For instance, Salesforce Einstein Analytics exemplifies forecasting by using machine learning to predict customer behaviors and optimize decision-making.
- **Backcasting** starts with a desired future state and works backward to define the steps needed to achieve it. Applications like Thrive leverage backcasting to help users create actionable plans for well-being goals, recalibrating as circumstances change.
- **Retrospective thinking** involves imagining a future scenario as if it has already occurred and identifying the pathways that led to it. This method encourages creative exploration and helps uncover potential blind spots in current strategies.

1.4 Academic Context and Necessity

The academic relevance of this research stems from three converging factors in human-computer interaction scholarship:

Theoretical Gap: Current HCI literature lacks comprehensive frameworks for designing proactive systems that anticipate user needs while maintaining autonomy (Zamenopoulos and Alexiou 2007). Existing approaches focus primarily on reactive personalization rather than predictive user support.

Methodological Need: The integration of temporal methodologies (forecasting, backcasting) with behavioral science principles in system design remains underexplored in academic literature, particularly within design research contexts (Poli 2017).

Practical Urgency: The rapid deployment of AI-powered systems without adequate human-centered design frameworks has created real-world implementation challenges that demand academic investigation and solution development (Armstrong 2021).

1.5 Motivations and Research Purpose

In today's digital age, individuals face an unprecedented influx of information and decisions. While technological advancements have revolutionized how we live and work, they often contribute to the very challenges they aim to solve. Cognitive overload, characterized by excessive information processing demands, leaves users fatigued and unable to make effective decisions. Over time, this can culminate in burnout, a state of emotional and physical exhaustion linked to prolonged stress (Maslach and Leiter 2016; Khan 2017).

The theoretical foundations of choice overload have been extensively documented in behavioral economics and cognitive psychology (Pine and Gilmore 2015; Schwartz 2004). Schwartz's (2004) seminal research demonstrates that beyond an optimal threshold (typically 8-12 options), additional choices decrease rather than increase user satisfaction and decision quality. This finding has been replicated across numerous domains, from consumer products to digital interfaces (Chernev et al. 2015).

The negative impact of cognitive overload and decision fatigue is well-documented in psychological and philosophical literature. In 1843, Kierkegaard (1980) explored the existential anguish caused by the vastness of choices, while Schwartz (2004) described the paradox of choice, where excessive options lead to poorer decision quality and reduced satisfaction. These insights highlight the psychological burden of decision-making in environments inundated with information and options.

For technology users, particularly those who engage with high-interaction platforms like e-commerce, productivity tools, and social media, the cognitive strain is amplified. Millennials and Generation Z, the most digitally connected generations, are especially vulnerable due to their high engagement with technology (Kelly 2021; Twenge 2017). Generation Z demonstrates higher rates of mental health concerns compared to previous generations, with research indicating a complex relationship between technology use and psychological well-being, as Generation Z individuals are more likely than other generations to report negative feelings about social media while simultaneously being more likely to report poor mental health (Coe et al. 2023).

Anticipatory systems have the potential to mitigate some of these challenges by reducing the cognitive burden placed on users. For Shapiro (2015), this approach shifts the design focus from presenting options to users to creating ecosystems where decisions occur more efficiently. Unlike traditional reactive systems—those that only respond when a user explicitly interacts with them—anticipatory systems predict user needs, offering timely and relevant solutions before the user even asks.

However, anticipatory systems are not without risks. Poorly aligned predictions can lead to user frustration, erode trust, or even jeopardize well-being (Shalaby 2024). Over-automation and misjudgments in predictions may restrict user autonomy, create unintended dependencies, or exacerbate cognitive strain if the system fails to align with user goals and motivations (Kleber 2016). Shapiro (2015) acknowledges that while this design philosophy can significantly simplify user experiences, it requires users to trust systems to make appropriate decisions on their behalf. These potential consequences highlight the importance of careful system design that prioritizes user objectives and provides mechanisms for feedback and control.

This research seeks to explore how anticipatory systems can be designed to maximize their benefits while addressing these risks. By integrating predictive methods, like forecasting and backcasting, and behavior science methods, this study aims to develop principles for designing systems that proactively align with user needs and preferences. The ultimate goal is to reduce cognitive overload, enhance digital experiences, and minimize conflicts with user goals or unintended consequences, fostering trust and satisfaction.

Anticipatory systems, as proactive technologies, offer a promising pathway to mitigate the challenges inherent to the digital age. Many platforms and services flood users with an overwhelming array of options, leading to decision fatigue and reduced satisfaction. Designing for anticipation involves more than reacting to current trends; it requires businesses to plan strategically for future user needs. Two critical concepts in this process are forecasting and backcasting.

- **Forecasting** analyzes past trends and data to predict future outcomes, helping businesses anticipate user needs.
- **Backcasting** starts with a desired future outcome and works backward to identify the steps needed to achieve that goal.

A simple way to understand the difference between both is to think of it like planning a dream vacation. Forecasting would involve looking at your past trips to guess where you might go next. But backcasting lets you pick your ideal destination first, then plan the perfect itinerary to get you there. Figure 2 illustrates how these two methodologies work together: the large circle represents future goals (backcasting), while the arrows show how past trends guide the way toward these goals (forecasting).

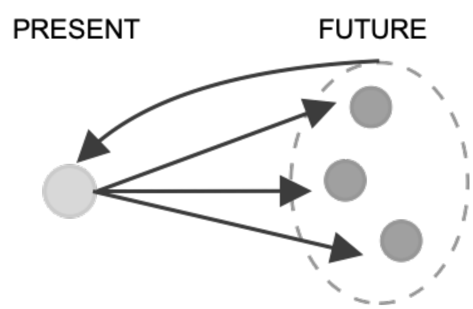

Figure 2: Visual Representation of Backcasting and Forecasting in Anticipatory Design.

Forecasting and backcasting represent the dual forces of circularity in anticipatory design: the future informs the present, and the present shapes the future. It implies circularity (Zamenopoulos and Alexiou 2007). In this research, we will explore how can the effect of an action determine the action in advance. Consequently, how can we design a future state of an experience that affects the present time?

- **Forecasting: A Core Concept for Future-Oriented Design**

  This method helps in planning and decision-making based on probable future scenarios. Consider Netflix, which uses forecasting to analyze viewers' past viewing habits and predict what they might want to watch next. By leveraging data from millions of users, Netflix can anticipate individual preferences and serve personalized recommendations that keep users engaged and satisfied.

- **Backcasting: Planning from the Desired Future**

  Backcasting takes a different approach. Instead of using data to predict the future, it starts with defining a desired future outcome — a clear user intent. The process then works backward to identify the steps needed to achieve that goal. This goal-oriented approach crafts an experience that actively guides users toward their desired future state.

For instance, a financial planning app might start with a user's long-term financial goal, such as saving for retirement, and then design an experience that guides the user through each step necessary to reach that goal, from budgeting tips to investment recommendations.

1.5.1 Relevance of Forecasting and Backcasting in Anticipatory Experiences

As user expectations for digital experiences continue to evolve, there is a noticeable shift toward systems that anticipate and proactively meet user needs. As shown in Figure 3, automation capacity correlates directly with reductions in cognitive overload, simplifying decision-making processes, and minimizing factors like decision fatigue, technological anxiety, and excessive screen interaction time (Kleber 2016).

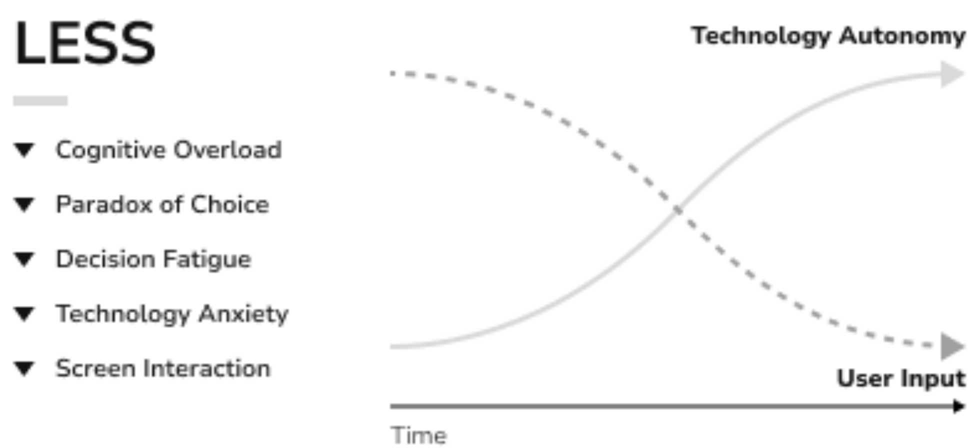

Figure 3: Increased automation reduces users' cognitive load (adapted from Kleber, 2016).

Forecasting is central to anticipatory design. It enables systems to analyze historical trends and contextual data to predict user needs and behaviors (Makridakis et al. 2008). By anticipating users' potential needs and actions, forecasting enables systems to:

- **Personalize More Effectively:** Deliver hyper-relevant recommendations and information.
- **Provide Proactive Assistance:** Offers assistance before user needs are explicitly stated, streamlining user journeys.

- **Reduce Cognitive Overload:** Present relevant options at the right time, minimizing mental effort.
- **Improve Decision-Making:** Predict potential outcomes based on user history and similar patterns.
- **Minimize Errors:** Foresee potential issues, reducing frustrations and mistakes.

However, forecasting relies heavily on historical data, presenting a significant challenge for new users with little to no interaction history—a phenomenon known as the *cold start* problem (Yuan and Hernandez 2023). In such cases, systems lack the behavioral data necessary to make accurate predictions, which can lead to frustration and disengagement. This limitation underscores the importance of backcasting as a complementary methodology. Unlike forecasting, backcasting starts with a desired future outcome and works backward to define the steps needed to achieve it. By using backcasting, designers can establish system behavior aligned with long-term user goals, even in the absence of rich historical data.

For example, a system might set a default pathway based on generalized behavioral patterns or initial user input, guiding new users toward a desired outcome while collecting data to refine its predictions over time. As Armstrong (2021, 23) notes, "Despite the difficulties around engaging the user before the system knows them well, the gradual optimization of ML experiences can become one of an intelligent interface's greatest strengths". Transparent feedback mechanisms are critical in this process, as they reassure users that the system is learning and improving.

Backcasting addresses this limitation by starting with a desired future outcome and working backward to define the steps needed to achieve it. By using backcasting, designers can establish system behavior aligned with long-term user goals, even in the absence of rich historical data.

1.5.2 The Evolution from Personalization to Anticipation

As AI becomes increasingly sophisticated, user expectations for digital experiences continue to rise. Anticipatory systems, which predict user needs and streamline interactions, are transforming how people engage with technology. While personalization lays the groundwork by tailoring content and suggestions based on user behavior, anticipatory systems go a step further—proactively addressing user needs before they are explicitly expressed. This evolution offers immense potential but also raises a key challenge: How can anticipatory systems enhance efficiency without compromising user autonomy?

1.5.2.1 *What Makes a Service Anticipatory?*

To understand the difference between personalization and anticipation, imagine a waiter at a restaurant. In a traditional scenario, the waiter waits passively for you to place your order. Personalization improves this experience by remembering your favorite drink or dish based on past orders. Anticipatory design, however, takes this further: the waiter not only recalls your preferences but also notices subtle cues—like your choice of sparkling water at every visit—and proactively offers it before you even ask. By combining historical data (past orders) with contextual insights (current behavior), anticipatory systems reduce the cognitive effort required to make decisions, enhancing satisfaction and creating a seamless experience.

1.5.2.2 *From Personalization to Anticipation: Key Milestones*

The journey from personalization to anticipatory design began with pioneering technologies in the late 1990s, where companies like Amazon and TiVo demonstrated the power of predictive analytics and ML to enhance user experiences.

- **Amazon's Recommendation Engine (Late 1990s)**

  Amazon revolutionized e-commerce by using purchase history to suggest products. Its "customers who bought this also bought" feature set a benchmark for personalized recommendations, streamlining the shopping experience and improving user satisfaction.

- **TiVo's Predictive Recording (1999):**

  TiVo introduced the ability to learn users' viewing habits and automatically record shows of interest, marking one of the earliest applications of predictive technology in home entertainment (Figure 4).

Figure 4: 1999's TiVO.

- **Netflix's Recommendation System (2006):**

  Netflix expanded on these ideas by introducing a recommendation engine that analyzed user ratings and viewing history to offer personalized movie suggestions. This system reduced the effort of searching through content, pioneering anticipatory design in the entertainment industry (Figure 5).

Figure 5: Netflix in 2006. (Image source: Web Design Museum[2])

These early implementations laid the foundation for anticipatory systems. Amazon and Netflix demonstrated how predictive analytics could simplify choices and improve satisfaction, moving beyond generic user interactions. While personalization has optimized suggestions, today, anticipatory systems leverage AI and ML to act proactively on users' behalf.

For instance, where a personalized system merely presents tailored options, an anticipatory system predicts the next logical action or choice—often automating part of the process. This evolution enables technology to shift from responding to user inputs to preemptively solving problems, thus reducing cognitive overload and creating experiences that feel effective and efficient.

The evolution from personalization to anticipation reflects a natural progression in digital design, where data-driven insights are increasingly used to predict and fulfill user needs. Early systems like Amazon's recommendations and TiVo's predictive recordings demonstrated the value of

2 https://www.webdesignmuseum.org/gallery/netflix-in-2006

personalization, while Netflix's recommendation engine showcased the potential for anticipatory systems to streamline user experiences. Today, as AI gains greater predictive power, anticipatory systems have the opportunity to move beyond personalization, offering proactive, user-centered solutions that simplify decision-making and improve satisfaction.

However, this evolution introduces a double-edged sword. When poorly executed anticipatory systems risk alienating users rather than empowering them (Shalaby 2024). For example, inaccurate predictions can leave users feeling misunderstood and unsupported, eroding trust in the system. Worse, over-automation can strip users of control, leading to frustration and helplessness (Kleber 2016; Shalaby 2024). For instance, systems that limit user choices or impose rigid recommendations without explanation can feel restrictive or coercive. Pariser (2011) warns that overly proactive systems may confine users to "invisible filter bubbles," limiting exploration and reducing diversity in decision-making.

Empirical Evidence for User Agency Concerns

Research demonstrates that users' sense of agency is enhanced by increasing automation but begins to decline when the level of automation exceeds 90%, suggesting an optimal balance between automation and user control. Sheridan and Verplank (1978), as cited in Beer et al. (2014), developed the foundational taxonomy for levels of automation, which has been extensively validated and applied in human-robot interaction contexts. Studies examining continuous human-automation interaction reveal that allowing operators even minimal contribution to control over automated tools during continuous operation may be sufficient to maintain their sense of agency while providing maximum improvement in performance.

Recent research emphasizes that user agency is pivotal for critical evaluation of AI systems, with studies showing that the prevalence of user agencies remains minimal, as most traditional AI research focuses on building autonomous systems in isolation (Raees et al. 2024). The relationship between automation levels and user satisfaction follows a complex pattern, where sense of agency is enhanced by increasing automation but begins to decline when automation becomes too complete (Ueda et al. 2021).

This tension is not only technical but also a deeply human problem. Trust is foundational to user acceptance of anticipatory systems. Users need to understand how these systems operate, feel empowered to intervene, and remain confident that the system is acting in their best interest. As noted by Kleber (2016), transparency and adaptability are essential for fostering trust and ensuring systems align with user expectations. Without these elements, anticipatory systems risk becoming a source of frustration rather than a tool for empowerment. To truly succeed, anticipatory systems must prioritize human needs by:

- **Respecting autonomy:** Offering customizable experiences and enabling users to override or adjust predictions.
- **Providing transparency:** Explaining how predictions are made to build understanding and trust.
- **Empowering users:** Striking a balance between proactive assistance and freedom of choice.

This evolution from personalization to anticipation exemplifies the core challenge of anticipatory design: mitigating risks while maximizing benefits. Thoughtful design, transparent communication, and constant evaluation are essential to ensure that anticipatory systems enhance, rather than hinder, user experiences. By addressing these challenges, anticipatory design can fulfill its promise of reducing cognitive overload and decision fatigue while empowering users in the age of AI.

1.5.2.3 Balancing Automation and User Autonomy

While anticipatory systems can effectively streamline decision-making, they must strike a delicate balance between automation and user autonomy. The central point of this challenge lies in balancing two opposing principles: reducing decision fatigue through automation and maintaining user agency. As digital systems increasingly present users with overwhelming choices, AI-assisted decision-making has emerged as a solution to reduce "the overwhelming plethora of choices that can lead to reduced satisfaction, poorer decisions, and potential disengagement" (Echterhoff et al. 2024) while maintaining user agency (Parasuraman et al. 2000). As Pariser (2011) points out, the best anticipatory systems are not just about responding to what users explicitly ask for—they foresee unspoken needs and act to fulfill them. While anticipatory systems can alleviate mental burdens by simplifying choices, excessive simplification risks disempowering users. As Shapiro (2015) argues, anticipatory systems must ensure they simplify interactions without undermining autonomy, providing users with clarity, flexibility, and control. Therefore, providing mechanisms for user control over automation levels fosters a sense of autonomy and enhances the user experience.

Over-automation—where decisions are entirely removed from users—creates the "out-of-the-loop performance problem," where "operators suffer from complacency and vigilance decrement" and struggle to regain control when automation fails (Gouraud et al. 2017). We argue that anticipatory design, therefore, must prioritize transparency and user trust, ensuring that systems make decisions in alignment with user preferences while maintaining opportunities for input and override.

Zamenopoulos and Alexiou (2007) highlight the importance of designing systems that augment, rather than replace, human decision-making. In situations of risk or uncertainty, AI systems should support users by simplifying complex decisions, reducing cognitive strain, and enhancing their ability to make informed choices.

1.6 Problem Statement

Despite unprecedented computational capabilities and sophisticated personalization algorithms, many digital systems continue to overwhelm users with excessive information architectures and choice complexity. This creates what researchers term the "digital paradox": increased technological sophistication that fails to improve, and often impairs, user experience quality (Reinecke et al. 2016).

This research has shown us that the increasing prevalence of cognitive overload and decision fatigue in digital environments presents a critical challenge for both users and designers. As platforms present users with an overabundance of information and options, the resulting psychological burden diminishes satisfaction and impairs decision-making quality. To address this challenge, it is essential to implement proactive measures such as AI-based risk scoring systems and universal safety standards that not only enhance user awareness but also embed protective features within digital technologies, ultimately fostering a healthier interaction with the digital landscape (Shalaby 2024).

1.6.1 The Paradox of Choice in the Digital Era

The digital era has provided unprecedented access to information, tools, and services, yet this abundance often presents a paradox: more choices do not necessarily result in better experiences. Platforms like Netflix exemplify this paradox, where the volume of options overwhelms users, leading to decision fatigue and cognitive overload. While Netflix aims to deliver entertainment at users’ fingertips, the platform's design often inhibits this goal.

Consider the familiar scenario of logging into Netflix (Figure 6). Anticipating a relaxing evening of entertainment, a user instead spends significant time scrolling through endless content lists. Recent research on streaming behavior demonstrates how platform design influences user decision-making, with studies showing that interface features significantly impact viewing session duration and user satisfaction (Schaffner et al. 2024). Industry data from streaming analytics companies suggests that Netflix users dedicate an average of 18 minutes per session[3] to browsing rather than watching, illustrating the practical manifestation of choice overload in digital media platforms. This underscores a fundamental design flaw: the platform emphasizes presenting options and publicizing content over facilitating meaningful choices. If a user with limited leisure time spends the majority of their session deciding what to watch, the experience becomes counterproductive, raising anxiety and even leading to decision paralysis. Rather than creating an engaging, seamless journey, Netflix's abundance of choices imposes cognitive demands that detract from user satisfaction.

Figure 6: Netflix Homepage view of its portfolio content.

1.6.2 The Cost of Choice and Cognitive Overload

Schwartz (2004) explains, increasing the number of available options does not necessarily enhance user satisfaction but, paradoxically, can lead to decision fatigue, regret, and lower-quality decisions. The cognitive effort required to evaluate a large number of options can leave users questioning whether they have made the "best" choice, increasing self-doubt and dissatisfaction. This phenomenon, known as the paradox of choice, highlights the need for systems that strategically curate options rather than overwhelming users with exhaustive lists. As Hirshleifer et al. (2019) explain, decision-making quality declines over time as cognitive

3 https://www.indiewire.com/2016/07/netflix-decide-watch-studies-1201708634/

resources are depleted. This aligns with the principle of information overload, where users are overwhelmed by the volume and complexity of data presented to them.

Schwartz (2004, xiii) emphasizes the importance of designers exploring the "cost and benefit of choice," balancing the freedom of selection with the psychological burden that choices impose. Therefore, anticipatory systems must strike a balance—simplifying decisions without sacrificing user agency or autonomy.

Younger, tech-savvy demographics—such as millennials and Generation Z—are particularly vulnerable to these challenges due to their high engagement with digital platforms where cognitive overload is pervasive. To Twenge (2017), high engagement with digital platforms has been linked to increased stress and burnout. These users often expect seamless, intuitive experiences but instead encounter systems that amplify their decision-making burden. Shalaby (2024) also emphasizes the importance of targeted interventions, such as AI-driven risk assessments and universal safety standards, to enhance digital literacy and mitigate the adverse effects of cognitive overload and decision fatigue in these populations.

1.6.3 The Role of Anticipatory Design

Anticipatory design presents a promising solution to the challenges of cognitive overload and decision fatigue brought about by the digital age. The way choices are framed significantly influences how we perceive and make decisions. By reducing the exploitation of cognitive biases, anticipatory design promotes more rational decision-making that genuinely prioritizes the user's best interests. This approach aligns with the broader goal of minimizing cognitive effort while enhancing user experiences by streamlining decision-making processes. Ultimately, anticipatory design has the potential to revolutionize how users interact with digital systems, offering seamless and thoughtful experiences by:

- **Reducing Information Overload**: Presenting only the most relevant options to users (Shapiro 2015).
- **Mitigating Decision Fatigue**: Automating routine choices and simplifying complex decisions (Schwartz 2004).
- **Promoting Better Decision-Making**: Framing information to minimize cognitive biases, such as the contrast effect and framing bias (Levin et al. 1998).

Levin et al. (1998) demonstrated that users perceive “75% lean” as more favorable than “25% fat,” even though the two are identical (Figure 7). Anticipatory design can mitigate such biases by presenting information in ways that align with users' best interests, enabling well-informed decisions.

Figure 7: Image to illustrate the comparison bias in practice via dscout.com[4]

Beyond framing and contrast effects, anticipatory systems can mitigate several other documented cognitive biases:

- **Framing Bias:** The way information is presented impacts decision-making. Levin et al. (1998) study on packaging language demonstrates how subtle changes in phrasing influence user perceptions and choices.
- **Contrast Effect:** Comparing options relative to one another can distort perceptions, leading to suboptimal decisions (Schwartz 2004).
- **Availability Heuristic:** Users overweight easily recalled information. Anticipatory systems can present balanced information sets that counteract recency and salience biases (Tversky and Kahneman 1974).
- **Anchoring Bias:** Initial information disproportionately influences subsequent decisions. Well-designed anticipatory systems can present information in orders that minimize harmful anchoring effects (Strack and Mussweiler 1997).
- **Choice Overload:** Beyond the documented threshold effects, anticipatory systems can dynamically adjust choice set sizes based on user context and decision importance (Chernev et al. 2015).

[4] https://dscout.com/people-nerds/preference-goes-wrong

Anticipatory design can mitigate these biases by presenting information in ways that promote rational, user-centric decision-making. By reducing the cognitive effort required to evaluate options, these systems can help users make better choices while minimizing the psychological burden of regret and second-guessing.

By strategically curating and prioritizing options, anticipatory design minimizes the cognitive effort required to navigate these biases. Such systems allow users to focus on making decisions that align with their goals, reducing regret and second-guessing while enhancing satisfaction.

1.6.4 The Psychology of Choice

The relationship between decision-making and choice is complex and deeply influenced by cognitive biases, heuristics, and the nature of human behavior when faced with an abundance of options. As we saw, anticipatory design offers methods to simplify decision-making by reducing choices, streamlining user experiences, and mitigating cognitive overload. While most current AI-driven solutions focus on augmenting human decision-making rather than replacing it, anticipatory experiences propose minimizing human involvement in certain decision processes to alleviate cognitive strain and workload (Anderson 2003; Zamenopoulos and Alexiou 2007). To fully understand the implications, it is critical to explore how decision-making operates under risk, uncertainty, and cognitive limitations.

The problem of excessive options is aggravated by cognitive fatigue. Research by Schwartz (2004) correlates the number of decisions with diminishing rationality: the more choices individuals are faced with, the less rational their final decisions tend to be (Figure 8).

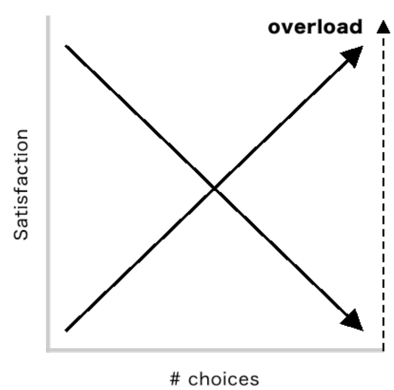

Figure 8: Negative aspect of having too many choices (Schwartz 2004).

In this regard, anticipatory design and anticipatory systems provide value by pre-selecting or prioritizing options according to people’s decision-making styles, reducing the number of decisions required and thus simplifying the user experience.

1.6.4.1 Decision-Making Styles – Maximizers vs. Satisficers

Herbert A. Simon’s (1955) foundational work on decision-making introduced the concepts of *maximizers* and *satisficers*. Maximizers are individuals who strive to identify the absolute best option among available choices, investing significant time and effort into comparisons. Conversely, satisficers aim to find a "good-enough" choice that meets their criteria, even if it is not the optimal solution (Schwartz 2004). Simon's research suggested that satisficing behavior is a practical approach, especially when exhaustive comparisons are costly or information is incomplete.

Empirical Evidence for Decision-Making Style Impacts

Longitudinal studies demonstrate that maximizers experience significantly higher levels of regret, depression, and decision-related stress compared to satisficers, despite often achieving objectively better outcomes (Schwartz et al. 2002). This research suggests that anticipatory systems designed to support satisficing behavior may provide psychological benefits beyond improved usability, including measurable improvements in user well-being and life satisfaction.

Both maximizers and satisficers experience decision fatigue when confronted with an abundance of options. The key difference lies in their response to the process: satisficers are generally more content once a choice meets their standards, whereas maximizers often continue to evaluate alternatives, seeking an unattainable "perfect" option. Despite their differing approaches, both groups are subjected to the same demanding decision-making process (Schwartz 2004, 49). For anticipatory design, this distinction presents an opportunity: by reducing the number of presented options, systems can satisfy both satisficers and maximizers, preventing decision paralysis and improving overall satisfaction.

Anticipatory design benefits satisficers by aligning solutions with their "good-enough" standards while freeing maximizers from exhaustive comparison processes. Schwartz’s (2004) work highlights the dimensions of decision-making (Figure 9), illustrating the effort required to evaluate, compare, and ultimately finalize a choice. By automating parts of this process, anticipatory systems can alleviate the burden of choice and enable users to make decisions more efficiently.

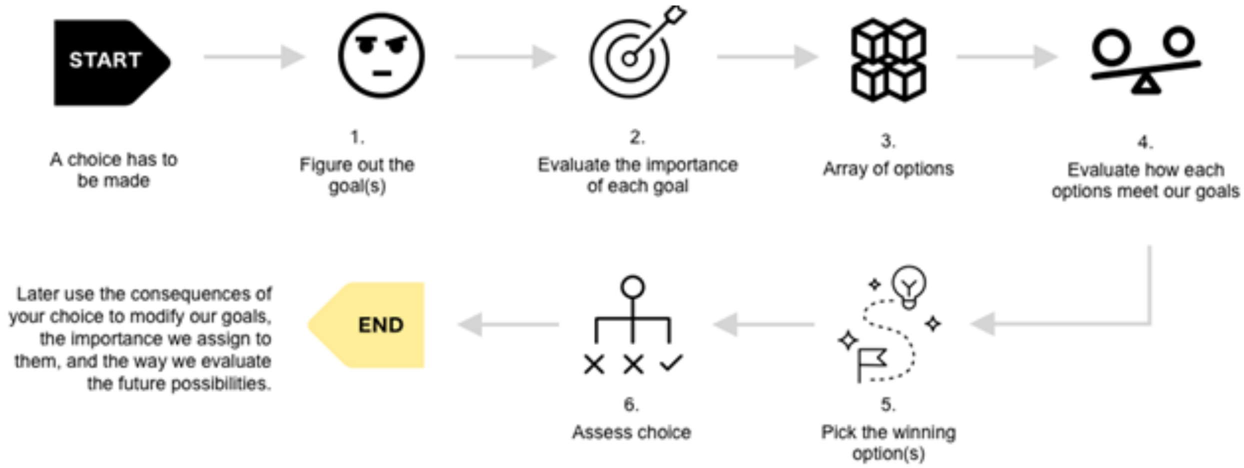

Figure 9: Our interpretation of Schwartz (2004) dimensions of choice.

1.7 Research Questions

The central challenge addressed by this research is the gap between the theoretical potential of anticipatory systems to reduce cognitive overload and their practical implementation in ways that maintain user trust, autonomy, and long-term engagement. Building on these challenges, this research will demonstrate that current anticipatory systems often fail due to insufficient understanding of human decision-making psychology, inadequate integration of temporal methodologies, and a lack of comprehensive frameworks for balancing automation with user agency.

To investigate this hypothesis and address the challenges outlined in the Problem Statement, this research adopts a scoping review methodology. Scoping reviews are particularly suitable for mapping key concepts, identifying gaps in knowledge, and synthesizing evidence to inform the development of a new design framework. For (2018), scoping reviews are a type of knowledge synthesis that follows a systematic approach to map evidence on a topic and identify main concepts, theories, sources, and knowledge gaps. Therefore, Chapter 4 will systematically explore current market standards, challenges, and best practices in anticipatory systems and related fields. To conduct this analysis, we have adopted the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) framework. This methodology was chosen for its specific guidance in ensuring scoping reviews' methodological rigor and transparency. The PRISMA-ScR checklist (APPENDIX 1) was applied comprehensively throughout the review process, enabling us to systematically identify, chart, and synthesize data from multiple sources. Key features of this framework include:

- **Clear Identification of Research Objectives**: Ensuring alignment with the study's goals to map trends, challenges, and opportunities in anticipatory design.
- **Rigorous Documentation of Eligibility Criteria**: Defining inclusion and exclusion parameters to focus the scope on relevant applications and industries.
- **Systematic Data Collection and Analysis**: Incorporating a multi-faceted approach to gather data from peer-reviewed publications, industry reports, and informal user-generated sources (e.g., forums, reviews).
- **Transparent Reporting with Flow Diagrams**: Employing a PRISMA flow diagram to illustrate the selection and screening processes for the included studies and examples.
- **Synthesis of Evidence**: Using thematic synthesis to organize findings into actionable insights, including best practices and gaps in anticipatory systems design.

Primary Research Question:

How can anticipatory systems be designed to reduce cognitive overload and decision fatigue in digital environments while maintaining user trust, autonomy, and alignment with long-term user goals?

To address this overarching question, the study explores several sub-questions:

- Which design principles can guide the development of anticipatory systems to address cognitive overload and decision fatigue?
- How can human-centered AI (HCAI) principles be integrated into the design of anticipatory systems to ensure transparency and user trust?
- In what ways can behavior science frameworks contribute to anticipatory systems that inspire sustainable behavior change?
- How can future studies methodologies support the identification of recurring design problems and guide anticipatory solutions?

Additional Research Sub-Questions:

- What are the optimal thresholds for automation levels in anticipatory systems across different user contexts and decision types?
- How can anticipatory systems effectively address the cold start problem while maintaining user engagement and trust?
- What evaluation metrics and methodologies can accurately assess the long-term impact of anticipatory systems on user cognitive load and decision-making quality?

By answering these questions, the scoping review aims to:

- **Identify existing frameworks, methods, and challenges** in anticipatory design and human-centered AI (HCAI).
- **Map gaps in current design practices,** particularly in addressing cognitive overload, user trust, and long-term behavior change.
- **Synthesize actionable insights** to propose a new framework for creating anticipatory systems that are proactive, user-centric, and adaptable to evolving digital environments.

1.7.1 Research Objectives

Beyond practical applications, this research aims to contribute to the theoretical understanding of anticipatory design by developing novel frameworks that integrate temporal methodologies with cognitive science principles. The research seeks to establish anticipatory design as a distinct discipline within human-computer interaction, with its own methodological approaches, evaluation criteria, and theoretical foundations.

The incorporation of behavior science is particularly critical for designing systems that reduce cognitive strain, foster healthier habits, and inspire meaningful, long-term behavioral change. By adopting established behavior science frameworks, anticipatory systems can move beyond mere prediction to actively support users in achieving sustainable and beneficial outcomes. Combining behavior science principles with anticipatory design ensures that systems are not only technologically robust but also grounded in an understanding of human psychology and decision-making processes.

This study emphasizes that creating anticipatory systems capable of addressing cognitive overload and decision fatigue requires a multidisciplinary approach. By leveraging insights from behavior science, human-centered AI, and future studies, designers can build systems that are both anticipatory and empowering, balancing proactive automation with user agency and trust.

1.7.1.1 Conduct a Scoping Review

This research aims to conduct a comprehensive scoping review to systematically map the existing knowledge, challenges, and opportunities in designing anticipatory systems. The scoping review will serve as a foundational investigation to identify current design principles, gaps in the literature, and practical frameworks that address cognitive overload, decision fatigue, and user trust in AI-driven experiences. By analyzing a wide range of academic, industry, and grey literature, this study will provide a structured overview of the state-of-the-art in anticipatory design and its application within digital environments.

As Hilary and O'Malley (2005) and Levac et al. (2010) outline, scoping reviews are particularly suited to exploring complex and underdeveloped areas of research. This objective recognizes the importance of systematically mapping relevant knowledge to inform future design solutions and identify recurring themes and barriers in current anticipatory practices. By adopting this approach, the study ensures that proposed frameworks and principles are grounded in evidence, offering actionable insights to advance the field of anticipatory design.

Specific Scoping Review Goals:

- **Industry Analysis**: Examine anticipatory systems across six key industries (finance, education, transportation, healthcare, retail, hospitality) to identify successful patterns and common failure modes.
- **Gap Identification**: Systematically document areas where current anticipatory systems fail to meet user needs or create unintended negative consequences.
- **Best Practice Synthesis**: Extract and codify successful approaches to balancing automation with user autonomy across different application domains.

Key considerations include:

- **Identifying Relevant Literature and Resources:** A systematic search will be conducted across academic databases, industry publications, case studies, and grey literature to capture diverse perspectives on anticipatory systems, HCAI, behavior science, and future studies methodologies.
- **Mapping Existing Design Principles and Challenges:** The review will chart established principles and identify recurring gaps in how anticipatory systems address cognitive overload, decision fatigue, user trust, and autonomy.
- **Synthesizing Actionable Insights:** Findings will be synthesized to uncover opportunities for enhancing anticipatory systems through behavior science frameworks, explainable AI, and user-centered methodologies.
- **Providing a Foundation for Framework Development:** The insights gained from the scoping review will inform the creation of a comprehensive design framework, ensuring it is evidence-based, adaptable, and reflective of current challenges and emerging opportunities.

By systematically mapping and synthesizing existing knowledge, this scoping review will lay the groundwork for developing a framework that equips designers and non-designers with the tools to create anticipatory systems that are proactive, trustworthy, and user centered.

1.7.1.2 Develop a New Design Language

This research aims to establish a comprehensive design language and set of practices tailored to the unique demands of future-oriented systems. Such a language will equip both designers and non-designers to navigate the complexities of anticipatory design, where systems proactively address user needs in dynamic and uncertain contexts.

As Armstrong (2021) argues, the evolution of human-machine relationships requires moving beyond traditional human-centered design methods toward approaches that account for emerging AI-driven interactions. This objective recognizes the need for a paradigm shift in design practices, enabling stakeholders to address both challenges and opportunities associated with anticipatory systems. The proposed design language will serve as a foundation for incorporating predictive capabilities into user experiences while preserving trust, transparency, and user agency.

Design Language Components:

- **Vocabulary Standardization**: Establish consistent terminology for anticipatory design concepts, including distinction between prediction, anticipation, and proactive response.
- **Methodological Frameworks**: Create structured processes that integrate forecasting, backcasting, and behavioral science principles into design workflows.
- **Evaluation Criteria**: Develop metrics and assessment methods specific to anticipatory systems, including measures of cognitive load reduction, user trust, and long-term engagement.

Key considerations include:

- Establishing a shared vocabulary and methodologies for cross-disciplinary collaboration between designers and data scientists.
- Defining principles for future-oriented design that balance the predictive power of anticipatory systems with the need for user autonomy and control.
- Ensuring the design language is accessible to both professional designers and non-designers, fostering inclusive participation in the development of anticipatory systems.

1.7.1.3 Leverage Explainable AI (XAI)

Transparency is critical to fostering trust in AI-driven systems, particularly those designed to anticipate and influence user behavior. This objective focuses on designing anticipatory experiences that leverage advancements in XAI to demystify how anticipatory systems generate predictions and make decisions.

Explainable AI enables users to understand the reasoning behind an anticipatory system's actions, addressing potential concerns about the *black box* nature of AI technologies. By incorporating XAI principles, this research aims to ensure that anticipatory systems are not only effective but also trustworthy, aligning with the values of human-centered design.

XAI Integration Strategies:

- **Layered Explanations**: Develop explanation systems that provide different levels of detail based on user expertise and context requirements.
- **Predictive Transparency**: Create mechanisms for users to understand how personal data contributes to system predictions and recommendations.
- **Confidence Communication**: Design interfaces that clearly communicate system confidence levels and uncertainty bounds for predictions.

Specific goals include:

- Identifying best practices for integrating XAI into anticipatory systems to support user understanding of AI decision-making processes.
- Developing guidelines for presenting explanations that are clear, concise, and meaningful to users without overwhelming them with technical complexity.
- Evaluating the impact of XAI-driven explanations on user trust, satisfaction, and willingness to engage with anticipatory systems.

1.7.1.4 Create a Framework for Anticipatory Systems

The final objective is to develop a comprehensive framework that guides designers in constructing anticipatory systems informed by both HCAI principles and future studies methodologies. This framework will provide actionable strategies for leveraging anticipatory systems to address cognitive overload and decision fatigue while maintaining user trust and autonomy.

Future studies methodologies, such as scenario planning and trend analysis, offer valuable tools for exploring potential design challenges and opportunities in uncertain contexts (Sardar 2010b).

By integrating these methodologies, the framework will enable designers to anticipate recurring problems, craft solutions that adapt to evolving user needs, and ensure the longevity of anticipatory systems.

Framework Core Components:

- **Temporal Integration Methods**: Structured approaches for combining forecasting (data-driven prediction) with backcasting (goal-oriented planning) in system design.
- **User Agency Protocols**: Guidelines for maintaining appropriate levels of user control and oversight across different automation levels.
- **Ethical Implementation Guidelines**: Frameworks for addressing bias, privacy, and fairness considerations in anticipatory system design.
- **Evaluation and Iteration Processes**: Methods for continuously assessing and improving anticipatory system performance and user satisfaction.

The framework will address:

- Strategies for integrating user inputs, contextual data, and predictive modeling into anticipatory systems.
- Approaches for balancing automation with user agency, ensuring systems empower rather than constrain users.
- Guidelines for incorporating foresight techniques to design systems that are robust, adaptable, and aligned with long-term user goals.
- Methods for evaluating the effectiveness of anticipatory systems in reducing cognitive overload and enhancing decision-making.

These objectives collectively aim to advance the field of anticipatory design by equipping designers and other stakeholders with the tools, principles, and frameworks needed to create systems that proactively meet user needs while respecting user autonomy and promoting long-term well-being. By focusing on a new design language, leveraging XAI, and integrating future studies methodologies, this research seeks to bridge the gap between theory and practice, offering actionable insights that contribute to the development of context-aware predictive systems capable of transforming user experiences in the age of AI.

1.7.2 Research Strategy

To achieve the research objectives and address the research questions, this study employs Action Design Research (ADR) as the primary methodological approach. ADR, as outlined by Sein et al.

(2011), offers an iterative and flexible framework that bridges theory and practice by enabling multiple design cycles for building, testing, and refining solutions (Figure 10). Compared to more rigid methodologies like Design Science Research, ADR allows us to incorporate feedback, adapt to contextual factors, and refine design decisions throughout the research process.

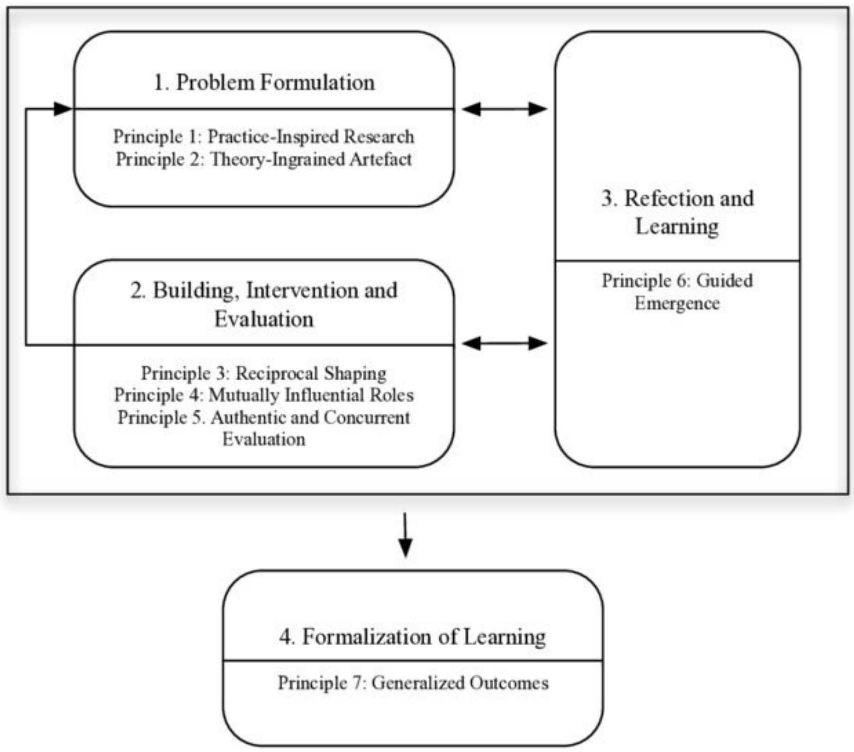

Figure 10: ADR Stages and Principles (Sein et al., 2011).

ADR fosters interactive cycles of inquiry, enabling rapid feedback and continuous refinement of hypotheses. This approach aligns with the goals of this research by supporting the development of future-oriented design solutions and facilitating collaboration between designers and data scientists. By applying ADR, we aim to develop a framework and design principles for creating anticipatory AI experiences that reduce cognitive strain, inspire behavior change, and align with user needs.

Clarification of ADR Role

While the primary strategy is a scoping review, the research will incorporate ADR principles in the framework development phase. ADR enables iterative cycles of building, testing, and refining the proposed framework, ensuring its practicality and alignment with real-world challenges.

1.7.2.1 *Methodological Integration Approach*

This research employs a sequential mixed-methods design that combines systematic analysis with iterative framework development:

Two-Phase Approach:

- **Phase 1:** A scoping review to map existing standards, challenges, and gaps.
- **Phase 2:** Design sessions and validation cycles (ADR) to refine the proposed framework with industry professionals.

Phase 1: Systematic Knowledge Mapping (Scoping Review)

- PRISMA-ScR methodology for systematic literature analysis
- Analysis of 20+ anticipatory systems across six industries
- Identification of design patterns, success factors, and failure modes
- Synthesis of theoretical frameworks and practical insights

Phase 2: Framework Development and Validation (ADR)

- Iterative design and testing of framework components
- Expert interviews with 15+ industry practitioners
- Validation workshops with design teams
- Refinement based on real-world application feedback

The research goals and questions emerged from a combination of the researcher's design experience, a comprehensive literature review, and existing practical resources. This prior knowledge serves as the foundation for the ADR program, which is divided into two distinct studies:

ADR Study 1: Analyzing Existing Resources for Designing HCAI

The first phase involves a systematic analysis of existing HCAI design guides and principles (Table 1). This review aims to identify key frameworks, methods, and ethical considerations relevant to designing trustworthy, user-centered AI systems.

Table 1: A Map of Available HCAI Guides.

Guide	Author	Principles	Year	Overview
People + AI Guidebook	Google PAIR	Fairness, accountability, and transparency	2019	Integrates responsible AI into user experiences

Design for AI Guide	IBM	User needs and responsible AI practices	2020	Emphasizes ethical AI development and user-centric design
AI Ethics Handbook	SAP	Transparency, fairness, and user-centricity	2021	Guidelines for ethical AI development
Responsible AI Design Checklist	Microsoft	Ethical considerations during AI system design	2018	Steps for ensuring responsible AI practices
Ethics Guidelines for Trustworthy AI	European Commission	Human agency, fairness, and transparency	2019	EU-wide ethical principles for AI systems
AI Meets Design Toolkit	AI x Design Community	Exercises aligning AI and user-centered design	2020	Templates for integrating AI into design workflows
Asilomar AI Principles	Future of Life Institute	Transparency, safety, and shared benefits	2017	Guidelines for safe and ethical AI development
AI Brainstorming Kit	Human-Computer Interaction Institute, Carnegie Mellon University	Collaboration, creativity, and ideation for AI design	2022	A toolkit supporting designers in brainstorming and ideating human-centered AI solutions.

Through this analysis, the study seeks to:

- Identify key principles for designing anticipatory systems informed by HCAI.
- Explore the role of future studies methodologies in forecasting user needs and addressing ethical challenges.
- Understand how to align user interaction goals with predictive AI technologies.

This review also lays the groundwork for developing a framework that addresses both the opportunities and challenges of anticipatory design in future-oriented systems.

ADR Study 2: Developing a Framework for Anticipatory AI Experiences

The second phase involves engaging with leading organizations, product managers, and designers who have successfully developed anticipatory AI services. Through a series of interviews and co-design sessions, this study aims to:

- Develop and validate a framework that equips stakeholders with tools for designing compelling and trustworthy anticipatory AI experiences.
- Explore how AI technologies can reduce cognitive overload while maintaining user trust and control.

- Integrate behavior science principles to design systems that inspire positive behavior change and deliver long-term, meaningful outcomes.

The co-design sessions will iterate through build-test-refine cycles, ensuring the framework is practical, adaptable, and robust.

1.7.2.2 Balancing User Experience with Responsible AI Design

This research acknowledges that designing anticipatory systems requires balancing user experience with the principles of responsible AI. To evaluate and deconstruct the failures of existing systems, this thesis will use a responsible AI framework as an analytical lens. Key areas of focus for this evaluation include empathy, transparency, user control, the role of behavioral science in reducing cognitive strain, and ethical considerations such as trust, explainability, accountability, and error recovery.

Responsible AI Integration Framework

To ensure a structured evaluation of ethical considerations, this study adopts a four-pillar approach to responsible AI design, which will be used to identify key areas of failure in the case studies presented:

1. **Transparency and Explainability**: All anticipatory systems must provide clear explanations for their predictions and recommendations;
2. **User Agency and Control**: Systems must preserve meaningful user choice and override capabilities;
3. **Fairness and Bias Mitigation**: Regular auditing for algorithmic bias and inclusive design practices;
4. **Privacy and Data Protection**: Minimal data collection principles and clear user consent mechanisms.

To address these themes, the study focuses on four critical knowledge domains:

The Field of Anticipation

Exploring theoretical and practical approaches to anticipatory design. This includes understanding how anticipatory systems predict user needs and reduce cognitive overload by transitioning systems from reactive to proactive states.

Future-Oriented Thinking

Examining how anticipatory systems influence behavior change for long-term benefits, such as encouraging healthier habits, financial planning, skill development, or improved decision-making.

This domain focuses on methods like forecasting, backcasting, and scenario planning to design for emergent futures.

Human-Centered AI

Addressing user concerns related to AI, including trust, transparency, fairness, and explainability. This involves integrating principles of XAI to ensure that predictive and anticipatory systems are both trustworthy and user-understandable.

Behavior Science

Investigating frameworks from behavior science to design systems that inspire positive behavior change, reduce cognitive strain, and foster sustainable outcomes. By incorporating insights from behavioral psychology, cognitive science, and behavior change models, anticipatory systems can be optimized to guide users toward healthier habits, improved decision-making, and long-term engagement without undermining autonomy.

In conclusion, through the systematic scoping review and iterative framework development using ADR principles, this research will develop a comprehensive, evidence-based framework for anticipatory AI experiences. By integrating HCAI principles, behavior science, and future studies methodologies, the study aims to advance the field of anticipatory design and contribute to a more ethical, effective, and user-centered design of AI systems.

1.8 Identifying Commonalities in Anticipatory Design Problems

To complement the scoping review and ADR strategy outlined in the previous section, this research explores future studies methodologies as a means to identify recurring design challenges and opportunities within anticipatory systems. While anticipatory experiences are gaining traction in several industries, a critical gap persists in the literature: there is a lack of structured frameworks to guide both designers and non-designers in adopting anticipatory design methods that foster trust, transparency, and adaptability.

This research focuses on a class of problems where the goal is to design services that leverage future studies methodologies to identify commonalities in anticipatory design challenges. As defined by Sardar (2010b), future studies—or futurism—explore social, technological, economic, environmental, and political trends to understand and prepare for potential scenarios. By acknowledging the existence of multiple possible futures, this approach equips designers with the tools to identify recurring challenges and opportunities across diverse scenarios.

Scenario planning, a core method of future studies, involves crafting narratives of various potential futures. This foresight empowers designers to identify problems that persist across multiple contexts while considering trends that are not immediately obvious. For anticipatory systems, such methodologies ensure that solutions are adaptable, innovative, and robust in the face of uncertainty.

To achieve this, we propose developing a framework that synergizes human-centered AI principles with future studies methodologies. This framework will address anticipatory systems from the perspective of user interaction, not merely technology integration. By leveraging anticipatory systems—systems that gather user inputs, contextual data, and environmental factors—we can develop anticipatory experiences that are both predictive and user-centric.

1.8.1 Challenges of Anticipatory Design

As outlined previously, while anticipatory experiences are gaining traction in several industries, a critical gap still exists in the literature as there's a lack of frameworks to guide designers and non-designers in effectively adopting anticipatory design methods that build user trust and transparency. This project proposes to address this gap. It focuses on a class of problems where the goal is to design services that leverage future studies methodologies to identify commonalities in anticipatory design problems.

Despite its potential, anticipatory design faces critical challenges. Poorly executed systems risk alienating users through over-automation, leading to frustration and a perceived loss of control. Shapiro (2015) highlights the importance of maintaining transparency and adaptability in these systems to preserve user trust.

Another critical challenge lies in decision-making under risk and uncertainty. Most AI-driven solutions augment human decision-making rather than replacing it entirely (Zamenopoulos and Alexiou 2007). However, anticipatory experiences propose minimizing user involvement in decision-making, raising concerns about trust and transparency. Users must be able to understand how systems arrive at predictions and retain the ability to override them when necessary.

1.8.2 The Need for Collaboration Between Designers and Data Scientists

Designing effective anticipatory systems requires collaboration. Designers bring a human-centered perspective, focusing on users' emotional and motivational needs, while data scientists contribute predictive insights based on historical patterns. For example, planning a family dinner requires both optimization (data-driven constraints) and empathy (user preferences), illustrating the importance of these complementary roles. This analogy illustrates the importance of collaboration between designers and data scientists. Imagine planning a family dinner. A data scientist might approach the task by analyzing what's available (fresh ingredients, seasonal produce) and budget limitations. Conversely, a designer would prioritize understanding family preferences, dietary restrictions, and overall enjoyment. Effective anticipatory design requires both perspectives, data-driven insights coupled with a deep understanding of human needs and desires. Only by bridging this gap can we ensure that AI and ML are used to create positive and enriching user experiences, not simply "optimal" but potentially irrelevant solutions.

So, how can we shift the design thinking process towards Human-Centered AI? The answer lies in fostering deliberate and structured collaboration between designers and data scientists to ensure AI delivers unique value aligned with human needs. This collaboration begins by pairing designers with data scientists to explore the intersection of user needs with AI's strengths. The concept of *pair design*[5], which traditionally involves two designers working together to produce better outcomes, can be extended to include data scientists. Pairing a designer and a data scientist creates a thought partnership where diverse expertise comes together to solve complex problems. This pairing encourages mutual learning (Figure 11), with data scientists gaining insight into user motivations and designers understanding the constraints and opportunities of data-driven systems.

[5] Pair design is a collaborative design practice where two designers work together throughout the design process, leveraging their complementary skills and perspectives to enhance creativity, efficiency, and problem-solving. It is an adaptation of pair programming from software development, applied within design contexts to enhance creativity and problem-solving.

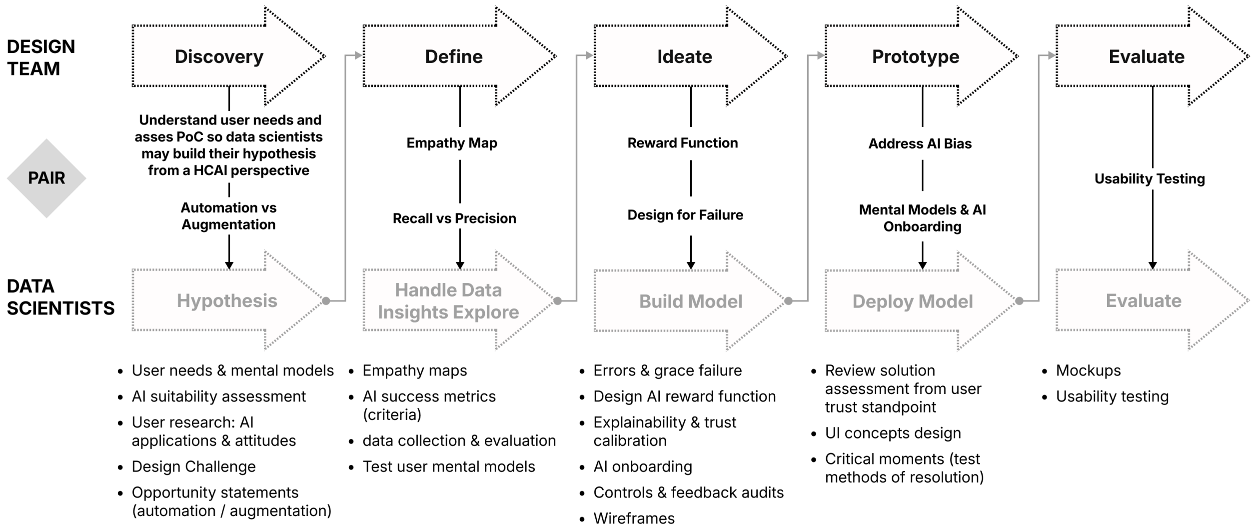

Figure 11: Our understanding of the design process when pairing design with data science.

However, the initiative for this collaboration often needs to come from engineering or data science teams recognizing the value of integrating designers early in the process. By involving designers at the inception of a project, teams can align technological development with a human-centered philosophy. This collaboration ensures that systems are not just technically optimal but also deeply relevant and empathetic to user needs.

1.9 Chapter Summary

Chapter 1—Introduction

The opening chapter establishes the central research problem: how anticipatory design can support user experience in AI-driven systems while addressing the risks of cognitive overload, decision fatigue, and trust erosion. It situates the study within the broader landscape of personalization, forecasting, and responsible AI, making the case that anticipation must be treated as a distinct design challenge rather than as an extension of personalization. The chapter defines the research questions and objectives, including the development of a conceptual framework, a scoping review, and a design language, and explains the methodological rationale for combining theoretical synthesis, case analysis, and systematic review. In framing these choices, it introduces the PICo framework (Population, Interest, Context), defining the scope as the cognitive challenges of tech-savvy demographics, particularly millennials and Generation Z, and contrasting anticipatory systems with traditional reactive systems. In doing so, the introduction positions the work as an effort to create a bridge between foresight methodologies, behavioral science, and design practice in order to establish anticipatory design as a rigorous area of inquiry.

Chapter 2 - Theoretical Foundations of Anticipatory Design

This chapter develops the conceptual underpinnings of anticipatory design by tracing how anticipation has been theorized across disciplines including philosophy, foresight studies, cognitive science, and HCI. It distinguishes between prediction, personalization, and anticipation, showing how anticipation involves a temporal and normative dimension that extends beyond data-driven forecasting. Drawing on authors such as Poli, Rosen, and Pezzulo, it introduces a layered model—intent, workflows, algorithms—that structures the analysis of anticipatory systems across different levels of design and implementation. The chapter also clarifies how concepts such as foresight, mental models, and behavior change intersect with anticipatory practices. By consolidating diverse perspectives into a coherent vocabulary, it fills a conceptual gap in the literature and equips the thesis with the theoretical scaffolding required for empirical analysis and framework development. Its contribution lies in establishing anticipation as a distinct construct with clear boundaries, which later chapters operationalize and test in practice.

Chapter 3 - Temporal Methods and Frameworks for Anticipatory Design

The third chapter examines the temporal methodologies that inform anticipatory design, focusing on forecasting, backcasting, and retrospective approaches. It evaluates the epistemic strengths and limitations of each method and shows how they can be adapted for design practice. By linking these temporal tools with behavioral frameworks such as Fogg's Behavior Model, Nudge Theory, and the Transtheoretical Model, the chapter demonstrates how anticipatory systems can be designed to support timely interventions and reduce cognitive strain while preserving user autonomy. It also highlights the challenges of applying temporal methods in practice, including the cold-start problem, uncertainty management, and aligning short-term predictions with long-term intent. This methodological mapping contributes a toolkit for designers, clarifying how different temporal approaches can shape what counts as success in anticipatory systems. The chapter's role in the thesis is to provide the methodological foundation that informs both the empirical case analysis and the framework developed later.

Chapter 4 - From Theory to Practice: Anticipatory Experiences in Industry

This chapter critically examines selected industry cases of anticipatory services—such as Digit, Vi Sense, and Mint—to ground the study's conceptual framework in real-world practice. Through comparative analysis guided by the layered model (intent–workflows–algorithms) and temporal methods (forecasting vs. backcasting), the chapter identifies recurring design strategies (*simplify, choice-edit, eliminate*) and differentiates between implicit and explicit anticipation. The cases reveal consistent pitfalls, including contextual insensitivity, misalignment with user intent, over-automation, and lack of explainability, as well as success patterns tied to transparency, progressive automation, and user control. These findings provide the empirical grounding for the heuristics and three-phase framework developed in Chapter 6, while also clarifying why anticipation cannot be reduced to personalization.

Chapter 5 - Scoping Review of Anticipatory Experiences

This chapter presents the results of a systematic scoping review, conducted according to PRISMA-ScR guidelines, of anticipatory systems across 21 industries and sectors including finance, healthcare, mobility, retail, and hospitality. Using a PICo framework to define inclusion criteria, the review maps the range of anticipatory approaches, their outcomes, and their recurring limitations. The analysis identifies patterns such as the dominance of forecasting-driven systems, recurring pitfalls around privacy and trust, and sector-specific opportunities for foresight-informed approaches. It also highlights gaps in empirical validation and long-term evaluation across the literature. By aggregating evidence across disciplines and sectors, the scoping review complements the case-based analysis of Chapter 4, broadens the empirical grounding of the thesis, and supports the development of design heuristics. Its contribution lies in providing a panoramic view of anticipatory practices, situating them within a structured evidence base, and identifying research gaps that inform the agenda outlined in the conclusion.

Chapter 6 - Proposing an Anticipatory Design Framework

Building on the theoretical, methodological, and empirical insights of previous chapters, this chapter introduces the main contribution of the thesis: a structured framework for designing anticipatory systems. Organized into three phases—Anticipate, Imagine, Shape—the framework provides a step-by-step approach for integrating foresight, predictive modeling, explainability, and behavior-change strategies into user-centered design. The chapter also presents a design language to facilitate collaboration between designers and data scientists, and a heuristics checklist to support the evaluation of anticipatory systems in practice. By operationalizing complex insights into actionable tools, this chapter transforms anticipatory design from a conceptual construct into a practical methodology. Its contribution is both prescriptive and pragmatic: it offers designers a structured process for reducing cognitive load, fostering trust, and ensuring transparency, while also equipping researchers with a foundation for further empirical testing and refinement.

Chapter 7 - Conclusion and Future Work

The final chapter synthesizes the thesis contributions and situates them within the broader context of anticipatory design and responsible AI. It highlights three core achievements: clarifying the distinction between anticipation and personalization, producing a three-phase framework with supporting heuristics, and extending responsible AI principles to the design of anticipatory systems. The chapter acknowledges limitations, including the reliance on publicly documented cases, the absence of longitudinal evaluation, and the methodological boundaries of the scoping review. It then outlines a forward-looking research agenda: empirical validation of the framework through longitudinal and experimental studies, deeper integration with cognitive science, the use of design fiction for speculative testing, and the exploration of ethical and governance challenges. By reflecting on both contributions and constraints, the conclusion positions the thesis as a foundational step in establishing anticipatory design as a rigorous, practice-informed research domain.

2 Theoretical Foundations of Anticipatory Design

2.1 Introduction

This chapter aims to establish the theoretical foundation for anticipatory systems, drawing on key concepts, frameworks, and interdisciplinary insights that support their design and development. Building on the challenges and opportunities outlined in Chapter 1, this chapter sets anticipatory systems within a broader theoretical and practical context, providing a comprehensive understanding of their role in addressing cognitive overload, decision fatigue, and trust in digital environments.

The chapter begins by tracing the origins and theoretical foundations of anticipation, exploring its relevance across multiple disciplines, and exploring its relevance in biology, psychology, and design. It then examines how anticipatory systems have evolved, from reactive technologies that respond to explicit user input to proactive systems capable of predicting and acting on user needs.

A key focus of this chapter is the integration of Human-centered AI (HCAI) principles and behavior science frameworks into the design of anticipatory systems. These frameworks provide a lens to understand and address user trust, transparency, and the psychological implications of automated decision-making.

The chapter also identifies critical gaps in existing literature, including the lack of structured frameworks to guide the design and development of trustworthy and adaptive anticipatory systems. By establishing this foundation, the chapter bridges the gap between theoretical insights and the research methodology presented in subsequent sections.

2.2 Connecting Theoretical Foundations to Research Goals

This theoretical foundation aligns with the research objectives established in Chapter 1 by providing a comprehensive framework for addressing the challenges of cognitive overload, decision fatigue, and trust in digital systems. The interdisciplinary insights presented here support the formulation of research questions aimed at exploring how anticipatory systems can:

- **Simplify complex decision-making processes** by integrating forecasting and backcasting methodologies.
- **Balance automation with transparency and user autonomy** through structured workflows and algorithms.
- **Enhance user experiences** by aligning system predictions with well-defined user intent.

Specifically, this chapter aims to:

- **Address Cognitive Overload and Decision Fatigue**: The exploration of anticipation across disciplines provides a foundation for understanding how systems can proactively reduce cognitive strain. Insights from psychology on predictive coding and goal-oriented behavior inform the design of systems that minimize decision fatigue by simplifying user choices through anticipatory mechanisms.
- **Bridge Gaps in Literature and Practice**: The chapter identifies critical gaps in the literature, particularly the need for structured frameworks to guide the development of anticipatory systems that balance automation with user autonomy.
- **Develop a Structured Framework for Anticipatory Design**: Building on Poli's theory of anticipation (2017), the research proposes a structured framework comprising *intent, workflows,* and *algorithms*. This layered approach not only provides a theoretical lens for analyzing existing systems and serves as a blueprint for designing anticipatory systems.
- **Advance Anticipatory Systems Toward Proactivity**: The shift from reactive to proactive systems directly supports the thesis's goal of advancing anticipatory systems through leveraging explicit and implicit anticipation theory (Poli 2017).

2.3 Essays on Anticipation

The term *anticipatory*, derived from the Latin *anticipalis*, means "to get ahead, foresee, or occupy beforehand" (Kaya and Öner 2019). At its core, anticipation reflects the ability to predict, prepare for, and respond to future possibilities. This capacity has influenced domains as diverse as science fiction—where the imaginative power of future technologies was first envisioned (Walorska 2015)—to modern design and AI systems (Shapiro 2015). Anticipation operates as a mental and cognitive function practiced across living organisms, enabling them to align current behavior with expected or desired outcomes (Rosen 1985).

The interdisciplinary nature of anticipation has made it a subject of extensive study across diverse fields, including biology, psychology, sociology, and design. These disciplines view anticipation as a mechanism for navigating uncertainty, fostering adaptation, and influencing decision-making processes.

Although anticipation, anticipatory behavior, and anticipatory systems are often used indiscriminately, they all have distinctive characteristics that differentiate them from predictive systems:

- **Anticipation** is an overall capacity, not exclusive to humans, to act in response to preparation for a potential future reality (Zamenopoulos and Alexiou 2020).
- **Anticipatory behavior** is a process, or behavior, that does not only depend on past and present but also on predictions, expectations, or beliefs about the future (Butz et al. 2003, 3)
- **Anticipatory System** is a system whose current state is determined by a future state. 'The cause lies in the future' (Rosen 1985).

2.3.1 The Concept of Anticipation Across Disciplines

Anticipation, broadly defined, refers to the ability to predict and act on future possibilities using information available in the present (Kaya and Öner 2019). While anticipatory design applies this principle specifically to human-computer interactions, its theoretical foundation extends across various disciplines.

Poli (2017) provides two complementary perspectives on anticipation:

- **A concise definition:** "future-based information acting in the present" (2017, 260).
- **A detailed perspective:** anticipation involves (1) a model of a system's future state and (2) the use of this model to inform present decision-making (2017, 261).

To highlight the cross-disciplinary nature of anticipation, research across various fields demonstrates how the concept is applied and studied. Each discipline uniquely frames anticipation, reflecting the specific methods, goals, and questions relevant to that field:

Table 2: Definition of Anticipation across multiple fields.

Field of Study	Author(s)	Overview
Natural Sciences		
Physics	(Fantappiè 1993)	In the 1940s, the Italian mathematician developed the idea of the synthropic process. It is a phenomenon of converging waves that cannot be caused. They grow in time. They do not follow the flow of time, implying synthropic phenomena are anticipation cases.

Biology	(Rosen 1985; Poli 2017)	Anticipation is the pivot on which the relational study of life revolves. An organism is the same example of an anticipatory system. In biology, anticipation has been studied both concerning the actual behavior of specific types of organisms and as a step towards understanding life itself. Behaving in an anticipatory way means adjusting present behavior to address future problems. An anticipatory entity (system or organism) takes decisions in the present according to 'anticipations' about something that may eventually happen.
Psychology	(Seligman et al. 2013)	Behavior is more goal-oriented than stimulus-driven. Psychology claims that ambient interactions reinforce anticipated outcomes. Psychologists study anticipation as causation of prospection, an ability to plan or to remember to do things in the future. It is guidance not by the future but by the present, evaluative representations of possible future states. An organism's ability to improve its chances for survival and reproduction lies in the future, not the past.
Social Sciences		
Anthropology	(Appadurai 2013; Guyer 2007)	Anthropology has traditionally focused on analyzing how societies develop a sense of their past. However, since the rise of industrial societies, anthropology has progressively studied how societies develop their sense of the future — anthropology studies anticipation as a tool to construe the future as a cultural fact. To develop "a general point of view about humans as future-makers and of futures as cultural facts. We need to construct an understanding of the future by examining the interactions between three notable human preoccupations that shape the future as a cultural fact, namely imagination, anticipation and aspiration".
Sociology	(Adam 1995)	Sociology has been rethinking and renewing its commitment to the future (abstract and concrete futures). With the growing degree of uncertainty experienced by contemporary society, sociology is studying anticipation as the difference between the distant future and the future in the present. For sociology, work on time helps clarify the complex nature of time and paves the way toward a better understanding of both natural and social temporalities.
Economics	(Abbott 2005; Beckert 2016)	Economics deals with the future in many ways, at many different levels. A significant difference between sociologists and economists is that "sociologists see present events as an outcome emerging from the past", while "economists reason backward from the future: Decisions are explained by the present value of expected future rewards". Economists study anticipation to predict the future that shapes present decisions.

Humanities		
Philosophy	(Mead 1932; Poli 2017)	Philosophers are interested in anticipation as a mechanism to understand the future, particularly in the connection between anticipation and ethics. They discuss anticipation from a metaphysics and biology lens. Past and future are both internal and external to the present. The past that actively determines the present is in the present, and so is the future we seek to address. Pasts and futures that are not in the present do not influence that present.
Applied Sciences		
Design	(Shapiro 2015)	The design explores anticipation as the difference between systems able to use the future as opposed to systems unable to do so. Design use anticipation as a mechanism to simplify systems interactions by responding to users' needs one step ahead of their decision or interaction. i.e., responding to user needs they have not expressed yet or automating a task and removing the need for user interaction.

The cross-disciplinary exploration of anticipation demonstrates its central role in systems, organisms, and decision-making processes. As Poli (2017) explains, anticipation allows us to "imagine actions that can only be tested once the future happens" (p. 265).

Biological, Psychological, and Social Dimensions

Anticipation's foundations in biology, psychology, and sociology provide unique insights into its dynamics (Rosen 1985; Poli 2017). Biological anticipation focuses on innate mechanisms that predict future states to ensure survival. Psychological anticipation addresses cognitive and emotional aspects, such as expectations and foresight. Social anticipation examines collective behavior and its influence on societal trends and decision-making. Together, these dimensions emphasize the need for interdisciplinary cooperation to design effective anticipatory systems.

Anticipation can be studied using both qualitative and quantitative methodologies (Kaya and Öner 2019). Each approach offers distinct advantages and challenges:

- **Qualitative Techniques**: Methods like trend analysis, scenario planning, the Delphi method, and brainstorming help explore diverse possibilities and create holistic frameworks for understanding potential outcomes. These techniques provide strategic insights but may be limited by subjectivity and resource intensity.
- **Quantitative Techniques**: Statistical models such as time series analysis, regression analysis, and predictive analytics offer precise, data-driven forecasts. While these

methods excel in capturing patterns and trends, they often require high-quality data and assume stable conditions that may not always exist.

Given the complexity of anticipatory systems, a combination of qualitative and quantitative methods is essential. For instance, qualitative insights can guide the development of robust quantitative models, while quantitative data can validate qualitative assumptions. This integrated approach ensures a comprehensive understanding of anticipatory systems' strengths and limitations, enabling better decision-making and design outcomes. These techniques can be used individually or in combination to enhance the accuracy and comprehensiveness of anticipatory analysis. However, it's important to consider the advantages and disadvantages of each technique to ensure effective decision-making and planning (Table 3).

Table 3: Strengths and limitations of mixed-methods in anticipation, adapted from (Kaya and Öner 2019).

Method Type	Advantages	Disadvantages
Qualitative		
Trend Analysis	Provides insights into long-term patterns and cycles.	May overlook abrupt changes or emerging trends.
Scenario Planning	Encourages strategic thinking and preparedness for various futures.	Requires considerable time and resources to develop multiple scenarios.
Delphi Method	Harnesses the expertise of a diverse group of experts.	Susceptible to bias or groupthink.
Environmental Scanning	Helps organizations stay informed about external factors impacting their operations.	Can be challenging to prioritize and interpret vast amounts of information.
SWOT Analysis	Simple yet effective for identifying internal and external factors affecting an organization.	Subjective assessment may lead to biased results.
Qualitative Risk Assessment	Provides a holistic view of potential risks, including those difficult to quantify.	Relies heavily on subjective judgments, which can vary among stakeholders.
Brainstorming	Fosters creativity and generates diverse perspectives.	May result in unfocused discussions or impractical ideas.
Quantitative		
Time Series Analysis	Utilizes historical data to identify trends and patterns.	Assumes past trends will continue, which may not always hold true.

Regression Analysis	Quantifies relationships between variables for predictive purposes.	Requires assumptions about the form and stability of relationships, which may not always be accurate.
Monte Carlo Simulation	Provides a range of possible outcomes based on probabilistic analysis.	Requires a good understanding of probability distributions and input variables.
Forecasting Models	Offers systematic and structured approaches to predicting future trends.	Accuracy heavily depends on the quality of historical data and the appropriateness of the chosen model.
Decision Trees	Visualizes decision-making processes and potential outcomes.	May oversimplify complex decision contexts and interactions between variables.
Bayesian Analysis	Incorporates prior knowledge and updates beliefs based on new evidence.	Requires specifying prior distributions, which can be subjective and influence results.
Predictive Analytics	Leverages advanced algorithms to extract insights and make accurate predictions.	Requires large datasets and expertise in data preprocessing and algorithm selection.

In design, anticipation becomes a powerful tool for streamlining user experiences by predicting needs before they arise. When applied to AI, anticipatory systems function as predictive models trained on historical data and contextual information (Riegler 2001), simplifying complex decision-making processes for users. This interdisciplinary foundation positions anticipatory design as a unique opportunity to align predictive capabilities with human needs, transforming AI-driven technologies into systems that enhance efficiency while reducing cognitive overload.

Given the complexity of anticipatory systems, a combination of qualitative and quantitative methods is essential. For instance, qualitative insights can guide the development of robust quantitative models, while quantitative data can validate qualitative assumptions. This integrated approach ensures a comprehensive understanding of anticipatory systems' strengths and limitations, enabling better decision-making and design outcomes.

2.4 Defining Anticipation: Theoretical Roots and Core Design Characteristics

The theoretical roots of anticipation originate in the biological sciences, where it was rigorously studied by Rosen (1985) in his seminal work *Anticipatory Systems: Philosophical, Mathematical, and Methodological Foundations*. Rosen defined anticipatory systems as those that contain a predictive model of themselves and their environment, which allows them to change state in accord with the model’s predictions of future states (Louie 2017).

Anticipation is a concept that resonates across a diverse range of disciplines, each offering unique perspectives that enrich its application in anticipatory systems. In biology, Rosen (1985) defines anticipatory systems as those capable of predicting changes in their environment, enabling them to adapt and survive. This biological understanding highlights how organisms inherently exhibit anticipatory behavior to optimize survival outcomes. Psychology extends this perspective by examining anticipation as a cognitive mechanism fundamental to processes like learning, decision-making, and prospection. As Seligman et al. (2013) emphasize, anticipation enables individuals to prepare for desired outcomes while avoiding negative consequences.

From a sociological perspective, anticipation operates at a collective level, structuring societal futures through trends, policies, and cultural narratives. As explored by Adam (1995) and Sardar(2010b), futures research investigates how societal foresight shapes trends, responses, and cultural practices, enabling communities to prepare for change and uncertainty. Philosophy offers yet another layer of insight, exploring anticipation as a metaphysical concept that aligns present actions with imagined futures. Mead (1932) and Poli (2017) delves into the interplay between present realities and anticipated futures, underscoring anticipation's role as a bridge between these temporal states.

Finally, in design, anticipation is operationalized as a proactive approach to streamline interactions and enhance user experiences. Shapiro (2015) describes anticipatory design as a method that predicts and responds to user needs one step ahead of their decisions, thereby reducing cognitive load and creating more seamless interactions. Together, these disciplinary insights provide a multidimensional foundation for understanding and applying anticipation in modern systems.

Biological and psychological principles inspire anticipatory design practices:

- **Biology** provides analogies for systems that adapt dynamically to future changes.
- **Psychology** informs the development of predictive algorithms, inspired by the brain’s ability to form expectations and refine predictions over time.

Anticipatory design relies on two core design characteristics: **Prediction** and **Foresight**. Prediction leverages historical and contextual data to forecast user actions and behaviors. Foresight explores long-term possibilities to anticipate evolving user needs. For instance, Amazon’s recommendation engine uses past behaviors to suggest, while smart home systems learn user routines to automate tasks..

Across disciplines, anticipation emerges as a cognitive and systemic tool for navigating uncertainty. It serves a dual function: guiding present actions toward desired futures and minimizing potential negative outcomes (Pezzulo and Butz 2008). Our ability to anticipate empowers us to:

- Formulate novel goals and plans based on future needs.
- Develop increasingly abstract expectations to guide future actions.
- Mentally manipulate representations before or instead of taking physical action.
- Significantly modify and adapt the environment to align with our goals and representations.
- Envision ourselves in the future and reason about potential scenarios.

2.5 Differentiating Comprehensions of Anticipatory Design

In the literature, anticipatory design is explored not only as a methodology for creating user-centered systems but also as a paradigm for shaping meaningful, adaptive, and predictive user experiences. While various scholars such as Celi and Colombi (2020), Cascini (2012), or Morrison et al. (2021) provide compelling perspectives on anticipatory design, our interpretation aligns more closely with the ideas proposed by Shapiro (2015) and Van Bodegraven (2017). Their perspective emphasizes pragmatic, user-centered principles and actionable methodologies that bridge predictive capabilities with immediate user needs.

This contrasts with other frameworks that often lean heavily on speculative, technical, or critical design methodologies, as we will explore in this section.

2.5.1 Alternative Frameworks

Celi and Colombi (2020) view anticipatory design as deeply embedded in foresight and future thinking, where the intentional exploration of future possibilities drives societal or cultural change. Their approach includes:

- **Future Orientation**: A focus on multiple potential futures, using speculative and exploratory methods to navigate complexity and uncertainty.
- **Role of Trends**: Trends are treated as critical "future prompts," helping designers interpret socio-cultural signals and project new meanings.
- **Metadesign Approach**: Anticipatory design, for Celi and Colombi, is a reflective framework characterized by open-ended, adaptable pathways rather than predetermined solutions.
- **Multi-layered Inquiry**: Borrowing from future studies, their approach delves into surface trends, societal myths, and deeper values to address wicked problems.

- **Cultural and Symbolic Innovation**: They emphasize cultural evolution through the redefinition of meanings and values.

While this approach is valuable for its speculative depth and cultural insights, it leans heavily on foresight methodologies and metadesign principles, which, in our perspective, risk remaining too abstract and detached from the actionable realities of user-centered design. In comparison, our approach is less speculative and more grounded in designing systems that proactively serve users' immediate and evolving needs, leveraging data, behavioral science, and predictive algorithms to create adaptive, transparent solutions. Our approach focuses on creating adaptive, transparent solutions that provide tangible user benefits.

On the other hand, Cascini's (2012) interpretation of anticipatory design focuses on predicting and shaping the future of products and processes through the Laws of Engineering Systems Evolution. His key contributions include:

- **Systematic Modeling**: Emphasizing the need for explicit models to investigate systems comprehensively.
- **Contradiction Analysis**: Highlighting subsystems for improvement while avoiding wasted efforts on mature subsystems.
- **Predictive Evolution**: Guiding strategic decisions for product development by forecasting evolutionary scenarios.

Cascini's (2012) framework is methodical and rooted in engineering principles, making it ideal for technical innovation and process optimization. However, it lacks an emphasis on human intent, behavioral change, and the emotional nuances of user experiences. In contrast, our interpretation of anticipatory design integrates human-centered methodologies with predictive technologies to create solutions that are deeply aligned with user aspirations and goals. This focus on user intent ensures that anticipatory systems not only address technical challenges but also resonate emotionally and practically with users.

Last but not least, Morrison et al. (2021) comprehend anticipatory design as a framework that emphasizes:

- **Relational Ontology**: Rethinking relationships between human and non-human elements, fostering long-term sustainable practices.
- **Multiscalarity**: Addressing complex issues like climate change through multi-perspectival design at various scales.

- **Cultural Context**: Recognizing futures as plural and contextually situated, reflecting diverse ways of knowing and being.
- **Speculative and Critical Design**: Using design fiction and speculative design to expand cultural imaginaries and explore alternative futures.

Their approach is innovative and reflective, addressing power dynamics, sustainability, and participatory politics. However, it prioritizes speculative and critical design over actionable, practical systems that deliver immediate value to users. While their macro perspective is valuable for broader societal and cultural considerations, our understanding focuses on a more micro evaluation that creates systems that are simultaneously predictive and user-aligned, emphasizing trust, transparency, and adaptability.

2.5.2 Research's Approach

Our interpretation of anticipatory design is deeply influenced by Shapiro (2015) and Van Bodegraven (2017), which prioritizes the intersection of behavioral science, user intent, and adaptive technology. This approach views anticipatory design as a pragmatic, practical, and iterative process that empowers users by aligning predictive systems with their immediate and long-term needs.

The key tenets include:

- **Human Intent at the Core**: We comprehend the foundation of anticipatory design lies in understanding and prioritizing user intent. By analyzing users' goals, motivations, and behaviors, systems can proactively provide meaningful and personalized solutions.
- **Temporal Synthesis**: Unlike purely speculative approaches, this interpretation integrates forecasting, backcasting, and real-time data to navigate both short-term predictions and long-term aspirations.
- **Behavioral Science Integration**: Principles such as nudging (Thaler and Sunstein 2008), cognitive load reduction (Schwartz 2004; Rutkowski and Saunders 2018), and behavior modeling (Fogg 2009) guide the design of systems that support and empower users rather than manipulate or unacknowledged them.
- **Actionable and Adaptive Systems**: This approach emphasizes creating tangible, user-centered solutions that are accountable, transparent, and capable of adapting to evolving user needs.

- **Pragmatic Foresight**: While acknowledging the importance of future scenarios, this approach avoids speculative excess, focusing instead on actionable insights derived from data and behavioral analysis.

To conclude, this research establishes anticipatory design as a pragmatic and user-centered methodology that integrates data science, behavioral insights, and foresight. While scholarly contributions enrich the broader discourse on anticipatory design, they often prioritize speculative, technical, or cultural frameworks at the expense of actionable, real-world applications. The framework proposed in this research bridges the theoretical and practical, offering a synergistic approach that pairs designers with data scientists and engineers to design systems that are engaging, ethical, and aligned with user goals and motivations. By emphasizing the principles of trust, adaptability, and transparency, my interpretation seeks to establish anticipatory design as a pragmatic tool for enhancing user experiences, rather than merely speculating on futures.

2.6 The Evolution of Digital Services: From Reactive to Anticipatory

Digital services are transitioning from reactive to anticipatory. Figure 12 depicts a shift from user insights triggering actions to anticipating user needs. Business models are evolving from manually designed experiences to automated services.

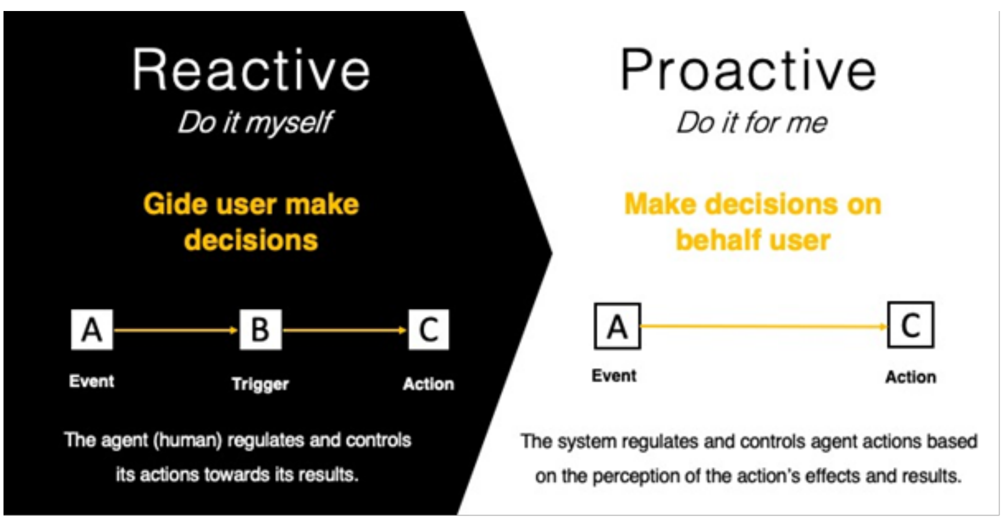

Figure 12: Our understanding of how experiences transition from reactive to proactive.

Current digital products often remain in a reactive state, designed solely to respond to user inputs (A → B → C). These solutions incessantly demand user attention and input, potentially leading to decision fatigue or analysis paralysis (Walorska 2015). The paradigm shift is towards proactive systems (A → C) where the system anticipates user needs and acts without explicit commands.

Forrester's survey of over 350 Business-to-Consumer (B2C) revealed that most struggle with anticipating customer needs (Ask et al. 2021). Anticipation requires a deep understanding of customer journeys and real-time customer monitoring capabilities.

Effective anticipatory systems incorporate and process a vast array of real-time user-specific variables to achieve specific goals. These evolving systems continuously learn and adapt by feeding information and data back into the process, potentially branching into new functionalities. Delivering value through user need anticipation is a multifaceted process (Figure 13). Both anticipating needs and acting are complex challenges.

Figure 13: Our comprehension of forecast and backcast.

Anticipatory design can reduce user cognitive overload throughout the interaction process. In the pre-interaction phase, it can offer users what they might need before they realize it. During the interaction, it suggests actions based on the solution's context. Post-interaction, it delivers insights or interprets information rather than simply displaying it. This holistic approach can minimize or eliminate decision fatigue throughout the interaction (Cerejo and Carvalhais 2020).

For example, anticipation plays a crucial role in goal-oriented and proactive behavior since patterns of actions can be selected depending on their expected outcomes and not (only) on stimuli that are available here and now. While reactive systems can be functionally described with STIMULUS → ACTION (S-A) behavioral patterns, anticipatory systems have instead (STIMULUS +) EXPECTATION → ACTION (E-A) behavioral patterns, which is permitted by the explicit prediction of a stimulus or an action effect (STIMULUS → EXPECTATION (S-E), or STIMULUS, ACTION → EXPECTATION (S-A-E)) (Pezzulo and Butz 2008, 24). This is the challenge we anticipate for the future of anticipatory design research: the passage from predictive systems toward anticipatory systems (Figure 14). The constitutive definition of anticipation indicates a state where something is expected, and action is taken toward that expectation.

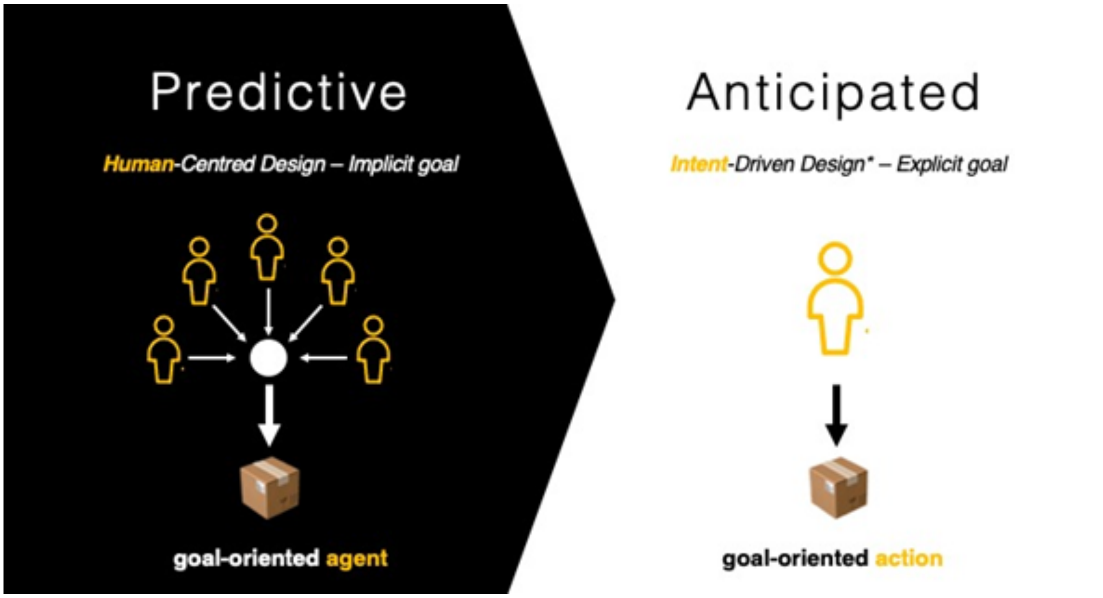

Figure 14: Goal-oriented actions are drawn on Intent-driven design (Kaneko et al. 2017).

This shift from prediction to anticipation is a key challenge for future anticipatory design research. Anticipation, by definition, involves expecting something and taking action based on that expectation. In the coming years will be moving from a goal-oriented agent where the human is the conductor of their outcomes towards a goal-oriented action where the system is set up to support the user to achieve their goals (Table 4). Understanding anticipatory behavior for enterprises is to understand the outcomes that people seek so that they can insert themselves into customers' moments to help them achieve their aspirations.

Table 4: Our Understanding of Predictive vs. Anticipatory AI Capabilities.

<table>
<tr><th>Hindsight Strategy</th><th>Foresight Strategy</th></tr>
<tr><td>Predicative</td><td>Anticipatory</td></tr>
<tr><td>Goal-oriented agent
(Reactive System)</td><td>Goal-oriented action
(Anticipatory System)</td></tr>
<tr><td colspan="2">PAST PRESENT FUTURE
Stimulus + Behavioral Patterns ACTION = Movement & Expectation + Goal</td></tr>
<tr><td>The agent (human) regulates and controls its actions towards its results.</td><td>The system regulates and controls agent actions based on the perception of the action’s effects and results.</td></tr>
<tr><td><u>Implicit goal</u>
the organism is designed/evolved to realize a goal that is not represented. Stimuli are designed to trigger agent action.</td><td><u>Explicit goal</u>
A mechanism exists that includes an explicit goal, which triggers action. Patterns of action can be selected depending on their expected outcomes.</td></tr>
<tr><td>Predictive systems use selected historical data to support agent recommendations or high-personalize actions.</td><td>In an anticipatory system, actions are selected, executed, and monitored thanks to an explicit, anticipatory goal representation.</td></tr>
</table>

We believe that such anticipatory systems can build an ecosystem that allows a service to anticipate actions and set up a route whose effect is judged to be positive, prevent dangers before experiencing them, actively search for information that is expected to be relevant, and so on. All these capabilities, based on processing information relative to the future, are the keys to passing from mere reactivity to proactivity and goal-oriented behavior (Pezzulo and Butz 2008, 6).

2.6.1 Integrating Causality in Anticipatory Systems

Causality is fundamental in the design of anticipatory systems, as it enables these systems to model and predict the dependencies between user actions and subsequent outcomes. Unlike reactive systems, which respond directly to explicit user inputs, anticipatory systems rely on understanding cause-and-effect relationships to infer future user needs and behaviors.

For instance, consider a smart home system that adjusts lighting and temperature. The system must discern causal relationships, such as the effect of ambient light levels on user comfort or the impact of room temperature on energy consumption. By analyzing these patterns, the system can anticipate adjustments that align with user preferences before a request is made.

The use of counterfactual reasoning, as highlighted in the work of Pearl and Mackenzie (2018), further strengthens anticipatory design. By asking "What would have happened if...?" systems can refine their predictions and decisions. For example, an anticipatory financial planning tool might simulate the consequences of different investment choices, helping users visualize the long-term effects of their actions and guiding them toward informed decisions.

While anticipation and causality are interrelated concepts, they are distinct. Anticipation involves not only predicting future events but also understanding the potential causes that could bring them about (Light 2021). It's about "materializing data in novel ways" to envision a future where a desired transformation occurs.

Causality refers to the relationship between two events: a cause and its effect. The effect is the consequence of the cause, answering the question "What happened?" The cause explains "why it happened?" There are various forms of causality, but this discussion focuses on understanding cause-and-effect relationships for predictive purposes. While the concept of causality seems intuitive, precisely determining cause and effect can be challenging. In this research, we explore causality through the work of Pearl and Mackenzie (2018). They emphasize the importance of counterfactual reasoning in establishing causality.

Counterfactual reasoning asks, "What would have happened if...?" This thought experiment allows us to consider alternative realities where the cause did not occur. By comparing the actual outcome with the hypothetical outcome (the counterfactual), we can gain a stronger understanding of whether one event truly caused another. This approach aligns with two key principles:

- **Temporal Precedence:** The cause must occur before the effect.
- **Counterfactual Explanation:** The cause provides unique information about the effect's future values, meaning that if the cause hadn't happened, the effect would likely be different.

While most of the academic research on causality focuses on statistical relationships between time series, Pearl and Mackenzie's work delves deeper, highlighting the importance of counterfactual reasoning to truly understand cause and effect. This distinction is crucial for various applications where precise cause-and-effect relationships are essential.

2.6.1.1 *Linear vs. Non-Linear Causality*

Traditionally, causality has been viewed as a linear, unidirectional flow of influence from past to present ("objective facts" affecting the present situation). However, non-linear, or circular causality, acknowledges a two-way cause-and-effect relationship between elements, characterized by feedback loops (Zamenopoulos and Alexiou 2020). In this model, an effect can create a cause, which in turn feeds back to influence the effect. Anticipation, by its nature, deals with complex, interconnected systems where cause and effect can be interwoven. Despite these limitations, causality plays a crucial role in enabling anticipation. Causality establishes the order and relationships between events in a process, allowing us to understand how one state leads to another (Poli 2019). This knowledge of cause-and-effect sequences is the foundation for anticipating future states.

2.6.1.2 *Applications of Circularity in Design*

Anticipatory design inherently involves a bidirectional interplay between present actions and future outcomes. Circularity, as proposed by (Zamenopoulos and Alexiou 2020), lies at the heart of this process, raising the question: How can the effect of an action determine the action in advance? Conversely, it asks: How can future states influence decisions made in the present? This principle challenges traditional, linear views of causality, introducing a dynamic and recursive perspective essential for anticipatory systems.

According to the authors, circularity refers to a feedback-rich relationship where actions and their anticipated effects are continuously interdependent. In an anticipatory system, future outcomes are not merely passive endpoints but active determinants of the present. For instance, a recommendation algorithm that suggests content based on predicted user preferences does so by simulating the user’s potential response. This simulation, in turn, informs the algorithm's recommendations—a circular interplay between cause and effect.

This dynamic relationship can be illustrated through two key mechanisms:

- **Forward Circularity**: Future scenarios shape present actions by framing goals, constraints, or opportunities. For example, a navigation system like Waze might adjust current routes based on projected traffic conditions, effectively allowing the anticipated future (traffic congestion) to influence the present (route choice).
- **Backward Circularity**: Present actions reshape the assumptions about the future. For instance, a climate policy anticipates reduced emissions from certain interventions but must revise these assumptions based on real-time outcomes and feedback.

2.6.1.3 *Applications of Circularity in Design*

Circularity in anticipatory systems draws significantly from counterfactual reasoning, which involves simulating and evaluating potential future states by asking, "What would happen if...?" (Pearl and Mackenzie 2018). For instance, hDrop a wearable health device predicting dehydration risks (Figure 15) exemplifies this interplay.

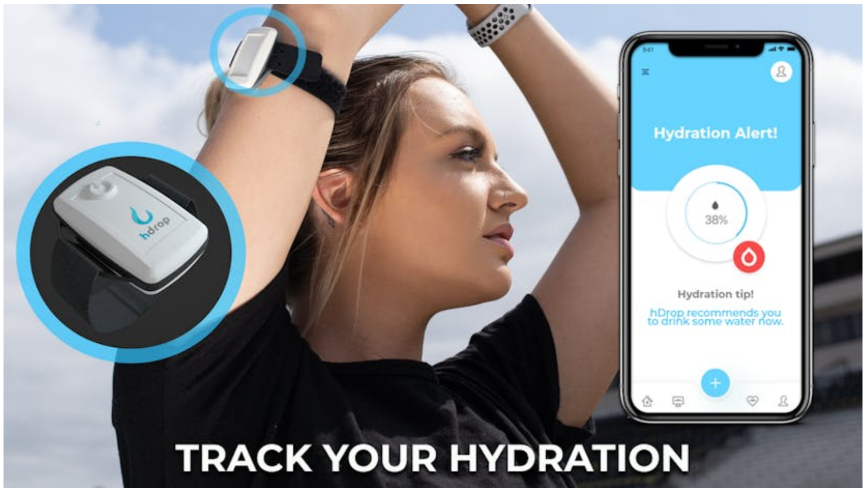

Figure 15: Representation of hDrop, a non-invasive device that claims to assess hydration and electrolyte levels accurately.

Such a device does not merely monitor current hydration levels but also uses future-oriented simulations, considering factors like anticipated physical activity or environmental conditions, to recommend immediate actions. This circular relationship between simulated outcomes and present actions ensures real-time decision-making aligns seamlessly with both immediate needs and long-term health goals, reflecting the essence of circularity in decision-making systems.

Another critical application of circularity is the integration of adaptive learning and feedback loops like absorb (Figure 16), an Intelligent LMS that learns from user behavior to anticipate content needs, which enables systems to continuously refine their predictions and actions.

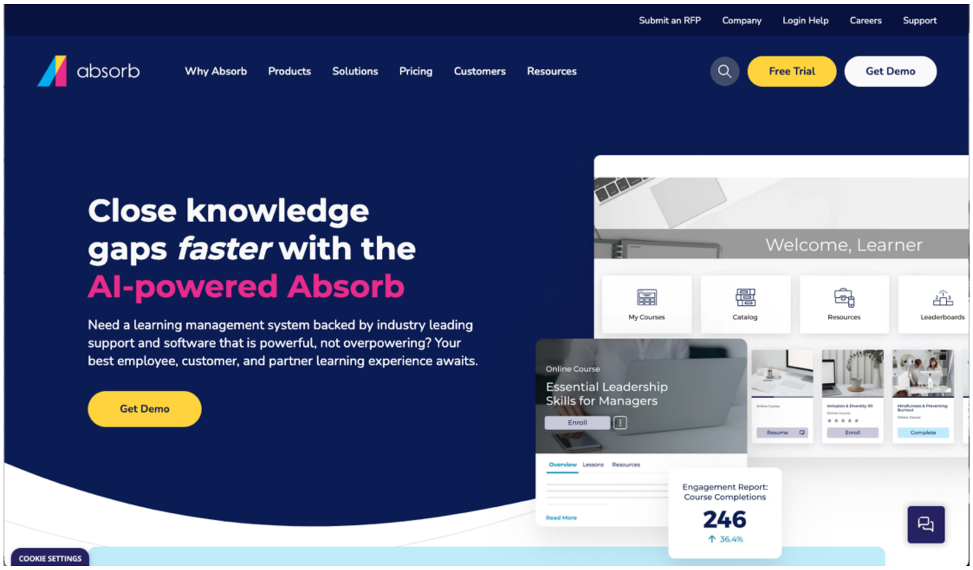

Figure 16: Absorb LMS website screenshot.

This anticipatory service adjusts its curriculum based on real-time user performance data, predicting future learning challenges and preemptively introducing tailored materials to address them. This dynamic adjustment process, grounded in principles of feedback and adaptability, allows systems to align with evolving user contexts while improving predictive accuracy. Such adaptive systems embody the iterative nature of circularity, where each user interaction contributes to refining future decisions, fostering a mutually reinforcing relationship between present inputs and anticipated outcomes (Zamenopoulos and Alexiou 2020; 2007).

Finally, scenario planning and foresight leverage circularity by utilizing potential futures to assess and recalibrate present strategies. For instance, consider a ride-sharing service anticipating a shift toward stricter carbon emissions regulations and the growing adoption of electric vehicles. Through backcasting, the service starts with a future state where its fleet operates entirely on electric vehicles to comply with emissions standards and consumer preferences for sustainability. From this vision, the company identifies present actions necessary to achieve that goal, such as investing in electric vehicle infrastructure or forming partnerships with manufacturers. This illustrates circularity's role in connecting future objectives with present decisions to build resilient, future-ready systems (Poli 2019).

Circularity introduces a layer of complexity that requires designers to carefully consider both intended and unintended consequences. For example, over-determination of actions, where excessive reliance on predicted future states could limit user agency by restricting choices based on probabilistic outcomes, poses a significant challenge. Additionally, bias in predictions can arise when circular systems rely on biased data or incomplete feedback loops, potentially reinforcing stereotypes or inaccuracies in decision-making. Transparency is also critical; users must understand how anticipatory systems make decisions and how their actions shape future predictions. Without clear explanations, trust in such systems can erode, undermining their effectiveness and adoption (Zamenopoulos and Alexiou 2020; 2007).

Circularity transforms anticipatory design into a dynamic, iterative process where the future is not a distant endpoint but an active contributor to present decision-making. By embracing this principle, designers can create systems that are not only predictive but also resilient, transparent, and adaptive—offering a truly human-centered approach to shaping future experiences.

2.6.2 Anticipation in Design: From Prediction to Future Shaping

Anticipatory design extends the role of systems beyond reactive responses to actively shape experiences. As stated previously, traditional design operates reactively: users initiate interactions, and systems respond. In contrast, anticipatory systems leverage BD, ML, and AI to proactively meet user needs, “responding to user needs one step ahead of their decisions” (Shapiro 2015). By shifting systems from reactive to proactive, anticipatory design simplifies user interactions and reduces cognitive load. One of the earliest and most successful examples of an anticipatory system is Nest, the smart thermostat (Figure 17). Nest leverages historical data on user temperature preferences, weather forecasts, and occupancy patterns to anticipate when to adjust heating or cooling.

Figure 17: Nest thermostats by Google.

Instead of waiting for users to manually adjust settings, the system proactively creates a comfortable environment while reducing energy waste. Nest transforms a traditionally reactive system into a proactive one. This pioneering use of anticipatory design demonstrates how systems can align with user needs before they are explicitly expressed, setting a standard for modern anticipatory technologies. The success of anticipatory design lies in its ability to balance automation with user agency and trust. Over-automation risks alienating users, while poorly aligned predictions undermine satisfaction. Designers must prioritize transparency, adaptability, and user-centric outcomes to ensure that anticipatory systems serve as enablers of convenience rather than sources of frustration.

The integration of anticipation into design practices holds immense potential for enhancing user experiences while addressing challenges like cognitive overload and decision fatigue. Anticipatory systems must balance predictive automation with user autonomy and trust. As Shapiro (2015) notes, the success of anticipatory design lies in its ability to "simplify user flows without alienating users through over-automation." However, achieving this balance requires a nuanced approach that integrates the following principles:

- **Transparency and Trust**: Users must understand how predictions are made and have control over automated actions.
- **Adaptability**: Systems should evolve with user behavior, learning and refining predictions over time.
- **User-Centric Outcomes**: Anticipatory systems must align predictions with user goals, avoiding frustration caused by irrelevant or poorly timed automation.

2.6.2.1 The Power and Pitfalls of Anticipatory Systems

Anticipatory systems offer transformative potential, yet their reliance on highly automated intelligent mechanisms brings inherent challenges. Understanding the interplay between existing anticipatory mechanisms and their influence on intelligent cognitive systems for goal-oriented behavior is critical to developing successful anticipatory designs. Despite advancements in AI, a persistent issue lies in the lack of transparency and interpretability of such systems. Users desire to understand the rationale behind a system's decisions, and without this transparency, anticipatory systems risk alienating users, particularly in trust-critical domains like healthcare and finance.

Recent technological advancements enable AI systems to mimic human intellectual processes such as learning, reasoning, and problem-solving, paving the way for truly anticipatory systems. However, the success of human-AI synergy hinges on building trustworthy and responsible AI solutions that prioritize user interests. Unfortunately, many systems fall short of user and business goals due to a lack of a comprehensive understanding of user cycles and touchpoints. This can result in systems that excel technically but fail to deliver meaningful, user-aligned outcomes.

2.6.2.2 *Case Study: IBM's Watson for Oncology*

The IBM Watson for Oncology project provides a cautionary tale of AI's potential pitfalls. After $62 million in investments, the project was canceled due to unsafe treatment recommendations. Initiated in 2013 in collaboration with the University of Texas MD Anderson Cancer Center, the project aimed to develop an AI-driven oncological advisor to recommend personalized treatments based on clinical guidelines. However, in July 2018, StartNews[6] reviewed internal IBM documents and revealed that Watson made erroneous and even dangerous recommendations due to reliance on a small set of hypothetical patient cases during training. These issues were compounded by a lack of scalability, transparency, and user trust in its decision-making process. The user interface, although functional, did not address transparency in recommendations, leaving health professionals unable to validate or trust the system's outputs. Figure 18 illustrates Watson's interface, which failed to provide the necessary explanations to instill user confidence.

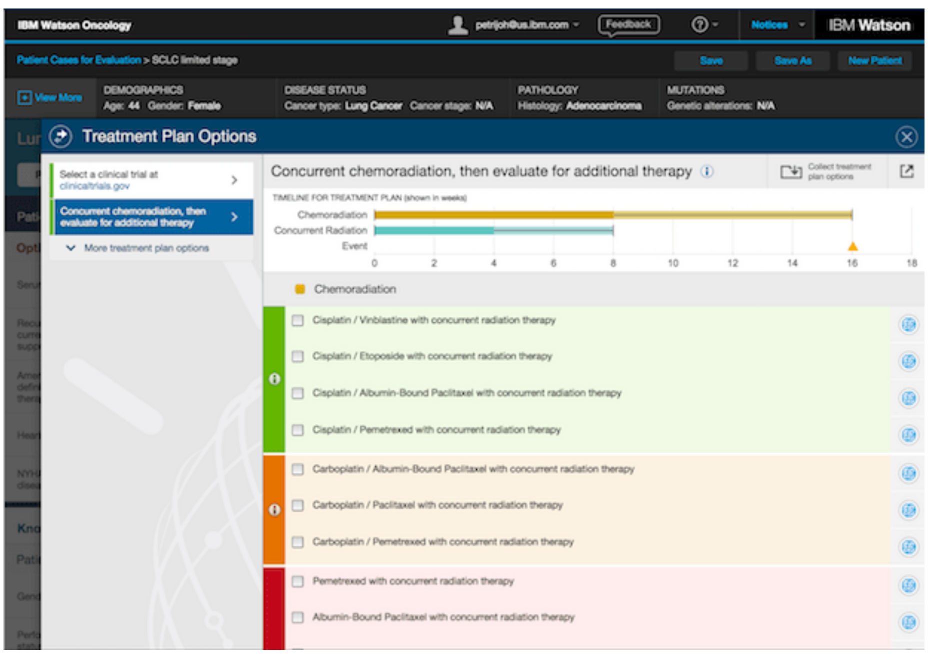

Figure 18: Watson for Oncology user interface screenshot.

Lessons Learned: Transparency and Trust in Anticipatory Systems

The Watson for Oncology case underscores the importance of transparency and explainability in AI-driven anticipatory systems. To foster trust, systems must explain their predictions, recommendations, and anticipations in ways that users can understand and evaluate. Simply

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[6] https://www.statnews.com/2018/07/25/ibm-watson-recommended-unsafe-incorrect-treatments/

achieving usability is insufficient; trust depends on users perceiving the system as transparent and aligned with their goals.

Building trust also involves managing user expectations around the capabilities and limitations of anticipatory systems. Given that AI operates based on probabilistic models, users often overestimate its capabilities. Clear explanations can guide users to understand when to trust the system and when to rely on their own judgment. This balance is critical for minimizing user frustration and fostering long-term trust as both AI technologies and user relationships evolve (Google 2021).

2.6.3 A Design Framework for Anticipatory Systems

The development of anticipatory systems is deeply rooted in a comprehensive understanding of human behavior and predictive technologies. By combining these elements, designers can create systems that do not merely react to user input but anticipate needs, optimizing outcomes before users articulate their desires. This section presents an extended theoretical framework for anticipatory systems, proposing three key components. Building on Poli's theory of anticipation, we comprehend anticipatory systems by being structured around three interconnected layers: intent, workflows, and algorithms (Figure 19).

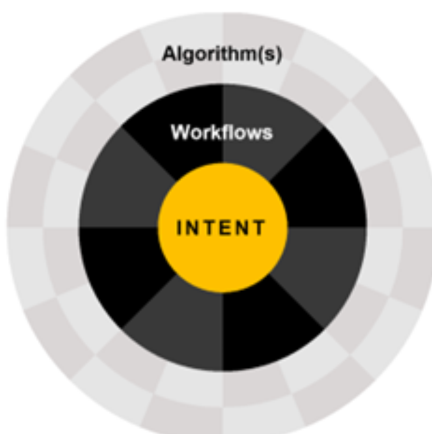

Figure 19: Anticipatory systems as a three-layered framework.

This layered framework provides a comprehensive approach to understanding how anticipatory systems operate by linking the foundational goals of user intent, the actionable processes of workflows, and the predictive capabilities of algorithms. Through this perspective, the study advances the theoretical and practical development of anticipatory systems, emphasizing their capacity to align predictive technologies with human-centered design principles.

Intent as the Core Driver

At the heart of any anticipatory system lies intent—the clear articulation of user goals and desired outcomes. Intent serves as the foundation for all anticipatory interactions, guiding the system's ability to personalize and adapt. For example, a user's intent to maintain a comfortable living environment with minimal energy consumption underpins the functionality of the Nest thermostat. By embedding this intent at its core, the system tailors its operations to ensure both comfort and efficiency, showcasing how anticipatory systems align technological capabilities with human objectives.

Workflows: Translating Intent into Action

Workflows form the bridge between intent and actionable processes. They encompass the structured sequences of interactions that guide users toward their goals. In the case of Nest, workflows include identifying user preferences (e.g., optimal temperatures at different times of the day), integrating external factors like weather data, and automating adjustments based on real-time occupancy detection. These workflows ensure that user intent is realized through seamless and intuitive processes, minimizing the cognitive load on users.

Algorithms: The Predictive Backbone

Algorithms power anticipatory systems by enabling them to process data, identify patterns, and make informed predictions. In Nest's case, predictive algorithms analyze historical temperature preferences, occupancy habits, and environmental data to forecast future needs. The system proactively adjusts settings to create optimal conditions without requiring user intervention, effectively eliminating the need for manual adjustments and delivering a superior user experience.

Take Thrive as an example (Figure 20). Thrive is a digital wellness platform that focuses on improving users' overall well-being. It perfectly exemplifies the three-layered concentric representation for achieving behavior change through anticipatory design.

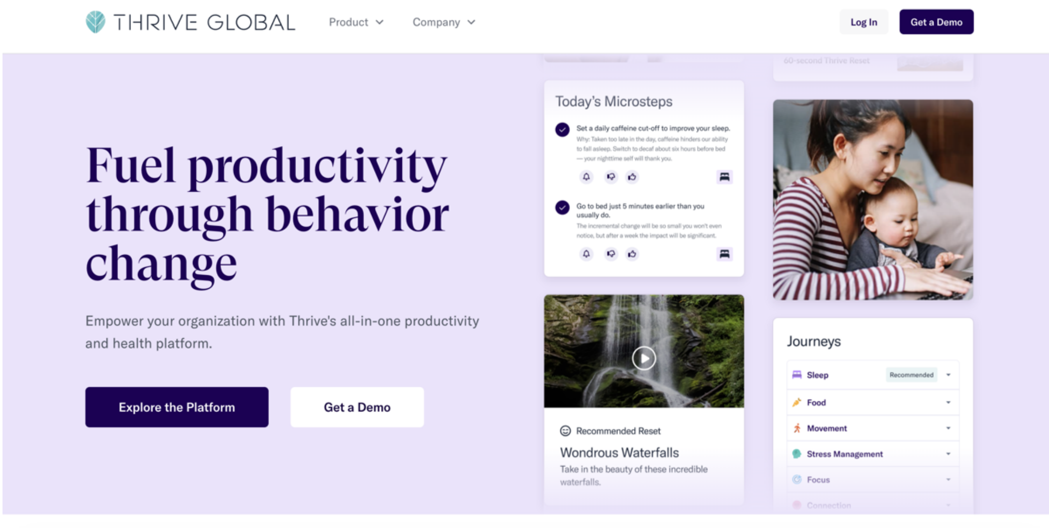

Figure 20: A screenshot of Thrive website: A personalized well-being platform utilizing a layered anticipatory design.

Thrive perfectly exemplifies the three-layered concentric representation for achieving behavior change through anticipatory design:

Innermost layer: Intent

Improve overall wellbeing: Thrive's core intent is to help users achieve a healthier and more fulfilling life. This encompasses aspects like managing stress, improving sleep quality, and boosting energy levels.

Middle layer: Workflows

Personalized programs and support: Thrive uses user data (sleep patterns, activity levels, mood) to create programs tailored to their specific needs and goals. These programs involve various workflows, such as:

- Guided meditations and breathing exercises to manage stress and anxiety.
- Personalized sleep routines aimed at improving sleep quality.
- Educational content and coaching tips to promote healthy habits and lifestyle changes.
- Outermost layer: Algorithms

Outermost layer: Algorithms

Data analysis and personalized recommendations: Thrive utilizes algorithms to analyze user data and generate actionable insights. These algorithms perform tasks like:

- Identify patterns in sleep, activity, and mood to understand user challenges.
- Predict user behavior to recommend interventions that address potential issues.
- Optimize program recommendations based on user progress and data analysis.

By aligning algorithms and workflows with the core intent of improving well-being, Thrive provides a personalized and proactive approach to behavior change. Here's how it benefits users:

- **Sustained behavior change:** Personalized programs and ongoing support empower users to develop healthy habits for the long term.
- **Data-driven insights:** User data analysis helps users gain valuable insights into their well-being and identify areas for improvement.
- **Proactive support:** Anticipates potential issues and recommends interventions before problems arise.

Thrive serves as a strong example of how anticipatory design can be effectively used to achieve positive life outcomes, aligning perfectly with this layered approach. But let us emphasize the importance of aligning algorithms and workflows with the underlying intent-based outcome (Figure 21). By doing so, anticipatory systems can provide personalized and proactive support to users, helping them achieve significant life outcomes rather than just completing isolated tasks.

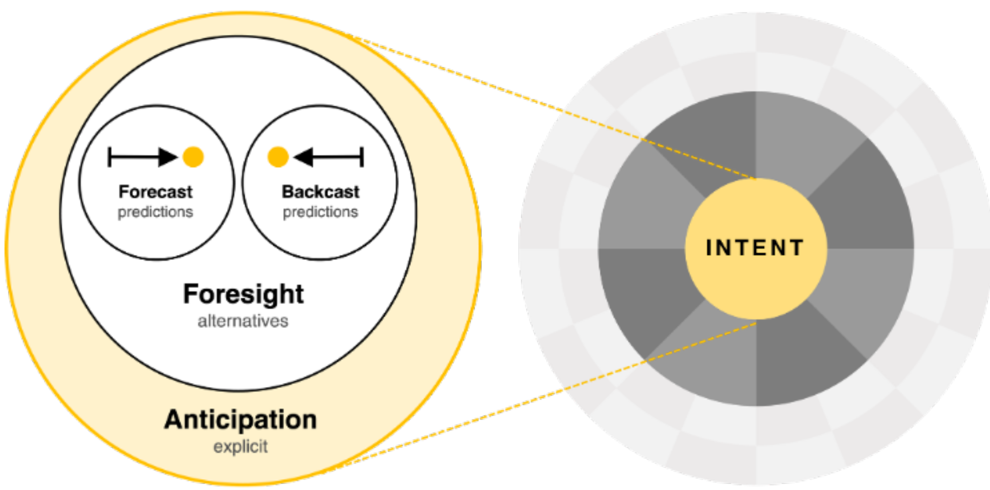

Figure 21: The role of anticipation and foresight in the user's intent.

The future-oriented nature of anticipation makes it both appealing and challenging to implement. Due to the future-oriented view, anticipation is a very appealing and complicated idea to pursue. To overcome these challenges, businesses can leverage two complementary approaches: forecasting and backcasting.

- **Anticipation—**involves making explicit predictions about future states or events. This is achieved through:
  - **Forecasting—** involves analyzing past trends and data to predict future outcomes. By examining historical data and current behaviors, businesses can create models that anticipate what users might need next. This method helps in planning and decision-making based on probable future scenarios.
  - **Backcasting—** on the other hand, starts with defining a desired future outcome and works backward to identify the steps needed to achieve that goal. This approach ensures that the service is aligned with long-term user goals and visions, rather than just responding to immediate needs.
  - **Foresight—**is a systematic approach to analyzing and anticipating future changes in a wide range of fields, including technology, politics, economics, environment, society, and culture. It includes considering alternative future scenarios and making informed decisions to navigate toward the desired outcomes.

This layered approach, complemented by anticipation and foresight, allows anticipatory systems to provide personalized and proactive support to users. By integrating forecasting, backcasting, and considering alternative future scenarios, these systems help users achieve significant life outcomes rather than just completing isolated tasks.

Anticipatory design empowers us to forecast or backcast users' future desires and intentions, ultimately influencing their behavior and learning. By anticipating future events, actions, and consequences, we can work towards desirable future states and avoid potential pitfalls.

Building on the layered structure of intent, workflows, and algorithms, anticipatory systems must incorporate additional dimensions to maximize their efficacy:

- **Feedback Mechanisms**: Continuous feedback loops are essential for refining predictions and adapting to evolving user behaviors. Systems like Nest incorporate user feedback by allowing manual overrides, which are then integrated into future predictions to better align with preferences.
- **Transparency and Trust**: For anticipatory systems to succeed, users must understand how predictions are made and retain the ability to intervene. Nest, for instance, builds trust through its transparent user interface, which clearly displays current settings, energy usage, and predicted adjustments.

- **Context-Awareness**: Anticipatory systems thrive on rich contextual data. For example, Nest’s ability to integrate weather forecasts ensures that adjustments are not only based on internal preferences but also external environmental conditions, demonstrating how context amplifies the system’s predictive accuracy.
- **Adaptability and Learning**: As user preferences and circumstances change, anticipatory systems must evolve. Nest’s adaptability is evident in its learning phase, during which it observes user behavior to improve its predictions over time, transitioning from static to dynamic optimization.

In sum, intent—the primary purpose or goal that the design must achieve—is at the core of this approach. Surrounding this are workflows, which represent the structured tasks to achieve the intent. Finally, algorithms analyze user data and optimize these workflows.

3 Temporal Methods and Frameworks for Anticipatory Design

Anticipatory systems distinguish themselves from predictive systems through their capacity to actively prepare for and influence future states rather than merely estimating potential outcomes (Rollier and Turner 1994; Poli 2017). Predictive systems rely primarily on historical extrapolation, identifying correlations and projecting them forward. Anticipatory systems, however, emphasize temporal reasoning that integrates past, present, and imagined futures to guide present actions toward desirable outcomes. Research in temporal cognition demonstrates that human decision-making operates across multiple time horizons simultaneously, suggesting that effective anticipatory systems must accommodate this temporal complexity (Suddendorf and Corballis 2007).

This chapter examines the methodological foundations that enable anticipatory design to transcend traditional prediction-based approaches. By integrating temporal analysis with behavioral science frameworks, designers can develop systems that not only anticipate user needs but also actively participate in creating preferred futures.

As discussed in the introduction, the temporal dimension of anticipatory design encompasses three complementary methodologies: forecasting (data-driven trend projection), backcasting (goal-oriented reverse planning), and retrospective thinking (learning from simulated future scenarios). These approaches collectively enable designers to create systems that anticipate needs while empowering users to navigate uncertainty. These temporal methods not only provide tools for envisioning futures but also highlight the importance of user intent, contextual adaptation, and transparent decision-making.

3.1.1 Forecasting in Anticipatory Systems

Forecasting involves algorithm analysis of historical data patterns to project future system states and user behaviors, and it's the most common form of temporal method in anticipatory design (Makridakis et al. 2008). Within anticipatory design, forecasting often serves as a starting point, supporting decisions with quantifiable accuracy. It allows designers to work with measurable outcomes, whether predicting demand, anticipating user preferences, or modeling system performance.

Contemporary forecasting methodologies in anticipatory design employ ensemble methods that combine multiple predictive models to enhance accuracy and robustness (Dietterich 2000). These approaches acknowledge the inherent uncertainty in human behavior while providing actionable insights for system design. Salesforce Einstein Analytics exemplifies advanced forecasting implementation by integrating multiple data sources—customer interaction history, market trends, seasonal patterns, and external economic indicators—to generate personalized business intelligence insights (Figure 22). The system combines machine learning algorithms with domain-specific knowledge to provide automated data discovery, personalized insights, and augmented analytics that enable organizations to anticipate market changes and customer behaviors.

Figure 22: Illustration of Salesforce Einstein AI service[7].

The implementation of forecasting in anticipatory systems involves several critical components:

- **Multi-modal Data Integration**: Effective forecasting systems synthesize diverse data types, including behavioral traces, environmental sensors, and contextual metadata to construct comprehensive user models. Recent advances in multimodal machine learning demonstrate the effectiveness of integrating heterogeneous data sources for improved predictive modeling (Baltrusaitis et al. 2019; Lipkova et al. 2022).
- **Temporal Pattern Recognition**: Advanced algorithms identify recurring patterns across different time scales, from immediate behavioral sequences to long-term preference evolution. Sequential pattern mining techniques have proven effective for discovering temporal dependencies in user behavior data (Fournier-Viger and Lin 2017).
- **Uncertainty Quantification**: Robust forecasting systems provide confidence intervals and uncertainty estimates, enabling users to make informed decisions about system recommendations (Gneiting and Raftery 2007).

[7] https://www.sweetpotatotec.com/salesforce-einstein-ai-vs-human-expertise-striking-the-balance/

3.1.2 Strengths and Limitations of Forecasting Approaches

Forecasting methodologies offer significant advantages in anticipatory design contexts. By leveraging established statistical and machine learning techniques, forecasting provides quantifiable predictions with measurable accuracy metrics (Hyndman and Athanasopoulos, 2018). This data-driven foundation enables systematic optimization and iterative improvement of anticipatory systems.

However, forecasting approaches face inherent limitations when applied to complex human-centered systems. The "cold start" problem remains particularly challenging, as new users lack sufficient interaction history for accurate predictions (Yuan and Hernandez 2023). Additionally, forecasting models may perpetuate existing biases present in historical data, potentially reinforcing inequitable outcomes.

Research in algorithmic fairness demonstrates that predictive systems can inadvertently discriminate against underrepresented groups when historical data reflects societal biases (Barocas and Selbst 2016). This limitation necessitates careful attention to data quality and algorithmic transparency in anticipatory design implementations.

Strengths

- **Building on Success:** Forecasting leverages past achievements to project future possibilities. This data-driven approach helps identify trends and anticipate potential outcomes.
- **Deeper Problem Understanding:** Analyzing past experiences can lead to a more nuanced understanding of the problem at hand. This knowledge is crucial for developing effective solutions.

Limitations

- **Optimism Bias:** Forecasting can be overly optimistic by focusing on past successes. This "extrapolation bias" can lead to inaccurate predictions, overlooking potential challenges.
- **Complexity Challenges:** Forecasting may not be sufficient for planning in complex, dynamic systems. These systems involve numerous interacting factors that are difficult to predict using solely historical data.
- **Data Dependence:** Forecasting is heavily reliant on data quality. Biased data sets can skew the results, leading to inaccurate or misleading predictions.

- **Big Data's Double-Edged Sword:** The rise of big data presents both opportunities and challenges for forecasting. While vast amounts of data can provide more comprehensive insights, the potential for bias also increases.

In essence, forecasting involves extrapolating[8] current data and trends to envision future possibilities and explore the long-term achievements technology can enable. However, this reliance on past data can introduce an extrapolation bias,[9] leading to overly optimistic predictions that may not account for unforeseen challenges. Furthermore, forecasting can be insufficient for planning in complex systems with numerous dynamic and interconnected factors. These intricate systems are difficult to predict solely based on historical trends. Another limitation is the dependence on data quality. Biased data sets can significantly skew forecasting results, leading to inaccurate and misleading predictions. The rise of big data presents a double-edged sword for forecasting. While vast amounts of data offer the potential for more comprehensive insights, the risk of bias also increases (Rollier and Turner 1994).

3.1.3 Implementing Backcasting in Anticipatory Systems

Backcasting represents a paradigm shift from trend-based prediction to goal-oriented planning, beginning with desired future outcomes and working backward to identify necessary implementation steps (Geden et al. 2019). Backcasting represents a goal-oriented methodology that begins with clearly defined desired outcomes and systematically identifies the necessary steps, interventions, and system behaviors required to achieve those outcomes (Robinson 1990). This approach proves particularly valuable in anticipatory design when systems must align with long-term user goals rather than simply extrapolating current behavioral patterns.

The methodology involves several distinct phases: vision articulation, pathway identification, and milestone definition. Unlike forecasting, which assumes continuation of existing trends, backcasting acknowledges that desired futures may require deliberate departures from current trajectories (Robinson 1990; Einhorn and Hogart 1987). The authors describe backcasting as a process of:

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[8] Extrapolation involves making statistical forecasts by using historical trends.

[9] Extrapolation bias is the tendency to take a recent experience and project that it will continue into the future. For example, if a company has grown its earnings by 25% in each of the past three years, we may project that it will grow earnings at 25% far into the future. Using this simplistic analysis, there are many variables we are not considering, and we are likely to be incorrect the farther into the future we project this rate. Source: https://www.aowealth.com/single-post/extrapolation-bias

- Recognizing patterns and connections between seemingly unrelated events.
- Exploring potential causal chains that could lead to a desired outcome.
- Developing metaphors or theories to inform future-oriented planning.

YNAB (You Need a Budget) demonstrates effective backcasting implementation in personal financial management (Figure 23).

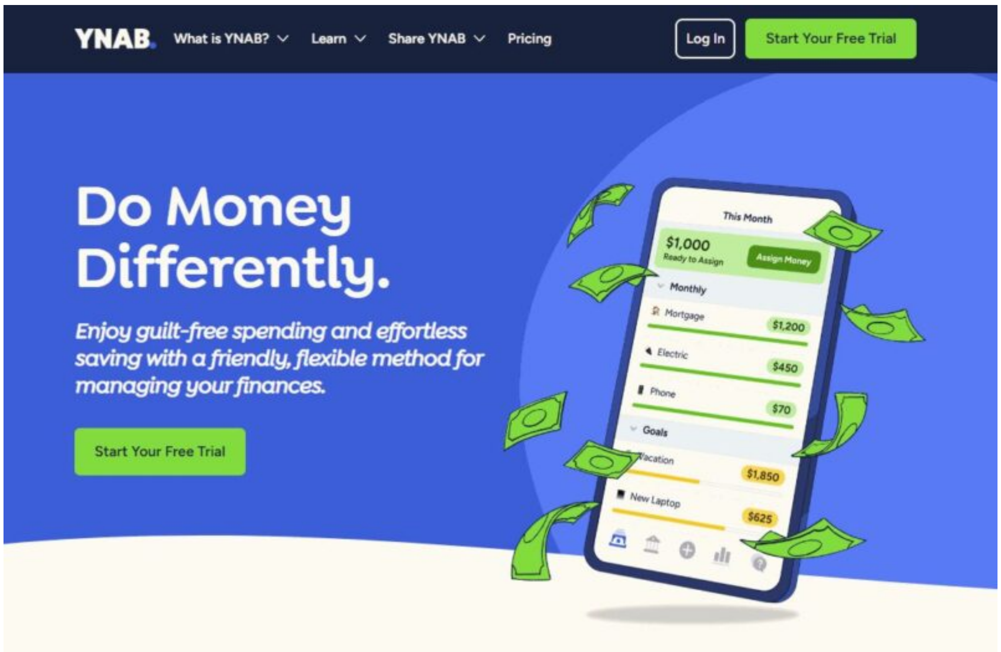


Figure 23: A screenshot of the YNAB service website.

Rather than simply tracking spending patterns, YNAB aims to begins with users' financial goals—such as emergency fund establishment or debt elimination—and constructs step-by-step action plans that adapt dynamically to changing financial circumstances. The backcasting process integrates pattern recognition across seemingly unrelated events, exploration of causal chains leading to desired outcomes, and development of theoretical frameworks that inform strategic planning (Einhorn and Hogart 1987). This approach enables systems to maintain coherence between immediate actions and long-term aspirations.

Similarly, FitnessAI exemplifies backcasting in health and wellness applications (Figure 24). This mobile app leverages AI to help users plan their fitness journeys. Instead of simply tracking workouts, FitnessAI allows users to set a desired future fitness state (e.g., run a marathon). The app then uses backcasting principles to create a personalized workout plan, including recommended exercises, sets, reps, weights, and rest periods. FitnessAI continuously tracks progress and adapts the plan in real-time, ensuring it remains aligned with the user's goals. This dynamic adaptation ensures alignment between daily activities and overarching health aspirations.

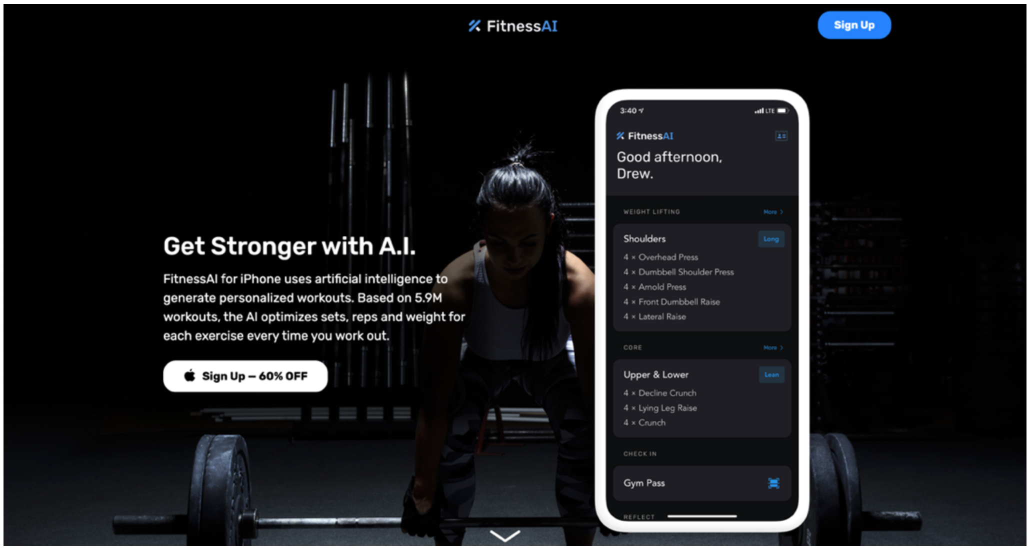


Figure 24: Caption of the FitnessAI application.

3.1.3.1 Addressing the Cold Start Problem

Backcasting provides a crucial solution to the cold start problem that plagues many anticipatory systems. When historical user data is insufficient for accurate forecasting, backcasting enables systems to establish meaningful default pathways based on stated goals and general behavioral patterns. As Armstrong (2021) notes, "the gradual optimization of machine learning experiences can become one of an intelligent interface's greatest strengths" when combined with transparent goal-setting mechanisms.

Effective backcasting implementation requires several methodological components:

- **Goal Specification**: Users must articulate specific, measurable objectives with defined timelines. Research in goal-setting theory emphasizes the importance of specificity and challenge level in motivation and performance (Locke and Latham 2002).
- **Pathway Analysis**: Systems must identify feasible sequences of actions that connect current states to desired outcomes. This involves constraint satisfaction and optimization techniques to balance multiple competing objectives (Russel and Norvig 2016).
- **Dynamic Recalibration**: In foresight practice, backcasting is not a one-off exercise but an *iterative, adaptive process*—sometimes referred to as "backcasting from principles"—where pathways are continuously recalibrated based on emerging trends,

real-world indicators, and shifting contexts. This requires ongoing monitoring and feedback loops to ensure alignment with the desired future vision (Bibri 2020).

3.1.4 Implementing Retrospective Thinking in Anticipatory Systems

Retrospective thinking involves imagining hypothetical future scenarios as completed events and analyzing the potential pathways that could have led to those outcomes (Rollier and Turner 1994). This methodology enables designers to identify blind spots in current planning and explore innovative approaches to system design (Geden et al. 2019).

The approach leverages counterfactual reasoning to explore alternative developmental pathways and identify factors that contributed to specific outcomes. By examining "what might have been," designers can better understand causal relationships and design more robust anticipatory systems (Pearl Judea and Mackenzie Dana 2018).

Contemporary generative AI tools, such as ChatGPT and Google's Gemini (Figure 25, facilitate retrospective thinking by enabling design teams to construct detailed fictional narratives about future system success or failure. These narratives reveal potential challenges, user needs, and strategic opportunities that might otherwise remain hidden.

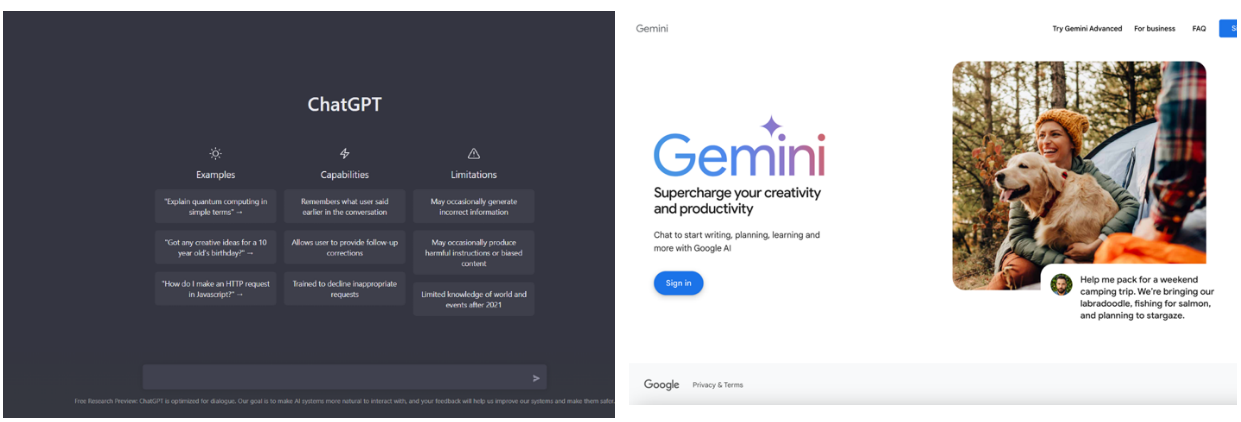


Figure 25: ChatGPT on the left and Google Generative AI Tool on the right.

3.1.4.1 Applications in Innovation-Focused Projects

Retrospective thinking proves particularly valuable in innovation contexts where teams must navigate uncertainty and identify novel solutions. By imagining successful outcomes and working backward through hypothetical development processes, teams can identify critical success factors and potential failure modes.

Consider a design team developing AI-powered educational tools. Using retrospective thinking, they might imagine a scenario five years in the future where their system has achieved widespread adoption and measurable learning improvements. By generating detailed narratives about the development pathway that led to this success—including technical challenges overcome, user adoption strategies, and pedagogical insights gained—the team can identify critical early decisions and potential pitfalls.

3.1.4.2 Core Cognitive Processes in Anticipatory Thinking

Regardless of the specific temporal methodology employed, anticipatory thinking involves three fundamental cognitive processes (Geden et al. 2019):

- **Situational Recognition:** The ability to interpret current conditions and constraints based on previous experience and domain knowledge. This involves pattern matching and contextual understanding (Klein 1998).
- **System State Extrapolation:** The capacity to envision how current conditions might evolve under different scenarios and interventions. This requires understanding of system dynamics and causal relationships (Sterman 2000).
- **Mental Model Construction:** The development of coherent representations of system behavior based on available evidence and theoretical understanding. These models guide prediction and decision-making under uncertainty (Johnson-Laird 1980).

These temporal methodologies emphasize that successful anticipatory systems are not merely reactive but are equipped to envision, plan for, and actively shape desirable futures.

3.1.5 Foresight and Future Studies in Anticipatory Design

Strategic foresight provides a comprehensive framework for exploring potential futures that extends beyond traditional forecasting and prediction methodologies. Unlike forecasting, which primarily extrapolates from historical data, foresight employs qualitative and participatory methods to explore multiple possible, probable, and preferable futures (Voros 2017).

The integration of foresight methodologies into anticipatory design enables designers to navigate uncertainty, identify emerging opportunities, and design systems that remain robust across diverse future scenarios. This approach proves essential when designing for rapidly evolving technological and social contexts where historical data may provide limited guidance (Miller 2007).

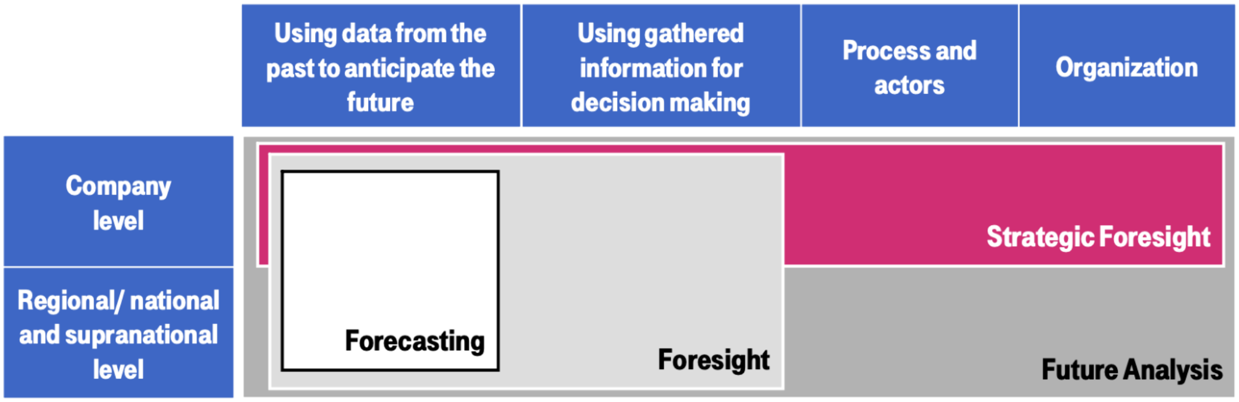


Figure 26: Scientific classification of research on future studies according to (Rohrbeck 2008).

Future studies, emerging from military planning applications in the 1950s, systematically explores possible and desirable futures to improve decision-making processes (figure 26), it provides a strategic framework for exploring potential futures and informing design decisions.

Future studies systematically explore possible and desirable futures to improve decision-making processes. Strategic foresight applies these methods and techniques to plan for the future, addressing complexity and uncertainty. Emerging in the 1950s as a military planning tool, foresight entered the business world in the 1960s, evolving into a discipline aimed at managing long-term change. As the United Nations Development Programme notes, “The premise of foresight is that the future is still in the making and can be actively influenced or even created” (GCPSE 2018). This proactive stance aligns closely with the goals of anticipatory design, which seeks to preempt user needs while shaping systems that adapt to evolving circumstances.

3.1.5.1 Forecasting vs. Foresight

The distinction between forecasting and foresight reflects fundamental differences in epistemological assumptions and methodological approaches (Figure 27). Forecasting assumes that future patterns can be predicted based on historical data and established causal relationships. Foresight acknowledges that the future is inherently uncertain and socially constructed, requiring exploration of multiple alternative possibilities (Miller 2007; Voros 2017).

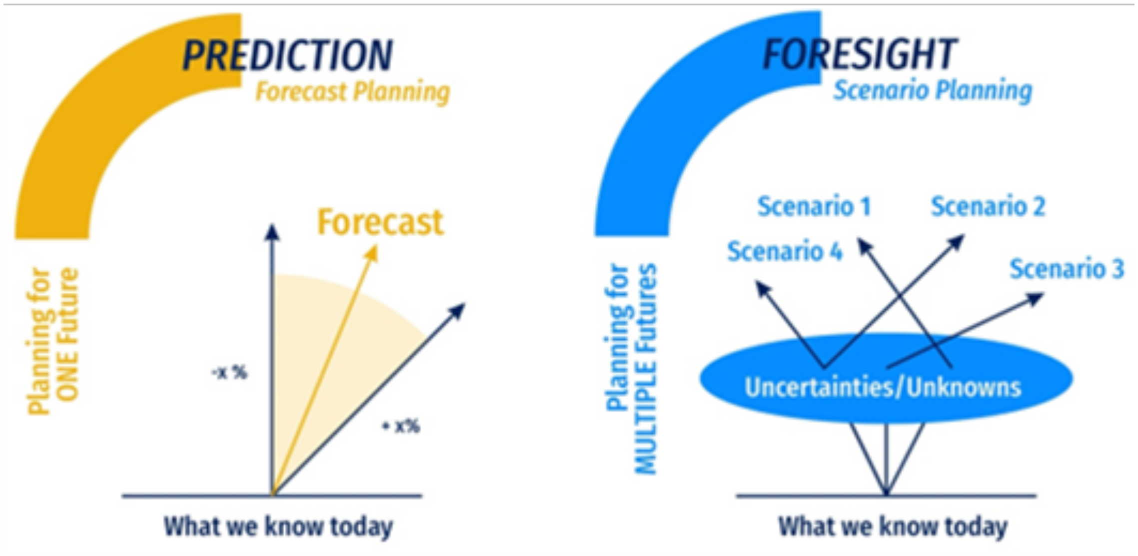


Figure 26: Difference between forecasting and foresight (Stafie, n.d.).

Foresight involves three key time dimensions:

- **Past**: Analyzing historical patterns to inform decisions.
- **Present**: Recognizing current conditions as a platform for action.
- **Future**: Imagining multiple scenarios to anticipate opportunities and challenges.

Key tools in foresight include:

- **Scenario Planning**: Constructing systemic and plausible future scenarios to explore alternative outcomes and their implications.
- **Trend Analysis**: Identifying patterns in historical data to forecast long-term shifts.
- **Environmental Scanning**: Monitoring external factors—economic, technological, and social—to anticipate disruptions and opportunities.

While forecasting excels in domains with stable patterns and abundant historical data, foresight proves more appropriate for emerging technologies, social innovations, and complex adaptive systems where historical precedents may be limited or misleading (Georghiou et al. 2008).

3.1.5.2 Key Methodological Differences

- **Data Requirements**: Forecasting requires extensive quantitative data, while foresight can operate with limited data by employing expert judgment and qualitative analysis (Armstrong 2001).

- **Time Horizons**: Forecasting typically focuses on near-term predictions (months to years), while foresight explores longer-term possibilities (years to decades)(Sardar 2010a).
- **Uncertainty Treatment**: Forecasting seeks to minimize uncertainty through improved models, while foresight embraces uncertainty as a fundamental characteristic of complex systems (Courtney et al. 1997).

3.1.6 The Futures Cone Framework

The futures cone model (Figure 28) provides a systematic framework for categorizing different types of future possibilities and their relationship to present knowledge and capabilities (Vohs et al. 2008; Miller 2007). This framework enables designers to navigate the spectrum from highly probable near-term developments to speculative long-term possibilities.

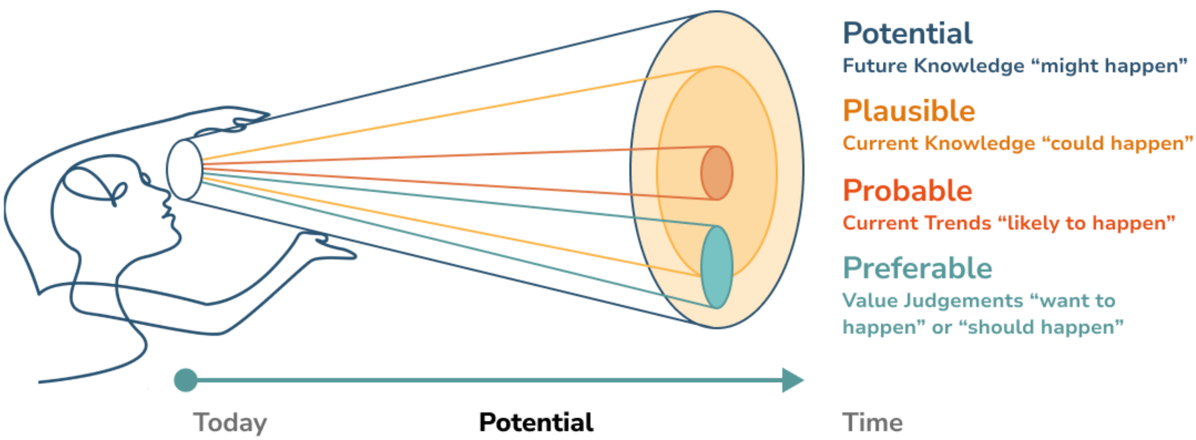


Figure 27: Future cone diagram of types of alternative futures. Adapted from (Vohs et al. 2008).

The cone encompasses several categories of futures:

- **Potential Futures:** The broadest category encompasses all theoretically possible outcomes, including those that challenge current understanding of physical or social laws.
- **Possible Futures:** Outcomes that could potentially occur based on current knowledge, though they may require significant technological or social developments.
- **Plausible Futures:** Scenarios that align with current understanding of how systems function and evolve, representing realistic possibilities given present trends and capabilities.
- **Probable Futures:** Outcomes with high likelihood based on quantitative analysis and current trajectories, representing the domain where forecasting methodologies prove most effective.

- **Preferable Futures:** Desired outcomes that reflect values, goals, and aspirations, representing targets for backcasting and participatory planning processes.

3.1.7 Integrating Foresight into Anticipatory Design

For Poli, the drawback with foresight and forecast is that these methods left out anticipation of the future studies equation (Figure 29). To overcome this, Poli has proposed a third level to the future studies field – Anticipation (Poli 2019).

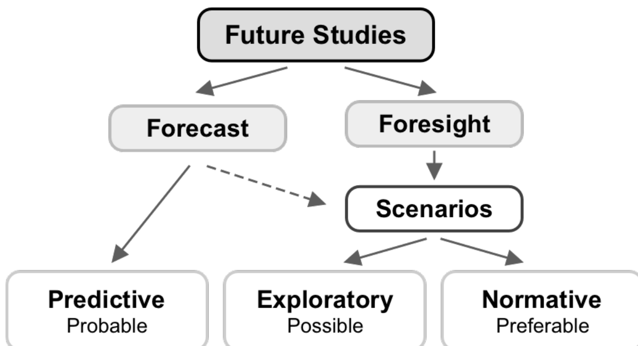


Figure 28: Visualization of the divisions of future studies without anticipation.

Poli felt that future studies were missing anticipation properties because anticipation (either explicit or implicit) is a way of generating the necessity of imaginary futures based on probabilistic or non-probabilistic thinking to understand and act in the present (2019). Therefore, the authors believe that anticipation within future studies is a process that not only depends on predictions, expectations, or beliefs about the future but is also highly dependent on the past and the present (Figure 30).

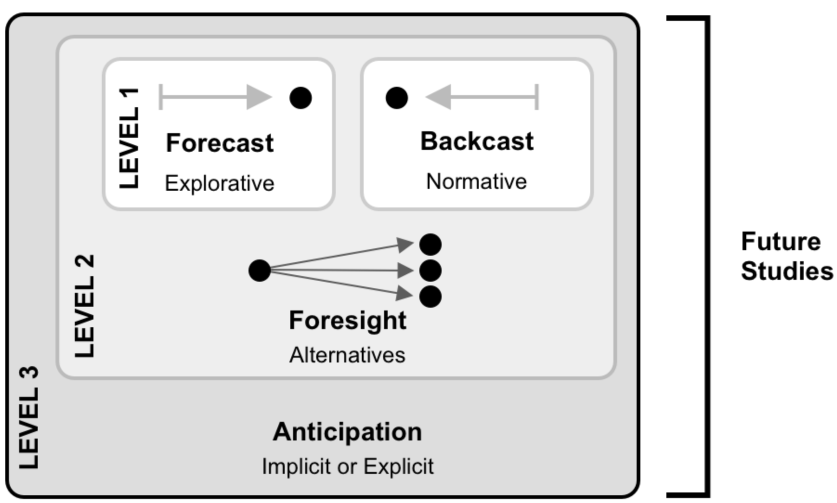


Figure 29: Our view of the three levels of future studies according to Poli's theory.

Poli (2017) argues that anticipation must be a distinct component of future studies, complementing forecasting and foresight. So, he adds a third level of anticipation to focus on present-oriented strategies, leveraging predictions and expectations to influence current actions. This approach acknowledges that the future cannot be fully predicted but can be shaped through deliberate, informed design.

Anticipation differs from traditional foresight by emphasizing past, present, and future interplay to create actionable insights. For example:

- **Forecasting** provides data-driven insights into likely outcomes.
- **Foresight** explores alternative futures and their implications.
- **Anticipation** integrates these perspectives to guide immediate actions that align with long-term goals.

To the extent that the future is unpredictable, only some aspects of the present reality or future alternatives can be envisioned. We are left with three actions: do nothing, prepare for the future, or shape the future actively. Forecast, foresight, and anticipation have unique properties when connected to future studies (Table 5) (Miller et al. 2013).

Table 5: Three levels of future studies according to Miller, Poli, and Rossel (2013).

Type	Nature	Theory	Complexity	Orientation
Forecast	Previsive	Good	No	Past-oriented
Foresight	Non Previsive	Poor	Poor	Future-oriented
Anticipation	Non Previsive	Presently under development	High	Present-oriented

In summary, integrating foresight into anticipatory design significantly enhances its ability to navigate uncertainty and tackle “wicked problems”—complex, multifaceted challenges that defy straightforward solutions. Foresight equips anticipatory systems with the tools to anticipate diverse scenarios, adapt to changing contexts, and design for long-term impact. Its key contributions include:

- **Temporal Dimensions**: Foresight bridges the past, present, and future, drawing on historical insights to inform strategies that are both forward-looking and grounded in current realities.

- **Scenario Planning**: Designers can leverage foresight to construct detailed and plausible future scenarios, enabling anticipatory systems to address diverse user contexts and adapt to evolving needs.
- **Alignment with Human-Centered Design**: Through techniques like environmental scanning and trend analysis, foresight empowers designers to anticipate user needs more effectively and proactively mitigate potential challenges.

The inclusion of foresight in the theoretical framework of anticipatory design underscores its strategic value in managing complexity and uncertainty. By integrating foresight with complementary temporal methods such as forecasting and backcasting, anticipatory systems can achieve greater alignment with user needs, adapt to emerging trends, and actively shape preferable futures. This interdisciplinary approach, rooted in human-centered principles, positions anticipatory design as a transformative methodology for addressing the challenges and opportunities of a rapidly evolving world.

Foresight methodologies specifically guide the development of anticipatory systems in the following ways:

- **Scenario Development**: Crafting diverse future scenarios helps uncover long-term user needs and identify potential system challenges, ensuring robust and adaptable design strategies.
- **Visioning**: Envisioning ideal future states provides a framework for aligning design strategies with user aspirations and broader societal goals, fostering innovation and relevance.
- **Backcasting**: By working backward from desired outcomes, backcasting ensures that current design efforts remain focused on achieving sustainable, user-centric futures.

By weaving these foresight methodologies into the design process, anticipatory systems gain the strategic depth and flexibility needed to remain relevant, resilient, and impactful in an increasingly uncertain world.

4 From Theory to Practice: Anticipatory Experiences in Industry

This chapter examines real-world implementations of anticipatory design across key industries, analyzing both successful applications and notable failures to extract actionable insights for practitioners. Building upon the temporal methodologies established in Chapter 3, this analysis focuses on practical deployment challenges, user acceptance factors, and the gap between theoretical frameworks and market realities. The chapter addresses the research question: How do anticipatory systems perform in practice, and what factors contribute to their success or failure in meeting user expectations?

4.1 Failed Anticipatory Design Implementations: Learning from Market Realities

The analysis of unsuccessful anticipatory design implementations provides essential empirical evidence for understanding the limitations of current approaches and the importance of user-centered validation (Amershi et al. 2019b). The following cases represent market failures that offer insights into the disconnect between technological capability and user acceptance.

Digit, LifeBEAM Vi Sense Headphones, and Mint—highlight critical pitfalls in anticipatory design, offering valuable lessons for future systems. Each example illustrates how insufficient foresight and poor execution of forecast-based predictions led to a mismatch between user expectations and service delivery.

4.1.1 Digit: Contextual Sensitivity and User Trust Challenges

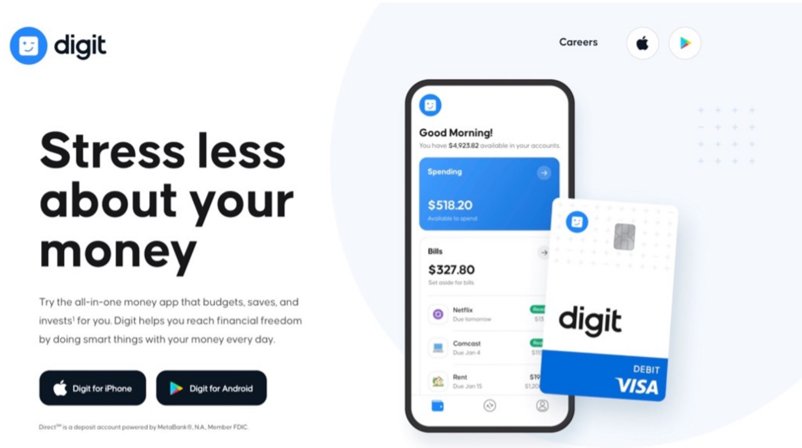


Figure 30: Screenshot of Digit app website back in 2020.

Digit (Figure 31) was designed to automate personal savings by analyzing user spending habits and transferring small amounts into savings accounts. While the concept was innovative, the system's failure to incorporate real-time contextual understanding led to a poor user experience. Unexpected withdrawals created financial stress for users living paycheck to paycheck, ultimately breaking trust in the system. Research in behavioral economics demonstrates that financial decision-making involves complex emotional and contextual factors that simple pattern recognition cannot capture (Tversky and Kahneman 1974; Thaler and Sunstein 2008).

The system's primary failure mode occurred when contextual awareness mechanisms proved insufficient for handling edge cases such as irregular income patterns or emergency expenses. This limitation highlights a critical gap in current anticipatory systems: the inability to distinguish between correlation and causation in behavioral patterns (Pearl Judea and Mackenzie Dana 2018).

Foresight Analysis: Comprehensive scenario planning, incorporating edge cases such as extreme scenario analysis (Courtney et al. 1997), like irregular income patterns or emergency expenses, could have identified these failure modes during the design phase. Environmental scanning techniques would have identified the diversity of user financial situations requiring adaptive response mechanisms.

Forecasting Limitations: The system's reliance on historical spending patterns without dynamic adjustment to changing circumstances demonstrates the limitations of purely data-driven approaches. Real-time contextual integration could have mitigated these issues through more sophisticated prediction refinement.

Lesson Learned: Effective anticipatory financial systems require sophisticated contextual awareness frameworks and transparent user control mechanisms. Users must understand when and why systems make specific recommendations, with accessible override capabilities when circumstances change (Mullainathan and Shafir 2013).

4.2 LifeBEAM Vi Sense Headphones: Complexity and Usability Challenges

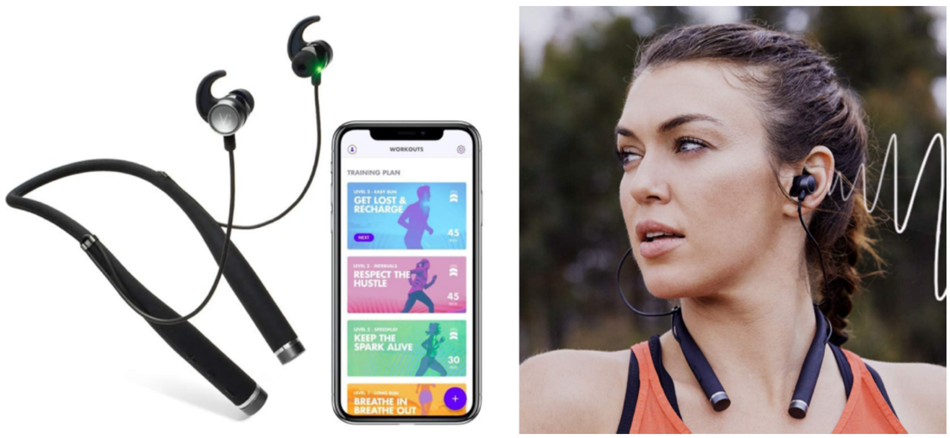


Figure 31: Vi's headphones and application.

LifeBEAM Vi Sense Headphones (Figure 32) were marketed as AI-powered personal fitness coaches, promising personalized workout guidance. The LifeBEAM Vi Sense headphones represent a common pattern in anticipatory design failures: promising advanced AI capabilities while delivering inflexible, context-insensitive implementations. Despite marketing claims of *AI-powered personal training*, the system provided rigid, generic recommendations that failed to adapt to individual users' diverse fitness contexts and progression patterns.

Recent research in adaptive learning systems demonstrates that effective personalization requires continuous model updating based on user feedback and contextual changes (Beer et al. 2014). The Vi Sense system's static approach to fitness coaching ignored these established principles.

Foresight Implications: Strategic foresight methodologies, including Delphi method surveys with fitness professionals and trend analysis of emerging workout patterns (Rowe and Wright 2001), could have identified the mismatch between marketing promises and technical capabilities. By exploring multiple user scenarios and use cases through participatory design processes, the development team could have identified the limitations of their approach before product launch (Cross 2008).

Forecast Perspective: The system's failure to support diverse fitness activities and experience levels reflects inadequate scenario planning and user research. Foresight approaches would have explored how different user populations might interact with the system across various contexts and identified necessary adaptive capabilities.

Lesson Learned: Successful anticipatory systems require extensive scenario testing and adaptive algorithms that can hyper-personalize experiences across diverse user contexts. The system must balance automation with user agency, providing value while maintaining user autonomy and choice (Xu et al. 2021).

4.3 Mint: Misalignment with User Goals

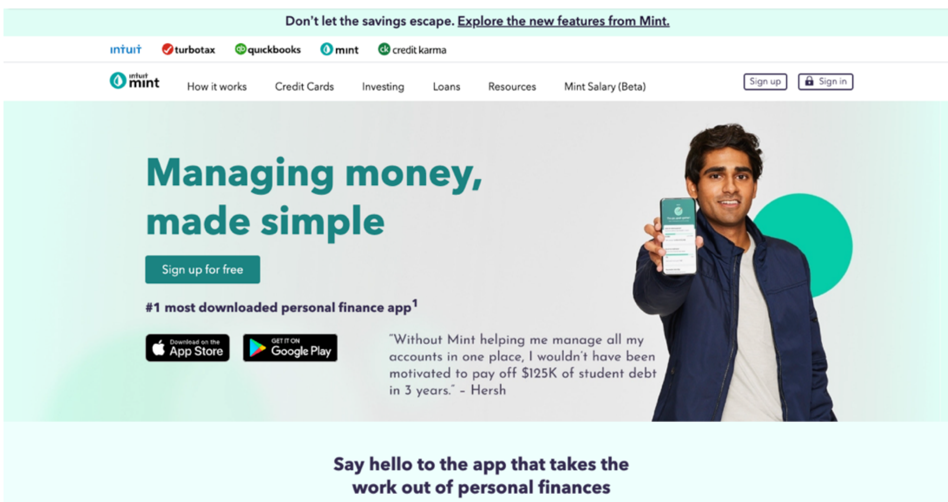


Figure 32: Screenshot of Mint app website back in 2021.

Mint (Figure 33) sought to empower users with automated budgeting tools and financial advice. Mint's financial management platform demonstrates how anticipatory systems can fail when they prioritize technical sophistication over user goal alignment. While the system successfully aggregated financial data and provided automated categorization, it struggled to deliver personalized insights that aligned with users' diverse financial aspirations and circumstances.

Backcast Perspective: The application of backcasting methodologies during Mint's development could have improved goal alignment by starting with user financial objectives and working backward to identify necessary system capabilities (Robinson 1990). Instead of focusing primarily on data aggregation and analysis, the system could have prioritized goal-oriented recommendations and progress tracking.

Forecast Perspective: Research in personal financial management demonstrates that users need systems that connect day-to-day financial decisions with long-term objectives. Effective anticipatory financial systems must bridge temporal scales from immediate spending decisions to long-term wealth building (Thaler and Sunstein 2008).

Lesson Learned: Research in personal financial management demonstrates that users need systems that connect day-to-day financial decisions with long-term objectives. Effective anticipatory financial systems must bridge temporal scales from immediate spending decisions to long-term wealth building (Thaler and Sunstein 2008).

These case studies reveal common failure patterns in anticipatory design implementations:

- **Failure to Evolve with User Needs:** Mint and Digit highlight the risks of static systems that fail to adapt to users' changing contexts. A foresight-driven approach ensures that systems remain flexible and responsive to evolving needs.
- **Complexity and Usability Issues:** LifeBEAM Vi Sense illustrates how overly complex systems can alienate users. Forecast-driven simplicity combined with foresight-led adaptability can balance functionality and ease of use.
- **Privacy and Trust:** Across all three cases, the lack of transparency in decision-making processes undermined trust. Anticipatory systems must prioritize user autonomy and communicate how decisions are made to ensure confidence in the system.
- **Edge Cases and Unpredictable Scenarios:** Forecasting alone often struggles with edge cases, as demonstrated by Digit. Foresight methodologies, such as scenario planning, can complement forecasting by preparing systems for outlier events and diverse user behaviors.

By addressing the gaps highlighted in these examples, designers can reimagine anticipatory systems that combine predictive capabilities with foresight and human-centered principles. This involves:

- **Dynamic Contextual Awareness**: Ensuring systems adapt in real-time to changing user conditions.
- **Seamless Personalization**: Moving beyond generic responses to deliver meaningful, tailored interactions.
- **Transparent Decision-Making**: Communicating system logic to foster trust and user confidence.

In conclusion, the failures of these services highlight the need for anticipatory systems to blend forecasting's data-driven precision with foresight's strategic breadth. By leveraging foresight to envision diverse user scenarios and employing forecasting to predict immediate needs, anticipatory systems can deliver meaningful, adaptive, and user-centered experiences. This alignment of foresight and forecast is not just a best practice—it is a necessity for businesses seeking to build trust, foster engagement, and navigate the complexities of user expectations in a rapidly evolving landscape.

Incorporating these lessons into future case studies will not only strengthen the design process but also showcase the transformative potential of anticipatory systems when done right.

4.4 Anticipation Capabilities: Implicit vs. Explicit

Building upon Poli's (2017) theoretical framework discussed in Chapter 3, this section examines how implicit and explicit anticipation manifest in practical system implementations. The distinction between these approaches has significant implications for user experience design and system acceptance.

Poli (2017; 2010) distinguishes between two levels of anticipation—implicit and explicit. Implicit anticipation in digital systems mirrors human intuitive responses to familiar stimuli, operating through learned behavioral patterns without conscious user awareness (Pezzulo and Butz 2008). Explicit anticipation involves deliberate planning based on predictive modeling and conscious reasoning about possible future states. Both are ways of generating the necessity of imaginary futures based on probabilistic or non-probabilistic thinking to understand and act in the present.

4.4.1 Practical Implementation Levels

Contemporary anticipatory systems implement these capabilities across three operational levels, each with distinct user experience implications (Kleber 2016):

- Simplifying selections or decisions
- Choice editing
- Eliminating decisions

4.4.1.1 Simplifying Selections or Decisions

Machine learning algorithms establish personalized pre-selection defaults and preference retention mechanisms that reduce cognitive load without eliminating user choice (Kahneman 2011). **Spotify's** personalized recommendation features, particularly 'Your Daily Drive' (Figure 34) leverage advanced ML algorithms to deliver highly accurate and tailored content to users. When Spotify suggests a playlist, it is not shooting in the dark but making an educated guess based on users' past listens and preferences. It is anticipating what kind of songs users like.

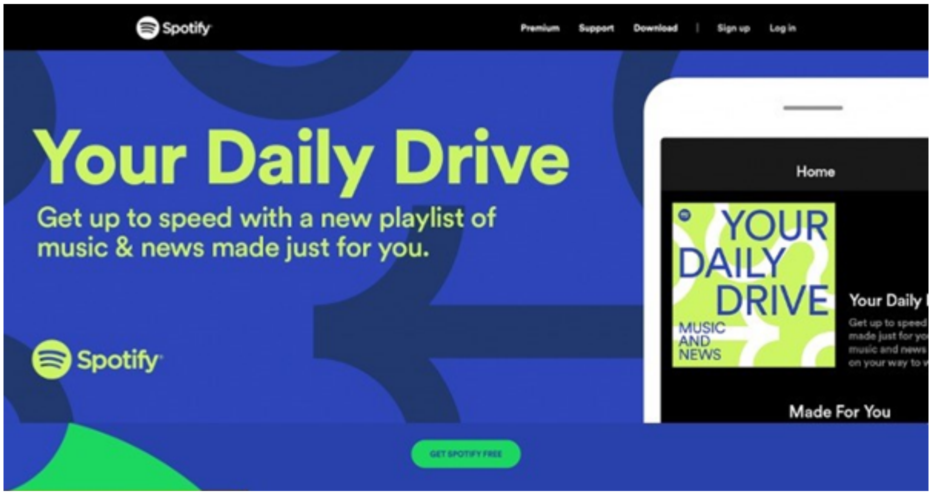


Figure 33: Anticipatory Design example - Spotify, playlist suggestion.

Spotify employs collaborative filtering and content-based recommendation algorithms, leveraging vast datasets including listening history, temporal patterns, and user behavior sequences to curate personalized playlists (Schedl et al. 2014). The system's effectiveness stems from its ability to balance exploration and exploitation in recommendation algorithms, introducing novel content while maintaining relevance to established preferences.

Because recommendation accuracy reaches approximately 80% for active users (based on implicit feedback metrics), users experience reduced decision fatigue while maintaining autonomy over their listening choices (Ekstrand 2011).

4.4.1.2 Choice Editing

Curation mechanisms reduce decision fatigue by filtering options and streamlining choices, particularly effective in domains with high choice complexity (Schwartz 2004). Easysize service is an example of choice editing (Figure 35), an AI-powered clothing company that uses big data and AI to curate information for users, resulting in improved sizing recommendations and reduced returns.

Easysize's system addresses a significant market inefficiency: 30-40% of online fashion purchases are returned due to sizing issues, representing approximately $32 billion in annual logistics costs globally. The platform utilizes comparative sizing algorithms that analyze garment measurements, brand-specific fit data, and user body measurements to generate sizing recommendations.

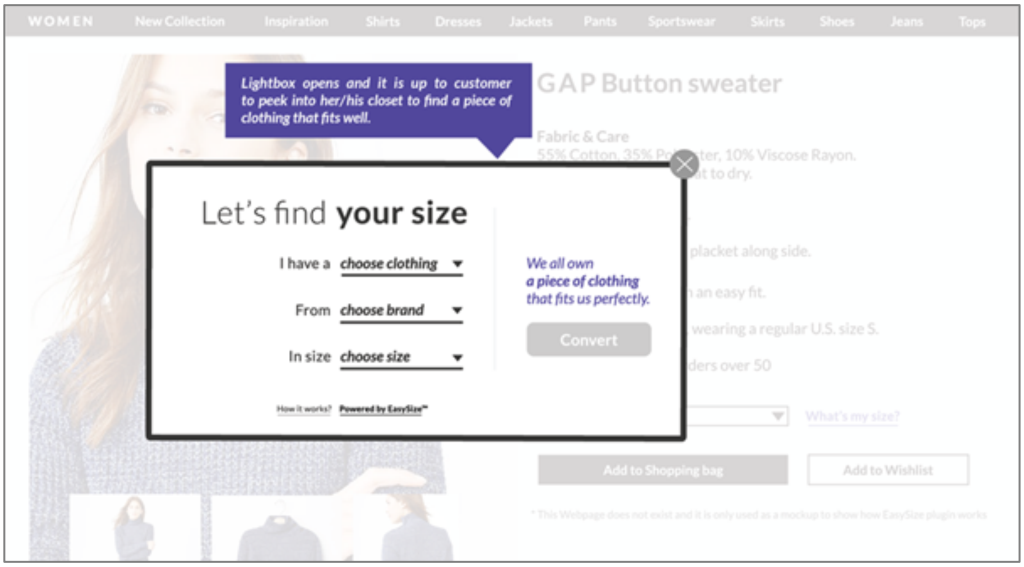


Figure 34: Anticipatory Design example - Easysize, a Human-centered AI service.

The system's effectiveness relies on contextual data integration, including fabric properties, cut styles, and user fit preferences. This comprehensive approach demonstrates how anticipatory systems can create value by addressing specific market inefficiencies rather than attempting broad behavioral modification.

4.4.1.3 Eliminating Decisions

Complete decision automation represents the most challenging implementation level, requiring sophisticated understanding of user contexts and preferences (Geden et al. 2019). Success at this level demands careful balance between automation benefits and user autonomy concerns..

Research in human-computer interaction demonstrates that users maintain preferences for perceived control even in highly automated systems (Parasuraman et al. 2000). Effective implementation requires transparent automation with clear override mechanisms.

4.4.2 Explicit Anticipation Applications

Designers can use explicit and implicit anticipation in different ways to explore new systems and needs. Within explicit anticipation (Miller and Gugerli 2018) describes there are three main use cases:

- Optimization
- Contingency
- Novelty

The point of distinguishing these three categories is to assist with the challenge of linking specific tasks to specific methods or approaches for both thinking about and shaping the future.

4.4.2.1 Optimization

Actively attempts to impose past patterns on the future. This means developing or improving existing systems or practices. It has the privileges of causal-predictive methods, often implemented through formal (usually algorithmic) models running historical data (Miller and Gugerli 2018). Optimization futures assume systemic continuity and are used to 'colonize' the future by assuming that specific assumptions will be estimated by extrapolation. In other words, we assume that existing trends will continue or that a current method will remain applicable. A designer may use optimization to actively attempt to improve patterns from the past to the future, creating predictive services that run on user historical data.

4.4.2.2 Contingency

It is the capacity to recognize and forecast possible surprises in the future. This means reading the present for something that might happen. The end goal here is not to optimize but instead to be prepared for a possible obstacle. Using novel futures to discover new ways of making sense of the emergent present provides one way of taking advantage of the unknowable as it becomes knowable, enhancing the capacity to discover the (Miller and Gugerli 2018). Contingent futures can be imagined as the outcome of external forces, and they are used to prepare and foresee anticipated surprises, with the proviso that they cannot take unknowable novelty into account. A designer may use contingent futures to actively plan how the service will be prepared to recognize possible surprises (especially negative ones). E.g., design and evaluate the reward function.

4.4.2.3 Novelty

This means novel futures include objects and processes, but they are unknowable in advance and present the greatest challenge for designers, requiring a capacity to explore openness. They can be used to discover new ways of making sense of the present. As far as explicit anticipation designed systems can only react in positive directions or negative evaluations. If positive, it maintains its behavior pattern, but if negative behavior occurs, it must adapt to prevent anticipated negative results (Poli 2017, 268).

There is a general agreement that these three ways of using the future under explicit anticipation do not live in isolation; all are usually employed in different proportions (Poli 2017; Miller and Gugerli

2018). Nevertheless, differentiating between these categories helps designers and non-designers to shape the future through specific methods and approaches, creating sustainable and trustworthy anticipatory experiences. These three categories assist in the idea that future goals and problems are perceptible and can be directly influenced (Miller and Gugerli 2018). The author argues that by distinguishing three ways of 'using the future', it provides a practical analytical framework for thinking about the future. The goal is to analyze how people are 'using the future' to make it easier to match tools to tasks. This will help establish an anticipatory system in four ways:

- Accelerating the pace of change in a high level of uncertainty
- Engaging and facing wicked problems and existential threats
- Assuming shared responsibility for positive outcomes
- Externalized assumptions, more creative thinking, and informed decision-making

4.5 Anticipatory Experiences

The concept of anticipatory experiences, while revolutionary, is not entirely new. Scholars and technologists have long theorized the potential of technology to foresee and cater to user needs proactively. Early literature suggested the potential of AI in creating systems that could predict user behavior (Pezzulo and Butz 2008; Poli 2017; Rosen 1985). More recent studies have delved deeper, examining the ethical implications (Nanayakkara et al. 2020), the balance between personalization and privacy to achieve optimal user experience (Cai and Mardani 2023), and the psychological impact on users when their needs are predicted accurately (Ahmad et al. 2023; Ljubica 2023).

HCI has traditionally focused on optimizing user interfaces and workflows for clearly articulating user needs with digital solutions. However, with the rise of intelligent systems and ubiquitous computing, a new design paradigm has emerged, that of designing for anticipation. One of the core principles of anticipatory design lies in leveraging user context to create anticipatory experiences. By analyzing past interactions, location data, sensor information, and even user demographics, anticipatory systems can build a profile of an individual's habits and preferences. This allows the system to anticipate potential needs and proactively offer relevant information or actions, providing an anticipatory experience. For example, a navigation app like Waze will predict a user's work commute based on time and location data, suggesting the fastest route with real-time traffic updates. This proactive approach can significantly reduce user effort and enhance the overall experience. Therefore, anticipatory experiences aim to understand and predict user intent, proactively offering support and streamlining interactions before explicit commands are issued.

4.5.1 From Theory to Application

AI builds on the concept of machines replicating human intelligence. Anticipatory design takes this a step further, aiming to introduce in them the human brain's remarkable ability to adapt and prepare for future events. From the literature review, we understand anticipatory design as a design-driven approach that leverages past and present data to generate intelligent predictions about future outcomes, ultimately supporting better human decision-making. However, there are also potential drawbacks to consider. Overly aggressive anticipation can lead to frustration if user needs are mispredicted or misunderstood. The reliance on user data raises privacy concerns, as extensive data collection is often required to build accurate user profiles. Furthermore, the ethical implications of anticipating user behavior need careful consideration. Should AI systems be allowed to influence user decisions by suggesting specific actions or choices? This research in anticipatory design and experiences should address these challenges while exploring the technology's full potential. Additionally, research into user trust and transparency is crucial. Users need to understand how anticipatory systems work and have control over the level of personalization and prediction offered. Additionally, research into user trust and transparency is crucial.

The importance of explainability is reiterated as critical to fostering trust. Without transparency and user control over anticipatory features, such systems may not achieve widespread acceptance. This applies particularly in fields like healthcare and finance, where trust and clarity are non-negotiable.

This research leverages the prior review on anticipation, intending to clarify existing knowledge about anticipatory experiences so we can establish anticipatory design as a distinct field, we will answer these key questions:

- What is anticipation within the context of anticipatory design?
- How do AI systems perceive and implement anticipation?
- What methods are currently used to conceptualize and develop AI services with anticipatory goals?

4.5.1.1 Anticipatory Experiences as a Design Methodology

Anticipatory design is the process that enables the creation of anticipatory experiences. However, from a design perspective, the anticipatory design methodology itself is still under development. Scholarly discussions surrounding anticipatory design should be more comprehensive, with a focus on further understanding its capabilities and challenges.

Anticipatory experiences require a holistic view encompassing numerous factors, including technological, social, cultural, and environmental considerations. To support designers working with complex AI-driven solutions, Malhotra et al. (2014) propose three key dimensions: Technological, People-Social, and Environmental. Failing to consider these three dimensions can lead to AI solutions that fall short, neglecting the connection between people, their social context, and the environment. The designer's role is to bridge these dimensions, ensuring a sustainable link between technological innovation and its application within social practices.

Design is an acknowledged strategic tool for innovation (Brown and Katz 2009; Cerejo and Barbosa 2012), competitive advantage (Martin 2009), and problem-solving (Kolko 2011; Dorst and Cross 2001). The rise of design acknowledgment was made possible by the success of design thinking, particularly in the last two decades. Since then, the recognition of design business value (Martin 2009) and innovation has never decreased. Our research anticipates a similar synergy between anticipatory design and successful AI technology – with thoughtful design, anticipatory systems can yield significant benefits.

Anticipatory experiences have the potential to become the cornerstone of future digital interactions. By proactively understanding user needs and proactively addressing them, we can create systems that effectively reduce cognitive load and generate positive societal impact. However, achieving this requires a nuanced understanding of the human decision-making process. Technology alone is insufficient; we need solutions that augment and enhance user lives, not simply automate them.

4.5.1.2 Historical Context: Buckminster Fuller's Vision

In 1927, Buckminster Fuller first articulated the concept of anticipatory design through his Comprehensive Anticipatory Design Science. This visionary framework called for designers to adopt a comprehensive approach, addressing entire systems rather than isolated components, and to anticipate future challenges and trends to envision optimal outcomes (Peckham and Berkebile 2003).

In 1950, Fuller took a significant step toward realizing this vision by outlining a course in Comprehensive Anticipatory Design Science. Taught at MIT in 1956 as part of the Creative Engineering Laboratory, it stood out as one of its more unconventional offerings (Peckham and Berkebile 2003). However, Fuller's aspirations for anticipatory design as a distinct field did not fully materialize (Galdon and Hall 2019). Now, with the advent of the digital age, especially with AI, there is renewed potential to leverage anticipatory design concepts that Fuller foresaw over seventy years ago. To Fuller, each word carries a profound meaning:

- **Comprehensive** – Encourages designers to frame the entire problem and work towards specific solutions, fostering whole-systems thinking.
- **Anticipatory** – Involves understanding current challenges and trends to envision the best possible outcomes for the future.
- **Design** – Encompasses the process of imagining and designing systems and components – an act of invention.
- **Science** – Implies the pursuit and application of knowledge and understanding for problem-solving.

4.5.2 Benefits and Risks of Anticipatory Experiences

Anticipatory experiences offer significant potential benefits while introducing novel risks and challenges that require careful design consideration. Understanding these trade-offs proves essential for creating effective and ethical anticipatory systems.

However, in practice, the implementation of anticipatory design often reveals unintended consequences that counteract these benefits. The over-automation of user experiences can inadvertently reduce a sense of control, leading to frustration, misaligned expectations, and a loss of trust. Moreover, while predicting user needs sounds appealing, it assumes a level of predictability in human behavior that doesn't always hold true, ultimately undermining the personalization that businesses seek.

4.5.2.1 Potential Benefits

- **Reduced Cognitive Load**: Well-designed anticipatory systems can significantly reduce the mental effort required for routine decisions and information processing, freeing cognitive resources for more complex and creative tasks (Kahneman 2011).
- **Enhanced Efficiency**: Automation of routine decisions and proactive provision of relevant information can streamline workflows and reduce task completion time across diverse domains (Beer et al. 2014).
- **Improved Decision Quality**: Access to relevant contextual information and predictive insights can enhance decision-making quality, particularly in complex domains where users lack complete information or domain expertise (Echterhoff et al. 2024).

4.5.2.2 Potential Risks and Challenges

- **Over-reliance and Skill Atrophy**: Excessive dependence on anticipatory systems may lead to reduced user capabilities and decision-making skills, creating vulnerability when systems fail or prove inadequate (Pariser 2011).
- **Filter Bubbles and Reduced Serendipity**: Algorithmic curation may limit exposure to diverse perspectives and unexpected discoveries, potentially constraining learning and innovation (Pariser 2011).
- **Privacy and Autonomy Concerns**: Anticipatory systems require extensive personal data collection, raising concerns about privacy, surveillance, and user autonomy that must be carefully addressed through design and policy mechanisms (Zuboff 2019).

Designers have a social responsibility to create optimal user experiences. As AI becomes ubiquitous, understanding it becomes crucial, as otherwise designers risk unintentionally amplifying marginalization. Conversely, by learning how to leverage AI and ML, we can enhance user experiences, augment user capabilities, and drive positive change across various sectors like business, education, healthcare, and environmental protection (Shneiderman 2020). The anticipatory design offers several potential benefits for user experience.

4.6 Redefining User Experience through Behavior Change

The integration of anticipatory capabilities with behavior change methodologies represents a significant opportunity to create systems that not only predict user needs but also actively support positive behavioral outcomes. This approach requires a deep understanding of motivation, habit formation, and behavior change processes (Fogg 2009; Locke and Latham 2002).

Behavior change is not a uniform process; individuals exist at different stages of readiness for change, and each stage requires distinct types of interventions. Effective anticipatory systems must ensure that predictions and interventions are tailored to users' specific needs, readiness levels, and preferences, thereby reducing the risk of over-promising and under-delivering.

4.6.1 Users’ Mental Models Around AI

User understanding and acceptance of anticipatory systems depend significantly on their mental models of AI capabilities, limitations, and appropriate applications. Research in human-AI interaction demonstrates that misaligned mental models can lead to inappropriate trust, misuse, and user frustration (Amershi et al. 2019a).

Effective anticipatory design must actively shape and support accurate mental models through transparent communication, appropriate feedback, and educational interactions that help users understand system capabilities and limitations (Abdul et al. 2018).

However, fostering trust in AI systems highly depends on users developing a proper understanding of how they work. This is especially important given the inherent uncertainty (probabilistic nature) of AI outputs. The challenge lies in designing interfaces that leverage users' past experiences (like familiar design patterns) while simultaneously shaping their mental models to build trust and acknowledge the system's limitations.

Mental models represent individuals' cognitive representations of how systems, concepts, or phenomena function. In the context of AI, it is essential to distinguish between automation (the execution of tasks without human intervention) and autonomy (the ability to make decisions independently). Clarifying this distinction is key to managing user expectations and fostering trust in AI systems (Xu et al. 2021).

The relationship between autonomy, automation, and human intervention creates a complex design space that requires careful navigation (Figure 36). The figure illustrates this relationship, showcasing the trade-offs and intersections among human oversight, automation, and system autonomy. This framework provides a valuable lens for understanding how varying levels of human involvement and AI control influence the effective design and implementation of anticipatory systems.

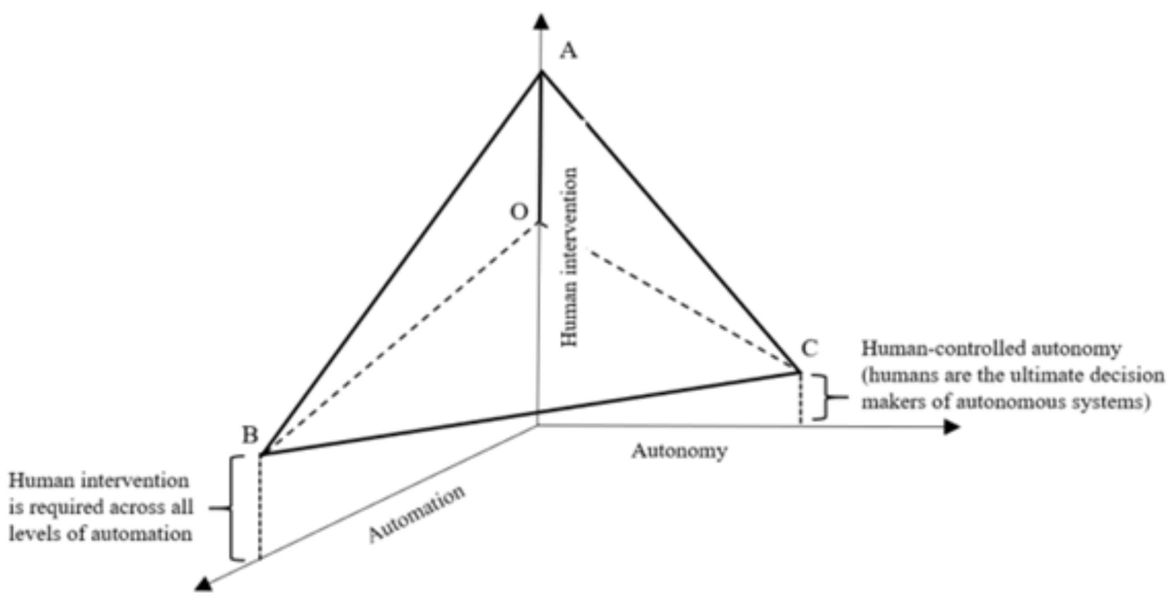


Figure 35: Interaction between autonomy, automation, and human intervention (Xu et al. 2021).

Mental models can be conscious or unconscious and vary in complexity depending on expertise, familiarity, and cognitive ability. They are dynamic, evolving as individuals integrate new information or experiences, and they influence decision-making, problem-solving, learning, and overall performance (Xu et al. 2021). Figure 37 illustrates our understanding of Lovejoy's (2018) three main outcomes in users' mental models:

- How the system works — *How to use it?* — Users may develop an understanding of how the system works and how it arrives at its recommendations. This mental model is influenced by the transparency of the system.
- System's impact on user work — *When to use it?* — Users may develop an understanding of how the system impacts their work and how they can best utilize the system to improve their productivity. This mental model is influenced by the level of control users have over the system.
- System's limitations — *What it can do?* — Users may develop an understanding of the system's limitations, including when it may not be accurate or when it may not provide the best recommendations. This mental model is influenced by the trustworthiness and value of the system.

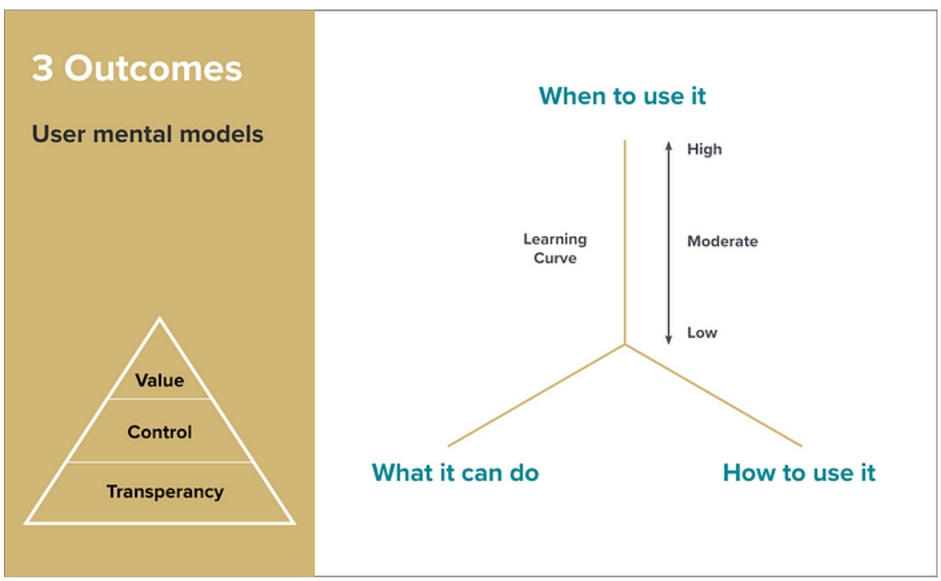


Figure 36: Our interpretation of Lovejoy's (2018) user mental models' outcomes.

4.6.1.1 Novelty

When users encounter novel AI capabilities, they tend to rely heavily on system transparency and reliability cues to develop appropriate trust and usage patterns. Research in technology acceptance demonstrates that initial experiences with novel systems significantly influence long-term adoption and appropriate use (Amershi et al. 2019a; Shneiderman 2020). This mental model is influenced by the transparency of the system (Figure 38).

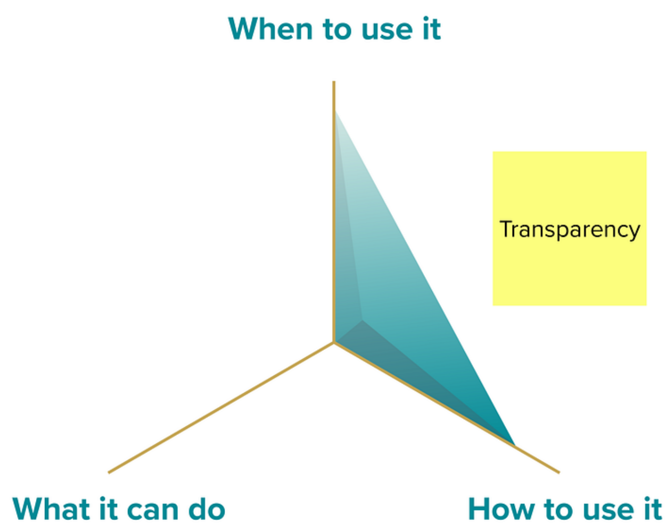


Figure 37: Transparency dimension under user AI mental models.

Transparency is key to building trustworthy AI solutions that ultimately benefit users. This includes not only making the AI’s workings clear but also actively avoiding "automation surprise," where users are caught off guard by the AI’s actions. Clear communication about what the AI can and cannot do helps in managing user expectations and builds trust (Xu et al. 2021). By making the service's inner workings as clear as possible, we can achieve several goals: maintain user trust in the brand, avoid confusion and disappointment, ensure users can access the solution's value, reduce drop-out rates, and foster overall trust in the system. This transparency also leads to easier interactions, as users understand what to expect from the AI.

When confronting our users with novel systems, we must design for trust and transparency. It is our job to help them understand how the system works—Explainable AI—be transparent about their abilities—Managing Expectations—construct helpful mental models and make them feel comfortable in their interactions—Design for Failure and Accountability—assume failure and design graceful recoveries. Take accountability for mistakes and minimize the cost of errors for your users.

Give users suggestions that help them make decisions by leveraging multiple data sources. The information must be objective and emphasize users’ best interests. To build user trust and comfort level, communicate what the user’s collected data is used for.

- Explainability—How will we help our users understand certain outcomes?

- Managing Expectations—How will we establish realistic expectations?
- Graceful Failure & Accountability—How will we design for trust in case of failure?

4.6.1.2 Agency

User agency concerns emerge when anticipatory systems operate with high levels of automation or when users perceive limited control over system behavior. Research in human autonomy demonstrates that perceived control significantly influences user satisfaction and system effectiveness (Ryan and Deci 2000). This mental model is influenced by the level of control users have over the system (Figure 39).

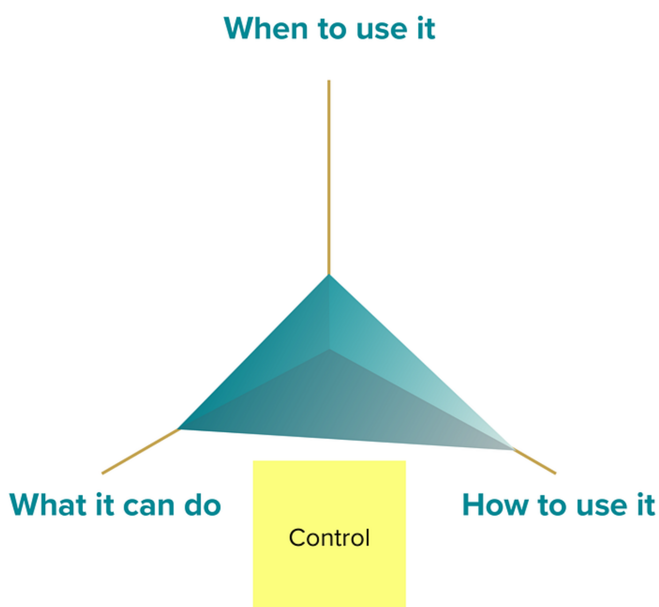


Figure 38: Control dimension under user AI mental models.

The solution focuses on empowering users with control over automation. This involves ensuring that users can intervene and override AI decisions when necessary. By allowing users to maintain control, we prevent feelings of helplessness and foster a sense of ownership and trust in the system. Additionally, clear mechanisms for user feedback and customization further enhance this control (Xu et al. 2021).

This approach ensures informed consent, prevents feelings of helplessness or surveillance, and ultimately creates more user value through customization. Additionally, by allowing users to control the level of automation, we gain valuable feedback about their needs, which can further improve the system. When we question the agency or autonomy of our users, we need to design for user autonomy and control so they can feel like they're in charge of the system.

People have justified concerns about giving up their agency to a (semi-) autonomous systems and sharing the personal data required to make them work well — Data Privacy and Security. We must respect the human need for autonomy — User Control and Customization — as well as creating mechanisms to control the level of system automation — Machine Teaching and User Feedback — users need a way to exercise consent and control over the system and their data based on their individual and contextual needs.

Communicate expectations to users immediately, so they know what your AI solution can and can't do. Cooperate and collaborate with users to let them feel in charge of the decision-making so they want to explore your AI solution. This builds trust and creates a more successful user experience.

- **User Feedback** — How will we help our users provide feedback to the system?
- **User Autonomy** — How will the user be able to customize their experience?
- **Data Privacy** — How will you collect, store, and handle user data and communicate that with them?

4.6.1.3 Capabilities

User understanding of AI capabilities often proves inaccurate, leading to either over-reliance or under-utilization of anticipatory systems. Research in calibrated trust demonstrates the importance of matching user expectations with actual system capabilities (Parasuraman et al. 2000; Beer et al. 2014)). This mental model is influenced by the trustworthiness and value of the system (Figure 40).

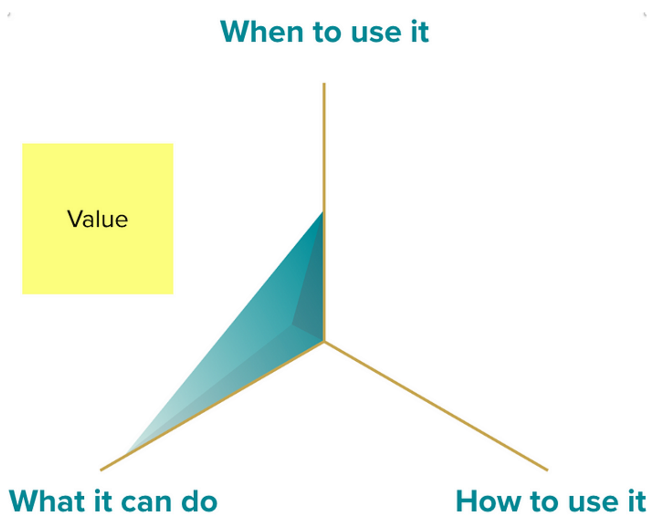


Figure 39: Control dimension under user AI mental models.

Focus on the problem, not the technology, to ensure AI solutions effectively address user needs. Instead of simply asking if AI can be applied to a problem, a more effective approach is to first consider "How might we solve this problem?" and then evaluate if AI offers a unique solution. By prioritizing the problem, we can ensure the technology offers a valuable exchange, considering factors like user convenience, expectations, and ethical implications. This focus also promotes responsible AI development by emphasizing accountability, positive impact, fairness, inclusivity, and avoiding harmful biases.

Deploying an AI system across layers of society will affect the lives of individuals and groups across the globe in different and sometimes unexpected ways. Responsible AI development must focus on fairness, inclusivity, and ethics. This includes avoiding biases, ensuring value alignment between the technology and societal benefits, and maintaining accountability for the system's impact. By prioritizing these ethical considerations, we can develop AI solutions that genuinely benefit humanity (Xu et al. 2021). When that happens, we must design for value alignment by focusing on the benefit and not on the technology.

Operating at an unprecedented scale and complexity, we must be mindful of biases, risks, system dynamics, and consequences— Accountability— to make thoughtful trade-offs in our AI applications —Fairness and Inclusiveness. Striving for value alignment between man and machine (and those operating the machine!) by integrating —Ethics— at the core of your projects is required to shape this technology to help humanity.

Help users understand your product's capabilities rather than what's under the hood. But no matter how novel your use of AI, when explaining your AI-powered product to your users, focus primarily on conveying how it makes part of the experience better or delivers new values, versus explaining how the underlying technology works.

- **Accountability** — *How will you turn needs into parameters?*
- **Fairness + Inclusiveness** — How will you prevent bias and guard inclusivity?
- **Ethics** — *Does the cost of errors or negative impacts outweigh the benefits that AI provides?*

4.6.2 Connecting to The Cognitive Burden of Technology

Contemporary digital environments create significant cognitive burden through information overload, constant decision-making demands, and attention fragmentation, contributing to measurable cognitive overload (Sweller 1988; Hirshleifer et al. 2019).

Technology, designed to simplify our lives, has inadvertently created a new kind of stress: information overload (Schwartz 2004; Rutkowski and Saunders 2018; Roetzel 2019). Studies indicate that digital overwhelm and technology-related stress have become increasingly prevalent among heavy technology users, with younger demographics particularly vulnerable due to intensive engagement patterns with digital platforms (Twenge 2017; Reinecke et al. 2016).

For technology users, particularly those engaging with high-interaction platforms such as e-commerce, productivity tools, and social media, cognitive strain is significantly amplified. What evolved as survival mechanisms now leave users overwhelmed and exhausted in contemporary digital environments (Twenge 2017).

This cognitive strain has profound implications not just for individual well-being but for the design of digital systems themselves. Decision fatigue and analysis paralysis are the cumulative exhaustion from making too many choices, which undermines the effectiveness of technology meant to help us (Schwartz 2004; Rutkowski and Saunders 2018; Roetzel 2019). It erodes trust, reduces engagement, and diminishes the user experience. In the pursuit of innovation, we have overlooked a critical question: how can AI technology alleviate rather than amplify the mental burden it creates?

Anticipatory design has the potential to offer a solution to cognitive burden through intelligent information filtering, decision automation, and proactive support. However, these interventions must be carefully designed to avoid creating new forms of cognitive dependence or reducing user capabilities. This research argues that it is where the fields of behavior change, design and anticipatory design can be transformative. Behavior-change design focuses on empowering users to form better habits and choices. While anticipatory design, on the other hand, aims to anticipate decisions entirely by predicting user needs and acting on their behalf. Together, these approaches have the potential to revolutionize how we interact with AI technology—transforming it from a source of stress into a tool that acts more as a helpful partner rather than a demanding child.

For designers, the challenge is clear: how can we design AI-driven systems that not only understand human behavior but also actively reduce cognitive strain? How can we balance automation with agency, offering users relief from decision fatigue without stripping them of control? These questions are at the heart of the UX discipline today, as we grapple with the psychological consequences of the digital age. But there is a caveat: not all AI-driven solutions have to be designed for behavior change. In our perspective, behavior change is only critical in experiences where the product or service is designed to address a gap between a user's current state and their desired state.

For these reasons, this research explores the dual promise of behavior change and anticipatory design, unpacking the insights, opportunities, and pitfalls of these approaches. By examining real-world examples and the lessons from failed AI projects, we'll uncover how UX professionals can design systems that respect human limits, foster trust, and anticipate user needs without overwhelming them. In doing so, we'll chart a path toward a future where technology works with us, not against us.

Therefore, in the quest to create seamless experiences, anticipatory design gained traction in many businesses due to its promise to simplify daily decision-making processes, either on a personal or professional level. Despite its promising potential, anticipatory design often falls short in real-world applications. This disconnect arises not from the limitations of the technology itself but from a fundamental misunderstanding of human behavior and the core principles of effective design. While AI systems can predict user needs, they often fail to account for the complexities of human decision-making and preferences, leading to mismatched expectations and frustration. A deeper understanding of user psychology, combined with transparency and user control, is necessary for anticipatory design to truly enhance the user experience rather than hinder it.

It's essential to explore why anticipatory design often fails to meet business expectations. This exploration requires examining not only the psychological aspects of user experience but also the risks associated with over-automation. In the next chapter, we will conduct a comprehensive scope review, delving into these challenges to uncover the underlying factors that contribute to such failures and to provide a structured framework for addressing them.

4.6.3 Trust Calibration: Balancing Autonomy and Automation

User mental models play a pivotal role in shaping how AI systems are perceived and trusted. Designing AI systems that prioritize explainability, manage user expectations, and ensure accountability is critical for fostering trust. Equally important is providing users with control and customization options to enhance transparency and maintain a sense of autonomy. Responsible AI design must focus on meeting user needs while adhering to ethical principles, fairness, and inclusivity.

Building trust in AI systems involves more than offering clear explanations; it requires aligning system functionality with user expectations. Addressing potential safety issues, such as the "out-of-the-loop" effect (Xu et al. 2021) and ensuring mechanisms for human interventions is crucial. Designing systems that balance levels of automation with user control fosters trust and promotes a seamless user experience. According to Kore (2022), two key factors are essential for building and calibrating user trust: explainability and user control over data and system outputs. Providing transparency in data usage and clear explanations about AI operations allows users to build accurate mental models of the system, strengthening trust and usability.

4.6.3.1 Levels of Automation and Explanation

The degree of explanation required to build and sustain trust in AI systems is closely tied to the system's level of automation (Kore 2022). Systems with lower automation, such as voice assistants, demand basic explanations that focus on high-level overviews of functionality with minimal technical details. In contrast, highly autonomous systems—like medical decision aids or autonomous vehicles—necessitate comprehensive explanations, detailing decision-making processes, data sources, methodologies, and potential limitations. These explanations allow users to understand the reasoning behind the system's outputs, assess reliability, and make informed decisions.

Table 5 presents a structured framework for aligning automation levels with appropriate explanations, emphasizing the critical role of transparency at each stage. For instance, low-automation systems may rely on general overviews, while highly autonomous systems require detailed transparency, including an account of potential failure modes, to foster trust and ensure safety. As the level of automation increases, the explanation must become more detailed and transparent, ensuring user trust is maintained at every stage.

Table 5: Balancing automation and explanation to build trust in AI systems.

Level of Automation	Level of Explanation	Examples	Description
Low Automation	**Basic Explanation:** General overview of factors considered by the AI, no need for technical details.	Voice assistants (e.g., Siri), recommender systems.	**Automation:** The AI performs simple, non-critical tasks where human intervention is frequent. **Explanation:** Users receive a high-level overview of how the AI works without going into technical details.
Moderate Automation	**Moderate Explanation:** Clear explanations of how the system makes decisions, key features, and main limitations.	Automated customer service, navigation systems.	**Automation:** The AI handles more complex tasks with significant but not complete autonomy. Users might interact frequently with the AI for guidance or assistance. **Explanation:** Users are provided with clear, understandable explanations of the AI's decision-making processes, including key features and limitations.
High Automation	**Thorough Explanation:** Detailed descriptions of	Medical decision-making	**Automation:** The AI supports critical decision-making processes, but final decisions often involve human judgment.

	decision-making processes, including model operation, data used, and limitations.	tools, financial advisory AI.	**Explanation:** Detailed information about how the AI model functions, including its data sources, methodologies, and constraints. Users need to understand how the system arrives at its recommendations.
Full Automation	**Comprehensive Explanation:** Nearly fully descriptive operation, exact limitations, and robust transparency in critical and non-critical scenarios.	Self-driving cars, autonomous drones, criminal justice AI.	**Automation:** AI operates autonomously with minimal to no human intervention required in real-time. **Explanation:** Comprehensive understanding of the AI's operation, covering nearly all aspects of its decision-making process, exact limitations, and potential failure modes. Essential for trust and safety.

This framework is visually represented in Figure 41, which maps the relationship between levels of automation and the depth of explanation and human involvement required. This image presents a continuum that maps *levels of autonomy* (on the vertical axis) against the *levels of trust needed* (on the horizontal axis). It categorizes automation into distinct stages ranging from low automation, where humans are fully in control, to full automation, where the AI operates independently with minimal or no human intervention.

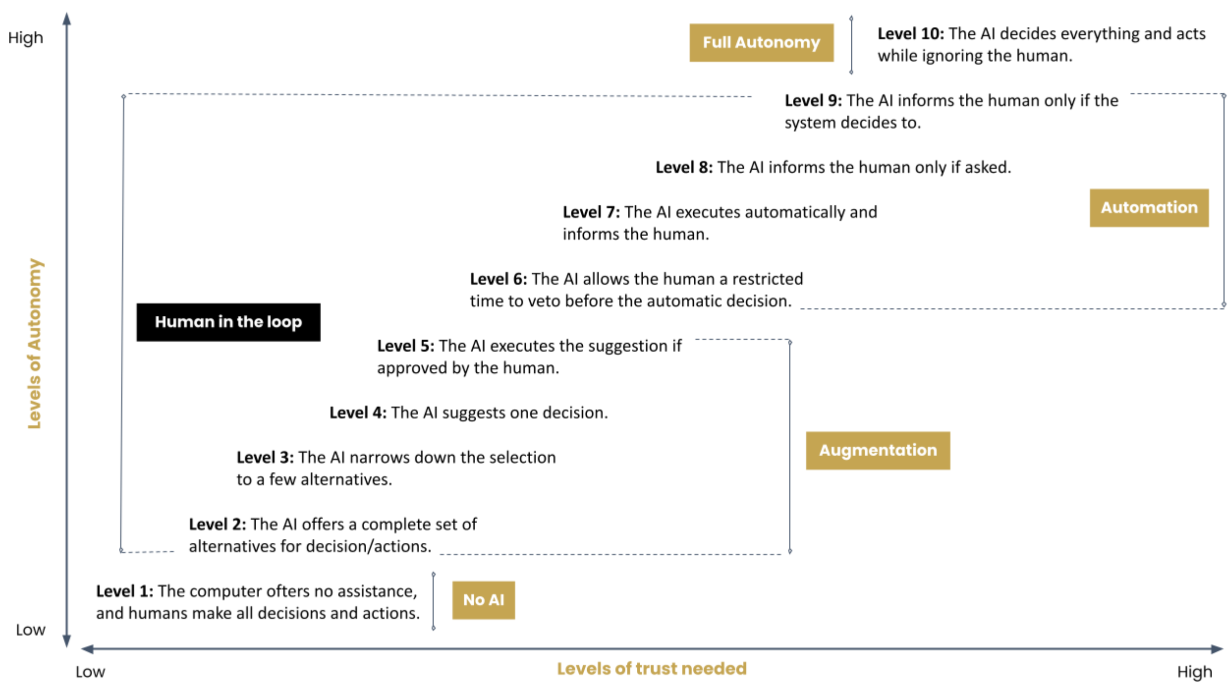


Figure 40: Levels of system autonomy according to Kore (2022).

At the lower end of the spectrum, **Level 1 (No AI)** involves systems offering no assistance, where humans are responsible for all decisions and actions. As the level of automation increases, systems transition into augmentation stages, where AI provides suggestions or narrows down decisions for human approval (e.g., Levels 3-6). These stages emphasize *human-in-the-loop* interactions, requiring moderate levels of explanation to build user trust and ensure accountability. In the higher levels of automation, **Levels 7-10**, the AI assumes greater autonomy, making critical decisions and informing humans only when necessary. These fully autonomous systems demand comprehensive explanations to establish transparency and ensure users trust the system's capabilities and safeguards. For example, Level 10 represents complete AI autonomy, where the system operates independently of human input and must provide detailed, robust transparency for trust calibration. In sum, Kore's (2022) works help us understand that:

- **Low Trust (Levels 2-3)**: Humans retain almost full control and primarily rely on AI for information filtering or option generation. Trust is minimal since decisions remain entirely human-driven.
- **Moderate Trust (Levels 4-5)**: Trust increases as AI suggests or executes decisions under human supervision.
- **High Trust (Levels 6-8)**: AI takes on more active roles in execution with limited human intervention, requiring substantial trust in AI's capabilities and accuracy.
- **Very High/Absolute Trust (Levels 9-10)**: Full reliance on AI, with humans only involved in failure scenarios or system monitoring. This level requires trust in AI's ethical, contextual, and technical decision-making.

Kore (2022) framework presents a helpful representation for understanding levels of human autonomy in AI systems. However, conceptually and theoretically, it doesn't explore a key element, the human-AI collaboration dynamic between the person and AI. For us, the model lacks a detailed exploration of how collaboration evolves between human and AI systems as autonomy increases. Thus, in Table 6, we propose to include a dimension to describe how the roles and responsibilities of humans and AI shift across levels.

Table 6: Mapping human and AI roles, responsibilities, and trust across levels of autonomy.

Level	Description	Human Role	AI Role	Shared Responsibility	Level of Trust Needed
1	No AI: Humans make all decisions.	Full decision-making and execution.	None	None	None (No AI involvement).
2	AI offers a complete set of alternatives.	Evaluate all options and make the decision.	Generate and present all possible alternatives.	Information gathering and presentation.	Low: Human retains full control.
3	AI narrows down to a few alternatives.	Select the best option from AI's suggestions.	Filter and refine the list of alternatives.	Decision refinement and risk evaluation.	Low-Moderate: Trust in AI's filtering ability.
4	AI suggests one decision.	Evaluate the suggestion and decide to act.	Propose the most optimal single decision.	Validation of AI suggestions.	Moderate: Trust in AI's ability to identify the best option.
5	AI executes with human approval.	Approve or reject the AI's proposed action.	Execute the action once approval is given.	Agreement on execution criteria.	Moderate-High: Trust in AI's execution capabilities.
6	AI allows veto before automatic decision.	Monitor AI decisions and veto if necessary.	Execute decisions automatically after delay.	Define veto criteria and monitoring feedback.	High: Trust in AI's ability to act without human interference.
7	AI executes automatically and informs human.	Set parameters for AI decisions; monitor outcomes.	Execute actions autonomously and notify results.	Ensure decision criteria are met.	High: Trust in both execution and reporting.
8	AI informs human only if asked.	Rarely involved; intervene only on request.	Autonomously act and store justification data.	Define edge cases for human intervention.	Very High: Trust that AI can act without oversight.
9	AI informs human only if system decides.	Passive observer unless system signals issues.	Fully autonomous, decides when to inform human.	Exception handling for critical decisions.	Extremely High: Trust in AI's judgment on when to involve humans.
10	Full autonomy: AI ignores the human.	No involvement: addresses failures if needed.	Fully autonomous, acts without human input.	Pre-set system design and regulatory oversight.	Absolute: Trust AI to function independently and reliably.

Moreover, in this context, it is important to differentiate between automation and autonomy, emphasizing that AI systems should always have a level of human oversight to prevent misuse and ensure safety. Lastly, before integrating AI solutions, it is important to evaluate if AI is truly necessary to address the problem at hand effectively.

4.6.3.2 Trust Calibration: Balancing Expectations and Capabilities

Trust calibration involves aligning users' perceptions of an AI system's capabilities with its actual performance, thereby avoiding the pitfalls of overtrust and distrust. Trust in AI centers around the belief that relying on it won't leave us vulnerable in uncertain or risky situations. Trust calibration refers to how well our trust in AI matches its actual capabilities. "Users can overtrust the AI when their trust exceeds the system's capabilities. They can distrust the system if they are not confident of the AI's performance" (Kore 2022, 119).

- **Overtrust (Misuse):** Users place excessive reliance on the AI, assuming it will perform flawlessly. For instance, overtrust in autonomous vehicles can lead to accidents if users neglect to monitor the system during unexpected scenarios.
- **Distrust (Disuse):** Users underestimate or reject the system's capabilities due to a lack of understanding or transparency, resulting in missed opportunities. For example, healthcare professionals may distrust opaque diagnostic tools, opting instead for manual methods despite the potential advantages of AI.

Both scenarios highlight the importance of fostering accurate mental models to ensure users understand how the system operates and when to rely on it.

For Kore (2022), two key factors are instrumental in calibrating trust: *explainability* and *user control*. Transparency in data usage and clear explanations of AI functionality help users develop accurate mental models, enabling them to assess when to exercise caution or intervene manually and how to rely on the system. Misaligned trust, whether excessive or insufficient, can result in frustration, misuse, or even abandonment of the system. Feedback loops and customization options further enhance user autonomy, even in highly automated frameworks.

Explanations are central to bridging the gap between users' mental models and the actual workings of an AI system. For low-automation systems, basic explanations suffice, focusing on high-level overviews of functionality. However, as automation increases, the need for detailed explanations grows, encompassing decision-making processes, data sources, and potential risks. Figure 42 illustrates the interplay between automation levels and the depth of explanation required to align user expectations with system capabilities.

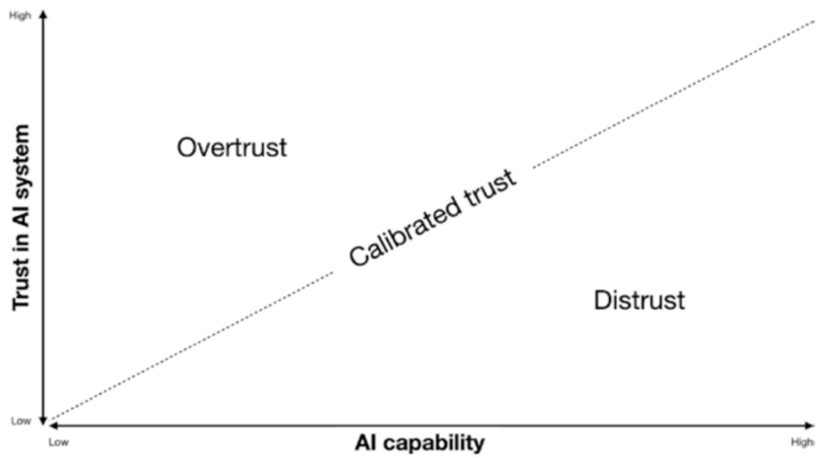


Figure 41: Trust calibration template according to Kore (2022).

To avoid misuse or disuse, anticipatory systems must carefully balance automation with user control and transparency. Figure 42 provides a framework for mapping the consequences of overtrust or distrust in AI systems and developing strategies to calibrate user trust. This calibration is critical, as it directly impacts the system's accountability, particularly in cases where errors or failures arise. Figure 43 further illustrates the application of this strategy in a Level 7-8 automated system designed for the automated personal data anonymization of court decisions.

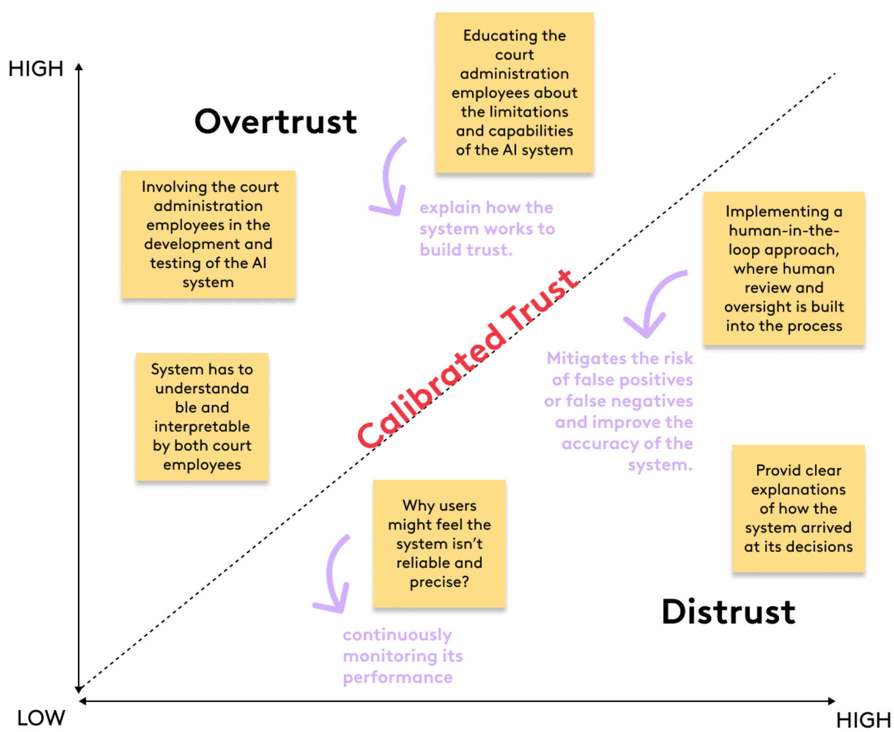


Figure 42: Illustration of trust calibration in an automated court administration decision system, demonstrating how to balance automation, user control, and transparency.

This trust calibration process also aligns with evolving regulatory standards, such as the EU AI Act[10], which emphasizes transparency, human oversight, and robust explanations for high-risk AI systems. By providing timely, context-sensitive explanations, anticipatory systems can ensure users perceive AI as reliable collaborators rather than autonomous decision-makers. This new legislative framework mandates that AI systems used in critical sectors, such as healthcare, transportation, and finance, must provide clear and detailed explanations of their decision-making processes. Providers must ensure that these systems are accurate, reliable, and transparent, with robust mechanisms for human oversight to prevent misuse and disuse.

Notably, the recent proposal passed by the EU Parliament on March 13, 2024, has significant implications for European providers of AI systems. The proposed EU AI Act classifies AI systems according to the potential risk and harm they could cause:

- **Unacceptable Risk—**AI systems that pose a clear threat to the safety, livelihoods, and rights of people.
    - **Examples**: Social scoring by governments, exploitation of vulnerabilities of specific groups (e.g., children), and subliminal techniques that manipulate behavior.
    - **Obligations:** These systems are prohibited outright.
- **High Risk**—AI systems that significantly affect people's lives and could potentially cause harm.
    - **Examples:** AI in critical infrastructure (e.g., energy, transportation), medical devices, employment processes (e.g., hiring algorithms), law enforcement (e.g., facial recognition), and migration control.
    - **Obligations:** These systems must meet strict requirements, including:
        - Risk management and mitigation.
        - High-quality datasets.
        - Documentation and record-keeping.
        - Transparency and provision of information to users.
        - Robust human oversight.
        - Security and accuracy standards.
- **Limited Risk**—AI systems that have a lower risk but still require some level of transparency.
    - **Examples:** Chatbots, AI that generates or manipulates content (e.g., deepfakes).

[10] https://www.euaiact.com/

- Obligations: Users must be informed that they are interacting with an AI system to ensure transparency.
- **Minimal Risk—**AI systems with negligible or no risk to people's rights or safety.
  - **Examples:** AI in video games, spam filters.
  - **Obligations:** These systems are largely exempt from additional regulatory requirements, though providers are encouraged to adhere to voluntary codes of conduct.

On the other hand, the Organisation for Economic Co-operation and Development (OECD) has created five value-based AI principles to promote the use of innovative but also trustworthy AI solutions that can respect human rights and democratic values. They were adopted in May 2019 to set standards for AI that are practical and flexible enough to stand the test of time. The five principles are the following:

- **Principle 1.1: Inclusive growth, sustainable development, and well-being** – "Stakeholders should proactively engage in responsible stewardship of trustworthy AI in pursuit of beneficial outcomes for people and the planet, such as (...) reducing economic, social, gender and other inequalities".
- **Principle 1.2: Human-centred values and fairness** – "AI actors should respect the rule of law, human rights and democratic values, throughout the AI system lifecycle. (...) To this end, AI actors should implement mechanisms and safeguards, such as the capacity for human determination, that are appropriate to the context and consistent with the state of art."
- **Principle 1.3: Transparency and explainability Transparency and explainability** – "to foster a general understanding of AI systems; to make stakeholders aware of their interactions with AI systems (...)"
- **Principle 1.4: Robustness, security, and safety** – "AI actors should ensure traceability, including in relation to (...) decisions made during the AI system lifecycle".
- **Principle 1.5: Accountability** – "AI actors should be accountable for the proper functioning of AI systems and for the respect of the above principles, based on their roles, the context, and consistent with the state of art."

The OECD AI Principles, emphasizing transparency, accountability, and human-centered values, provide a foundational ethical framework that aligns with the goals of anticipatory design to empower users and foster trust in AI-driven systems. This emerging regulation highlights the critical importance of transparency and human control in AI systems, establishing strict requirements for quality, oversight, and safety, particularly in high-risk applications. These regulations are designed to build trust in such systems by prioritizing explainability, robust human oversight, and user empowerment. As anticipatory systems continue to advance, adopting principles of trust calibration will be crucial for developing AI that is not only effective but also aligned with user expectations and ethical standards. By providing tailored explanations, enabling user control, and balancing automation with autonomy, anticipatory systems can position themselves as reliable and trusted collaborators across diverse contexts.

The EU AI Act and OECD AI principles seek to protect users by imposing rigorous obligations on AI developers and operators, demanding adherence to transparency, safety, and performance benchmarks. These requirements will likely influence the level of explanation expected, as well as the presentation of accuracy and performance metrics—especially in high-stakes scenarios where societal and individual impacts are significant.

Overall, these regulations are poised to enhance trust in AI systems by ensuring they function safely, transparently, and in alignment with ethical and responsible AI development principles. Clear and context-sensitive explanations will play a key role in helping users calibrate their trust, ensuring they neither overestimate nor underestimate an AI's capabilities. For instance, a fitness app that automates workout recommendations based on user data should justify its suggestions by explaining how it analyzed past activities and goals. Such transparency empowers users to override or adjust recommendations as needed, fostering a sense of control and reinforcing trust in the system.

4.7 The Science of Behavior Change

Designing for behavior change sits at the intersection of behavioral science, technology, and user experience. Its core objective is to enable users to adopt healthier habits, make informed decisions, and achieve long-term goals by integrating insights from psychological frameworks and technological innovations. Notably, Fogg's (2009) Behavior Model (B=MAP), a psychological framework designed to explain and predict how human behaviors occur, has been particularly influential in persuasive design, behavior change, and human-computer interaction. The model offers a foundational understanding of how motivation, ability, and triggers converge to influence behavior (Figure 44), and is applied to human behavior for people of all ages and in all cultures.

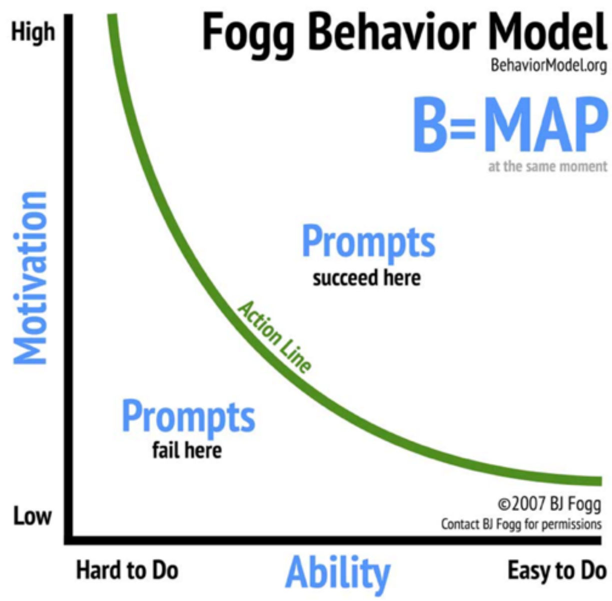


Figure 43: Representation of Fogg's Behavior Universal Model via behaviormodel.org

For Fogg, "Behavior happens when motivation, ability, and a prompt come together at the same time. When a behavior does not occur, at least one of those three elements is missing" (2009, 1). The universality of this model underscores its applicability across cultures, demographics, and contexts. According to Fogg, Behavior (B) is the result of three interacting elements:

B = MAP

- **M**: Motivation — The degree to which a person wants to perform the behavior.
- **A**: Ability — The ease or difficulty of performing the behavior.
- **P**: Prompt — The trigger or cue that initiates the behavior.

This model emphasizes that designing for behavior change requires a careful consideration of all 3 elements. Fogg argues that for a behavior to occur, all three elements must be present simultaneously and at sufficient levels. If one element is missing or inadequate, the behavior is unlikely to happen. For example:

- **High motivation and ability, but no prompt** → No behavior occurs. The user does not know when or how to act.
- **Strong prompt and high motivation, but low ability** → Behavior is unlikely to happen due to difficulty.
- **Clear prompt and high ability, but low motivation** → Behavior may not occur because the person does not care enough. The user lacks the drive to engage in the behavior.

Fogg's framework is not just a tool for explaining behavior but a guide for crafting interventions that drive meaningful change. Each component of the model plays a distinct role:

Motivation

Motivation represents the degree to which an individual is driven to act. According to Fogg, motivation can be dissected into three primary dimensions that guide behavior:

- **Pleasure vs. Pain**: These are immediate emotional drivers that push an individual toward or away from a behavior.
- **Hope vs. Fear**: These are anticipatory emotions tied to potential future outcomes. Hope motivates action by promising a positive result, while fear compels action to avoid negative consequences.
- **Social Acceptance vs. Rejection**: The need for social belonging plays a critical role, as individuals are often motivated by the desire to align with societal norms or avoid ostracism.

By leveraging these dimensions, designers can craft interventions that resonate with users on an emotional and social level, fostering stronger motivation to act.

Ability

Ability refers to the ease with which a person can perform the desired behavior. Fogg emphasizes simplicity as a critical factor in increasing ability, identifying six elements that can either enable or hinder an action:

- **Time**: How much time is required to perform the behavior?
- **Money**: The financial cost associated with the behavior.
- **Physical Effort**: The level of exertion needed.
- **Mental Effort**: The cognitive load required.
- **Social Deviance**: How aligned the behavior is with social norms.
- **Non-Routine**: Whether the action is familiar or part of the individual's habits.

To enhance ability, designers must lower the barriers associated with these factors. For instance, reducing the mental effort required to complete a task, such as through intuitive interfaces or guided instructions, can significantly increase the likelihood of behavior change. Smart Sparrow (Figure 45) serves as a compelling example of an adaptive learning platform that effectively integrates behavioral frameworks, such as Fogg's B=MAP and the TTM, to drive meaningful behavior change.

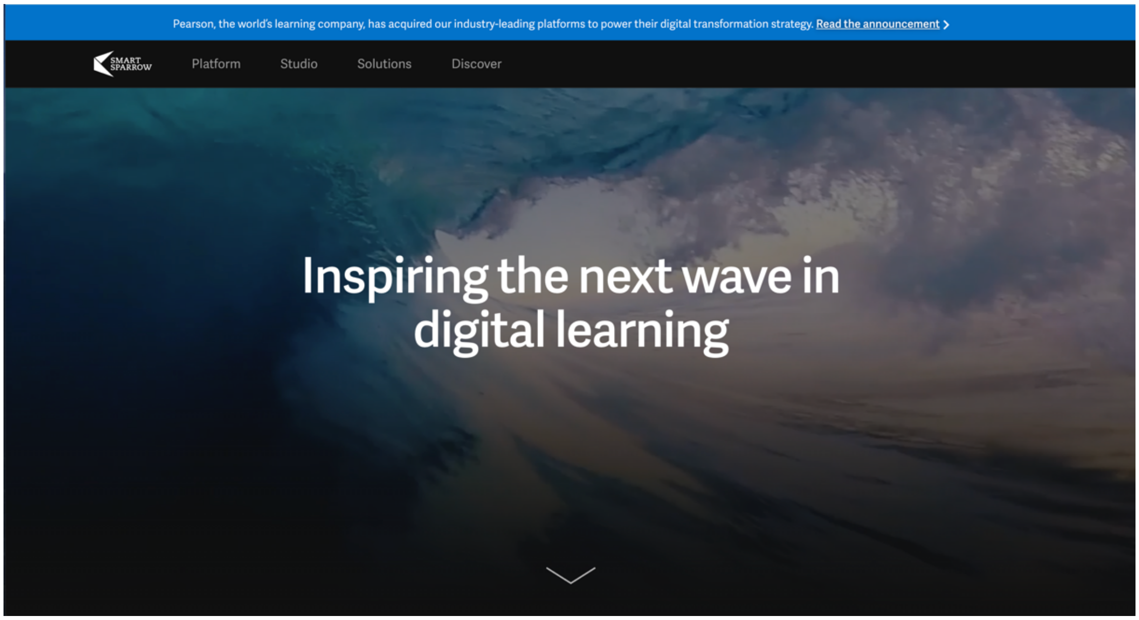


Figure 44: Screenshot of Smart Sparrow website.

For users in the pre-contemplation and contemplation stages, the platform uses emotional triggers and simple onboarding processes to build awareness and intent. For example, by showcasing performance metrics like "Struggling learners improve 20% faster with adaptive lessons," Smart Sparrow sparks curiosity among educators who may not yet recognize the need for tailored learning solutions. Additionally, it acts as a facilitator, providing intuitive templates and simplifying course design processes, thus lowering the ability barrier while maintaining motivation to adopt adaptive learning tools.

As users progress to the preparation and action stages, Smart Sparrow leverages timely signals and actionable prompts, such as notifications about improved student engagement when interactive simulations are added. These interventions ensure that users engage with the platform at the right moments, aligning with Fogg's principle of timely prompts. In the maintenance stage, Smart Sparrow sustains long-term engagement through personalized recommendations and dynamic feedback loops. For instance, by identifying specific areas where students are struggling and suggesting targeted tutorials, the platform adapts to the evolving goals of educators, maintaining relevance and motivation. This stage-specific approach exemplifies the critical role of personalized, adaptive systems in achieving behavior change, while also demonstrating how anticipatory design principles can meet users' diverse and evolving needs.

Prompts

Prompts are the triggers or cues that initiate behavior. Without a prompt, even highly motivated individuals with the ability to act may not perform the desired behavior (Figure 46). Fogg categorizes prompts into three types:

- **Sparks**: These are emotional triggers designed to create motivation. For example, a health app might use a motivational message to encourage users to complete their daily steps.
- **Facilitators**: Prompts make a behavior easier by addressing barriers to ability. A guided tutorial in a fitness app can simplify complex exercises, enhancing the user's ability to perform them.
- **Signals**: These are simple reminders or cues, such as notifications, that prompt users to take action.

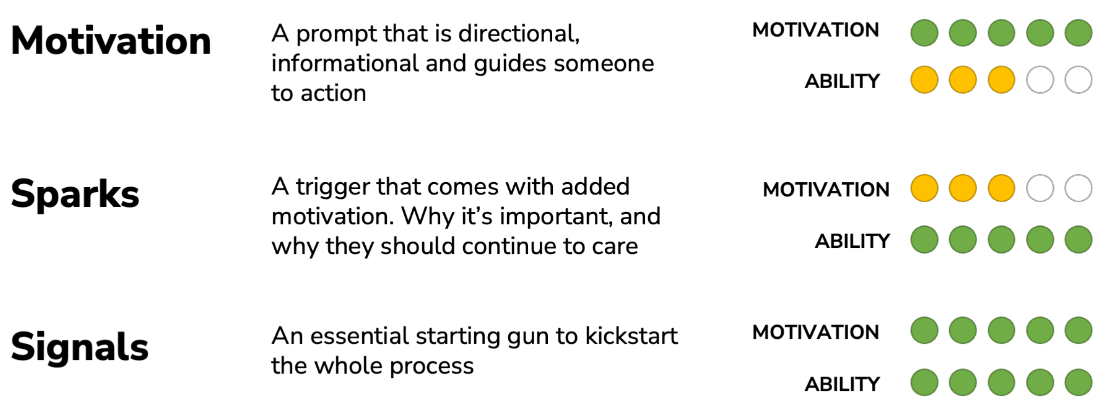


Figure 45: Motivation levels for prompts adapted from Fogg's (2009) behavior model.

This type of prompt has a high motivation level, but as you look at ability, you see that it is lower than motivation. The high level of motivation overcomes the lower ability level to trigger the user to buy or purchase a solution. But this can backfire because if the motivation is not strong enough, the user's confusion about the next steps or how to use the solution may not lead the user to convert. After all, they will be unsure if the user has the necessary ability to change their behavior. Because of that, this facilitator may require some education investment to convert the user. That's why it may involve some directional guidance that gives somebody a plan to follow. A spark, on the other hand, is a trigger that comes with added motivation. In this regard, this is something that tries to remind people of why certain things are important and why they should continue to care.

The relationship between these elements is dynamic and requires careful balancing. For instance, when motivation is high, a behavior can occur even if the ability is low. Conversely, when motivation diminishes, maximizing ability becomes essential to sustain behavior.

The B=MAP model provides a scientifically grounded and actionable framework for designing behavior change interventions. By focusing on the interplay between motivation, ability, and prompts, designers can create systems that effectively guide users toward desired behaviors.

4.7.1 Integrating Additional Frameworks for AI-Driven Solutions

Although frameworks like Fogg's B=MAP provide valuable insights, designing for AI-driven solutions requires more comprehensive approaches. Behavior changes in the age of AI demand integrating multiple frameworks to account for the complexities of human decision-making and the dynamic nature of technology.

As Fogg states, behavior is not merely a result of intrinsic willpower but a product of well-designed systems that align motivation, simplify ability, and deliver timely prompts. Therefore, we defend that to effectively design for behavior change and anticipatory design, in the age of AI, we should borrow from behavioral science two additional frameworks: the Transtheoretical Model (Prochaska and DiClemente 1983), also known as Stages of change, and the Nudge Theory (Thaler and Sunstein 2008). The first one represents a person's readiness to change, and the second one is their innovative approach to behavior influence. It advocates subtle interventions guiding individuals toward better choices without imposing restrictions. We should examine these complementary frameworks because AI amplifies behavior change processes by offering features like real-time feedback, personalization, and automated nudges.

4.7.1.1 Prochaska's Transtheoretical Model (TTM)

Complementing B=MAP with TTM provides a stage-based approach to understanding behavior change (Figure 47). TTM conceptualizes behavior change as a process involving progression through stages:

- Pre-Contemplation
- Contemplation
- Preparation
- Action
- Maintenance

Figure 46: Prochaska Transtheoretical Model (TTM), recognizes behavior change as a process that unfolds over time, involving progress through a series of stages.

A notable example of an AI anticipatory experience that failed to address the full spectrum of user stages is the case of Noom (Figure 48), a digital health app designed to support weight management and healthy living.

Figure 47: Representation of the Noon App service for weight loss.

While Noom's AI-driven platform excelled at targeting users already in the action stage—providing detailed, structured coaching and tracking tools—it struggled to engage users in earlier stages, such as pre-contemplation and contemplation. These users, who might not yet recognize the need for change or are still weighing their options, were often met with rigid, overly prescriptive recommendations that lacked the subtlety needed to build initial motivation or foster commitment.

The app's limited effectiveness extended to the maintenance stage as well. Its approach often lacked the adaptability required to support users in sustaining long-term behavioral changes. Instead of evolving alongside users' shifting goals and routines, it relied on generic coaching strategies that failed to account for individual progress or setbacks over time. As a result, many users reported disengagement after completing their initial goals, with limited support to prevent relapse or reinforce positive habits in the long term.

This case underscores the critical importance of designing behavior change systems that address users across all stages of the TTM framework. Interventions must be stage-appropriate—such as providing non-intrusive prompts for pre-contemplation, motivational messages for contemplation, and dynamic, adaptive coaching for maintenance. Designing for behavior change requires aligning nudges and interventions to users' stages, ensuring relevance and adaptability. By failing to do so, even the most sophisticated AI anticipatory systems risk losing their effectiveness and long-term user engagement.

4.7.1.2 Nudge Theory: Subtle Guidance Without Coercion

While frameworks like TTM and Fogg's B=MAP offer foundational principles for behavior change, their application in AI-driven design requires a nuanced understanding of how users transition through stages over time. Complementing B=MAP with TTM enables designers to map motivational and ability-related interventions onto a temporal framework that captures the fluid nature of behavior change.

However, the complexity of AI-driven solutions demands more than just these frameworks. The Noom case demonstrates how failing to address users in the pre-contemplation and contemplation stages results in disengagement and missed opportunities. To fully realize the potential of TTM, AI solutions must align with the psychological needs of users across all stages while leveraging advanced capabilities like real-time feedback, predictive analytics, and personalization.

That is why we also recommend integrating TTM with other behavioral science frameworks, such as Nudge Theory (Thaler and Sunstein 2008). Nudge Theory complements these frameworks by advocating for subtle, timely interventions that guide individuals toward better choices without imposing restrictions. Figure 49 includes these principles for effective nudges which includes:

- Aligning incentives with desired behaviors.
- Providing immediate feedback to reinforce actions.
- Simplifying choices for complex decisions.

- Making goals and progress visible through feedback loops.

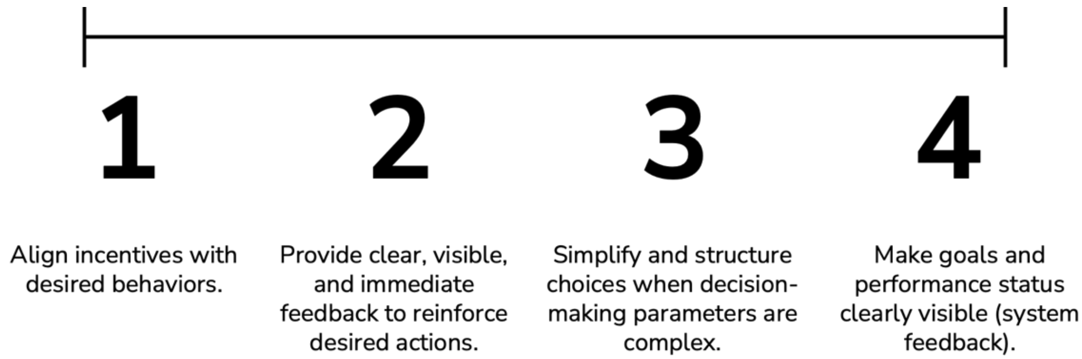


Figure 48: Representation of Nudge theory according to Thaler and Sunstein (2008).

These elements turn nudges into powerful tools to support behavior change and sustain motivation. Personalized nudges, rooted in data and attuned to the user's stage of change, increase the likelihood of sustained engagement and effective learning.

Consequently, anchoring these insights in robust ethical and user-centered design principles, we can craft AI-driven solutions that are not only effective but also responsible and empathetic to the complexities of human behavior, emphasizing how timely interventions can subtly guide users toward positive behaviors without coercion.

4.7.2 Designing Behavior Change with AI

To design impactful anticipatory experiences, there is a need for a more nuanced approach to anticipatory systems. By integrating B=MAP, TTM, and Nudge Theory behavior models we can address gaps such as early-stage engagement, long-term adaptability, and transparency, we can formulate a set of guiding principles for effective behavior change design:

- **Dynamic Adaptability:** Design systems that evolve with user behaviors, incorporating feedback loops and recalibration.
- **Stage-Specific Engagement:** Address pre-contemplation through exploratory prompts and maintenance through personalized, evolving strategies.
- **Transparency-Driven Trust:** Foster user confidence by making predictions explainable and actionable.

By leveraging these frameworks and principles, designers can create AI-driven solutions that are not only effective but also empathetic to the complexities of human behavior. Reflecting on the previous behavior frameworks, we may infer that there are 3 core principles of behavior change that we can use in design—User Agency, Personalization, and Timely Interventions (Figure 50).

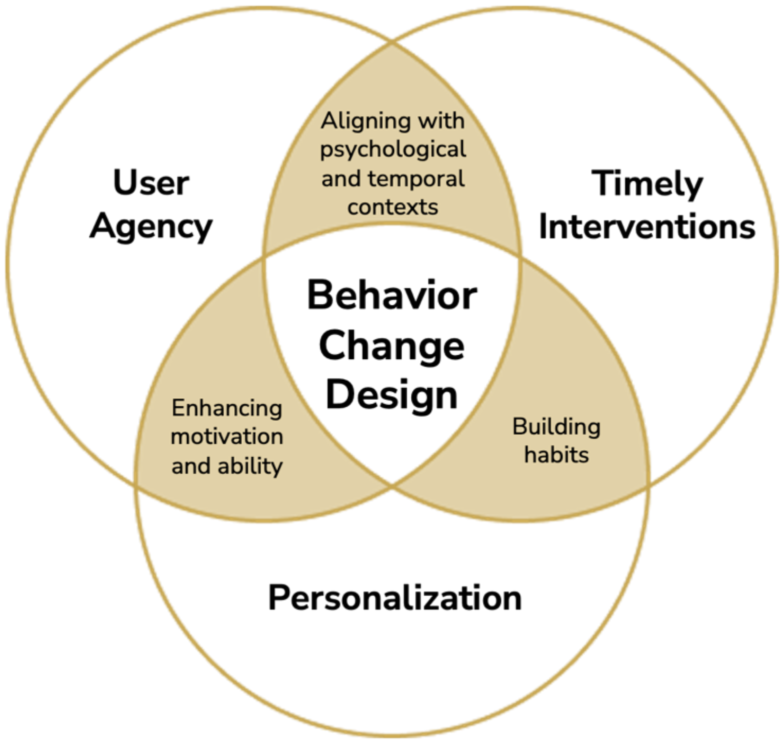


Figure 49: Integrating three behavioral science frameworks to design anticipatory experiences.

If we combine the previous frameworks, we now have an effective way to design successful anticipatory experiences that sustain behavior change:

- We need user agency to emphasize control and autonomy to foster control and trust.
- We need personalization to adapt to users' stages of change to align with their needs.
- And last, we need timely Interventions to guide users effectively, to guide decisions at the right moment.

When these 3 models overlap, we create systems that empower users, adapt to their needs, and guide them toward long-term results.

4.7.2.1 User Agency in Anticipatory Design

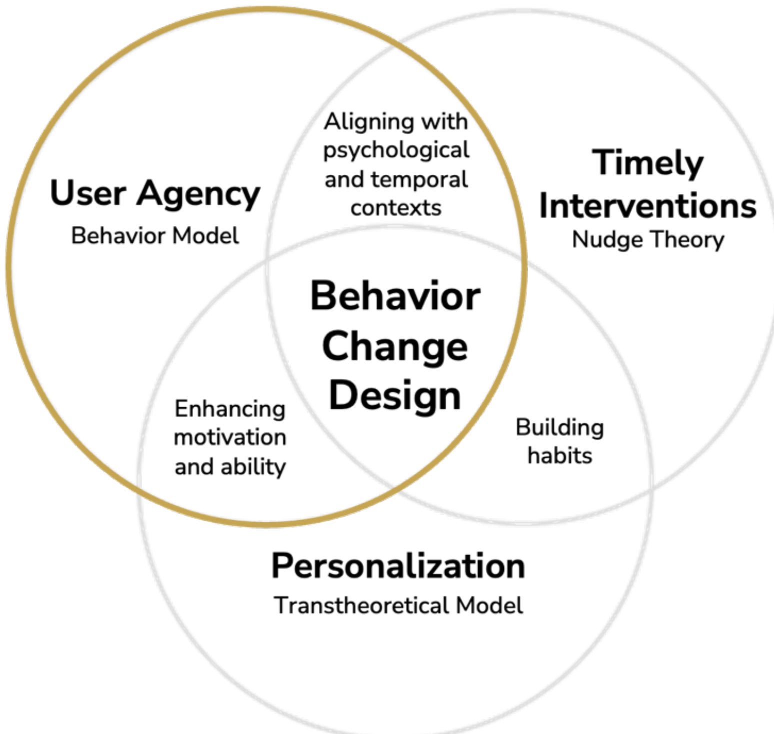


Figure 50: Highlight of user agency in behaviors science framework.

The first principle, user agency (Figure 51), is based on Fogg's (2009) Behavior Model, which suggests that behavior is a function of three factors: motivation, ability, and triggers. A key insight from Fogg's work is that users must feel they have control over their actions. When users perceive a system as coercive or manipulative, they are less likely to engage effectively. Empowering users to make decisions—even when nudged in a particular direction—maintains their autonomy while guiding them toward better choices. Behavior change is most effective when people feel they are in control, which is essential for fostering long-term engagement and building trust in the system.

In anticipatory design, systems are designed to predict and preemptively respond to user needs. However, user agency remains crucial to avoid over-promising and under-delivering, as well as the risk of losing control. Therefore, we should always design conditions and system mechanisms to:

Give users control over predictions and actions

The author describes motivation and ability as the key elements to whether users engage with a system or not. Thus, it's essential to provide users with choice and flexibility over how their needs are predicted and addressed (Fogg 2009). Even if the system is designed to predict their behavior, users should always have an override or a means to customize their preferences. This empowers users to feel in control, mitigating any potential sense of coercion or manipulation.

Provide Options for Customization and Transparency

While anticipatory design anticipates user actions, Fogg's model stresses that users need to understand and adjust the predictions made by a system. Transparency is key—users should know why certain actions are being suggested (transparency and explainability) and provide them with the power to adjust those predictions. For example, a health or learning app needs to explain why certain reminders or lessons are being pushed based on data analysis (e.g., "We noticed you tend to study best after lunch, so we’ve suggested a review session around 1 PM.")

Avoid Over-Reliance on AI Decisions

While anticipatory design relies on AI predictions, it must also empower users to control those predictions. Giving users the option to adjust or cancel predictions ensures they remain in control, preventing frustration and fostering trust. For instance, in a smart home system that anticipates the user's ideal room temperature, the system can offer a recommendation, but it must provide a clear option to override or adjust settings based on the user's current preferences or comfort level. Anticipatory design must ensure that predictions or recommendations do not become overbearing or paternalistic. Users should always feel that they can cancel or refine the system’s predictions to fit their needs.

Providing Active Feedback on Predictions and Results

Fogg’s model also points to the importance of feedback loops that help users feel they are in control of the change process. In anticipatory design, feedback mechanisms should reinforce user agency by showing how the system is adapting to their preferences, and by offering meaningful choices at each stage. For example, a time-management tool might suggest a schedule based on the user's productivity patterns and ask, “Does this schedule work for you?” This allows users to accept, decline, or modify the suggestion.

4.7.2.2 Personalization in Anticipatory Design

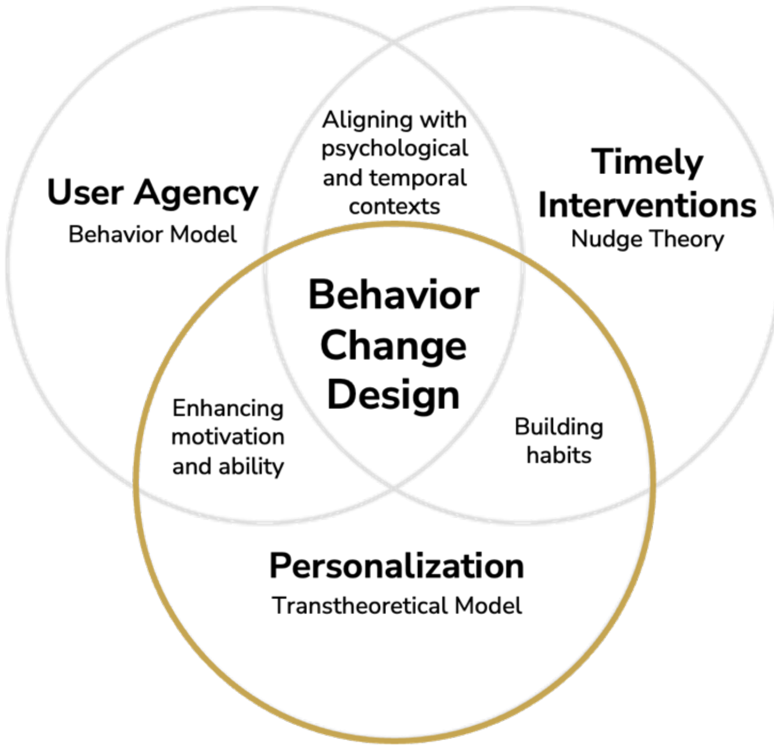


Figure 51: Highlight of personalization in behaviors science framework.

The second principle, personalization (Figure 52), aligns with the Transtheoretical Model (Prochaska and DiClemente 1983), which emphasizes that behavior is not static—individuals progress through different stages when adopting new behaviors. Personalized interventions that align with a user's specific stage of change are significantly more effective than generic, one-size-fits-all approaches.

Personalized interventions increase the likelihood of behavior change by aligning with the user's current needs and goals. This aligns with the Transtheoretical Model, which emphasizes the importance of stage-specific interventions. An anticipatory learning app could recommend short, engaging lessons for a user in the preparation stage while suggesting in-depth projects for a user in the maintenance stage.

Personalization lies at the heart of anticipatory design, as it adapts interventions to align with each user's unique needs and context. By accounting for individual preferences, personalization ensures that suggestions remain both relevant and actionable. Without this tailored approach, systems risk appearing generic and intrusive, ultimately diminishing their effectiveness and user engagement.

For example, a learning app that dynamically adjusts its difficulty level based on the user's proficiency delivers a personalized experience that maximizes engagement and long-term success.

Aligning Predictions with User Context

Anticipatory design thrives on accurate predictions of user needs, but these predictions are only valuable if they consider the user's unique circumstances. Personalization, as outlined in Prochaska and DiClemente's Transtheoretical Model, ensures that interventions align with the user's specific stage of change and readiness to act. For instance, a fitness app might predict that a user would benefit from morning exercise. Personalization refines this prediction by factoring in the user's recent behavior and context—such as extended inactivity during the day. Instead of broadly suggesting a morning workout, it might recommend targeted stretches to alleviate lower back discomfort caused by prolonged sitting. This tailored approach makes predictions both relevant and actionable.

Personalization Provides Gradual Learning and Adjustments

Behavioral change takes time, and Prochaska's Transtheoretical Model emphasizes the importance of gradual progress. Anticipatory design systems must allow users to adjust the influence of the system incrementally. For example, a budgeting app could begin by providing a general overview of spending and gradually increase the specificity of notifications or alerts, giving users control over how much intervention they want to help maintain agency and trust.

Avoiding One-Size-Fits-All Frustration

Without personalization, anticipatory systems can frustrate users by offering irrelevant recommendations. Personalization ensures that interventions are adapted to individual preferences, making them more relevant and engaging. For example, a meal-planning app might personalize recipes to align with dietary restrictions and goals, such as vegetarian options or high-protein diets. By making predictions more aligned with user needs, personalization transforms the system from a one-size-fits-all solution to an engaging, trusted partner.

Allow for Personalization and Adjustments to Nudges

Nudges should be adaptive, enabling users to fine-tune how and when they receive reminders or prompts. This customization ensures that nudges don't become intrusive or overwhelming. For example, a fitness app might allow users to adjust the frequency and timing of exercise reminders to suit their preferences, maintaining user agency while guiding them toward healthier habits.

4.7.2.3 Timely Interventions in Anticipatory Design

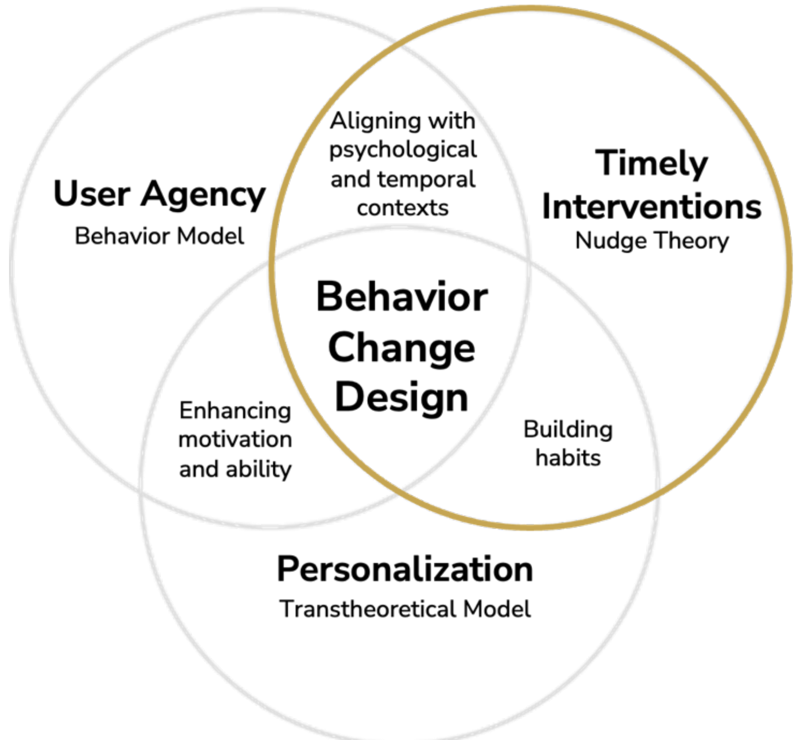


Figure 52: Highlight of timely interventions in behaviors science framework.

Finally, when designing anticipatory experiences, it is essential to consider the principle of timely interventions (Figure 53), drawing on Thaler and Susteins's (2008) Nudge Theory. This concept emphasizes delivering interventions at precisely the right moment to encourage positive behavior without coercion. Timely nudges significantly enhance the likelihood of achieving desired behaviors by targeting moments when users are most receptive. For instance, sending well-timed reminders to save money or take the stairs can subtly guide individuals toward healthier or more beneficial choices, making the experience both seamless and effective.

Nudging is especially important for anticipatory design because timely, context-aware interventions are at the heart of what makes anticipatory systems effective and user-centric. Anticipatory design relies on predicting user needs and acting preemptively, but without nudges that are well-timed and subtle, these predictions can feel intrusive or irrelevant.

Nudges Bridge the Gap Between Prediction and Action

In anticipatory design, the system aims to predict what users need and guide them to act without overwhelming or frustrating them. A nudge, delivered subtly and at the right time, ensures that users engage and trust the suggestion. For example, a smart thermostat that predicts temperature preferences but doesn't remind users about energy savings might underuse its predictive capability. A nudge—like a friendly prompt saying, "Lowering your thermostat by 2 degrees saves $15 this month!"—turns the prediction into a more meaningful action.

Nudges Ensures Predictions Are Contextually Relevant

Timing and context are everything in anticipatory design. Nudges that are sent at the wrong time or lack relevance can make users feel misunderstood or annoyed. Imagine a grocery app that anticipates you need milk and adds it to your cart—but you just bought milk yesterday. A nudge that confirms its reasoning (e.g., "Based on your usual patterns, you'll run out in 2 days—shall we add it?") validates the prediction and ensures users remain engaged.

Nudges Allow for Personalization and Adjustments to Prompts

Nudges should be adaptive, enabling users to fine-tune how and when they receive reminders or prompts. This customization ensures that nudges don't become intrusive or overwhelming. For example, a fitness app might allow users to adjust the frequency and timing of exercise reminders to suit their preferences, maintaining user agency while guiding them toward healthier habits.

Nudges Respect User Autonomy While Guiding Decisions

In anticipatory design, users might feel that automated decisions reduce their control. Nudges help systems avoid this pitfall by offering suggestions instead of mandates and empowering users to make the final choice. For example, a calendar app that auto-schedules all your meetings could feel overbearing. However, a nudge— "Would you like me to book a 15-minute buffer before your next meeting?"—preserves user autonomy while still providing anticipatory assistance.

Nudges Mitigates the Risks of Over-Prediction

Anticipatory systems are not perfect and may occasionally misinterpret user needs. Nudges serve as checkpoints, allowing users to verify or adjust predictions. For example, a health app predicting hydration needs after a run can prompt: "Did you complete your run? If not, we'll adjust your reminder," offering flexibility without diminishing trust.

Nudges Reduce Cognitive Load Without Over-Automating

A hallmark of anticipatory design is reducing decision fatigue. Nudges help achieve this by providing just enough guidance without taking over the decision entirely. A budgeting app that nudges users with “Here’s where you could save $50 this month—tap to apply!” simplifies decisions without overwhelming the user with unnecessary options or steps.

Nudges are essential in anticipatory design because they bridge the gap between the system’s predictions and the user’s actions, ensuring that interventions are timely, contextually relevant, and respectful of user autonomy. By leveraging nudges effectively, anticipatory systems can guide users toward better outcomes without being overbearing, intrusive, or diminishing trust. This aligns perfectly with the principles of behavior change design—user agency, personalization, and timely interventions—while making anticipatory design more intuitive and human-centered.

4.7.3 Critiques and Opportunities in Behavior Change Design

While behavior change frameworks such as Fogg’s Behavior Model (2009) and Prochaska’s Transtheoretical Model (1983) provide a robust foundation, their application in AI-driven anticipatory systems often highlights significant challenges. A key issue is the limited capacity of many systems to sustain user engagement across the entire behavioral change journey, particularly in the critical stages of habit formation.

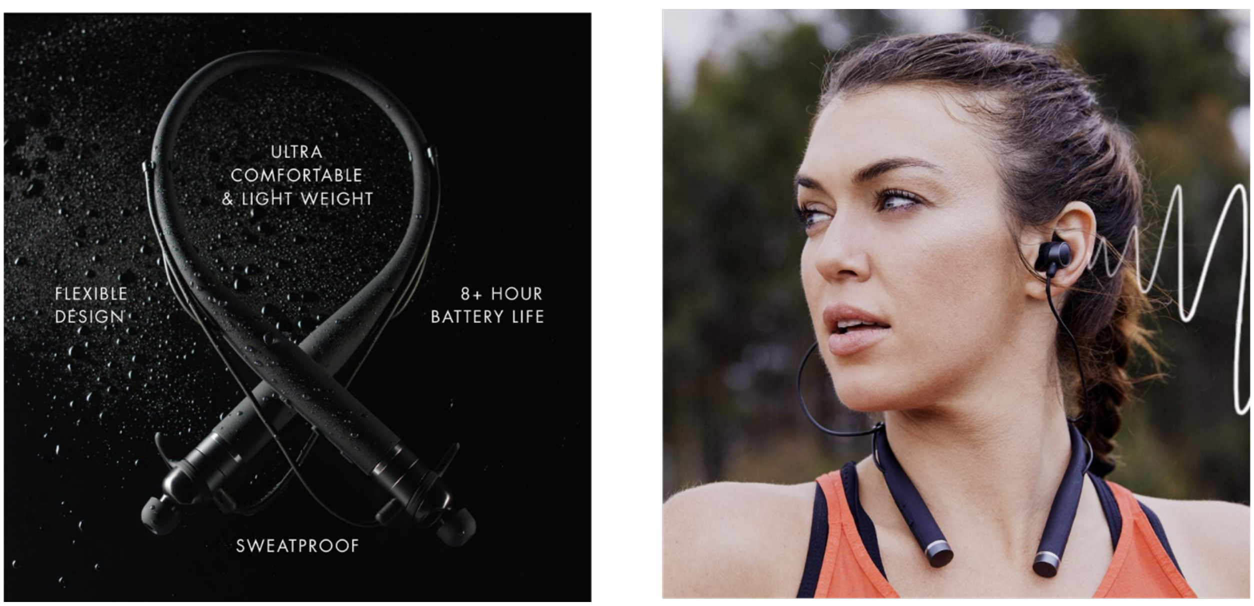


Figure 53: Representation of Vi Sense headphones.

Vi Sense (Figure 54) was marketed as the first AI-powered headphones promising to revolutionize fitness coaching. Imagine a personal trainer in your ears, offering real-time guidance, encouragement, and coaching every step of the way. Launched in June of 2016[11], Vi Sense promised more than just fitness tracking—it aimed to create personalized fitness journeys with a conversational AI that felt more like a friend than a machine. But despite its ambitious vision, Vi Sense struggled to meet users' expectations.

Although marketed as a real-time AI coach, Vi Sense’s inflexible system only worked for running outdoors, excluding other activities like cycling or indoor workouts. Despite its innovative features, this solution felt rigid and overly tailored to beginner runners. With just six predefined goals, advanced runners felt constrained and underserved. Moreover, Vi failed to anticipate user performance or adapt to changing conditions, undermining its promise of personalized, adaptive coaching. This formed a gap between the promise of truly adaptive, real-time AI coaching and the reality of its limited and inflexible functionality. This left many users frustrated and ultimately disengaged.

The system succeeded in attracting users who were already motivated to engage in fitness activities—those in the action stage of Prochaska’s Transtheoretical Model. However, Vi Sense fell short in supporting users during the pre-contemplation and contemplation stages, where building awareness and initial motivation is critical. Without low-pressure, curiosity-driven prompts or exploratory tools to make users consider their fitness goals, many potential users disengage early in the journey.

Furthermore, the importance of habit formation—research shows it takes approximately 21 days on average to form a habit (Lally et al. 2010)—Vi Sense failed to have a 21-day strategic plan for their users. For a habit to become automatic, regular reinforcement through dynamic, timely, and context-sensitive interventions is crucial. Vi Sense’s coaching model provided rigid, generic feedback that failed to adapt to users' unique progress and setbacks during these critical habit-forming periods. This inability to recalibrate interventions not only limited their effectiveness but also led to a high rate of user dissatisfaction.

From our perspective, to overcome such limitations, systems must prioritize dynamic adaptability. This involves designing feedback loops that integrate user progress and recalibrate suggestions as habits form or regress. For example, during the habit-forming window (Lally et al. 2010), Vi Sense could have utilized its predictive capabilities to send timely nudges that align with user routines, like suggesting a quick workout based on past activity patterns and real-time weather

[11] https://en.wikipedia.org/wiki/LifeBEAM#Vi

data or sleep cycles. This would ensure interventions remain relevant, actionable, and supportive of sustained engagement.

Another critical factor is transparency and trust, which are foundational to maintaining user engagement in anticipatory systems. Habit formation is a complex psychological process, and users need to understand why certain recommendations are made and how they align with their long-term goals (Abdul et al. 2018). For instance, Vi Sense could have explicitly communicated how small, consistent actions contribute to the larger goal of habit formation over 20 days. This would empower users to see progress while fostering trust in the system's guidance.

Vi Sense’s failure to address these nuances demonstrates the necessity of stage-specific and adaptive interventions. Therefore, we argue that by integrating habit-formation insights, user feedback loops, and transparent communication, anticipatory systems can provide users with the tools and motivation needed to navigate the complexities of behavioral change. Designing for these principles ensures that systems not only initiate behavior change but also sustain it, fostering long-term user satisfaction and success.

5 Scoping Review

5.1 Introduction

Anticipatory design, a critical facet of user-centered AI systems, focuses on creating proactive solutions that predict, and address user needs before they arise. This scoping review systematically maps existing knowledge on anticipatory design to identify trends, challenges, and opportunities across industries. The review synthesizes evidence from diverse sources to bridge the gap between theoretical frameworks and real-world applications, establishing a foundation for ethical, inclusive, and effective anticipatory systems.

To achieve methodological rigor and transparency, the review employs the PRISMA-ScR framework (Tricco et al. 2018), building on established guidelines for scoping reviews (Levac et al. 2010). This approach ensures the systematic identification, screening, and inclusion of relevant studies and applications. The PRISMA-ScR checklist (APPENDIX 1) guided every step of the review process, from formulating inclusion and exclusion criteria to charting the data and synthesizing thematic insights. The inclusion of a PRISMA-ScR flow diagram provides a visual representation of the selection process, reinforcing the transparency of this analysis.

In addition, the scoping review leverages the PICo framework (Aromataris and Munn 2017), introduced in Chapter 1, to structure its focus:

- **Population (P):** Users and stakeholders interacting with anticipatory systems across six frontrunner industries—education, healthcare, finance, retail, transportation, and entertainment.
- **Interest (I):** Core dimensions of anticipatory systems, including data types, focus of analysis, outcomes, opportunities, pitfalls, and potential improvements.
- **Context (Co):** Real-world environments where anticipatory systems operate, encompassing physical, digital, and hybrid spaces.

Through this structured approach, the chapter systematically addresses the research objectives outlined in Chapter 1, including the identification of design principles, user engagement strategies, and gaps in existing implementations. Specifically, this chapter addresses the following research questions:

- What are the key trends in anticipatory design across industries?

- How do anticipatory systems leverage forecasting and backcasting methodologies to design effective user experiences?
- What challenges and opportunities exist in implementing anticipatory systems?

By mapping patterns and identifying emerging themes, this chapter contributes to the overarching aim of developing a human-centered AI framework for anticipatory systems. This review complements the framework proposal discussed in Chapter 1, focusing on how anticipatory systems integrate forward- and backward-looking methods to align with user needs and system goals. Insights from this review also complement the behavioral theories discussed in Chapter 2, providing actionable strategies and paving the way for the design and evaluation efforts detailed in subsequent chapters (Fogg 2009; Thaler and Sunstein 2008).

The structure of this chapter progresses systematically:

- **Methodology** – Detailing the data collection, inclusion criteria, and thematic analysis guided by PRISMA-ScR and PICo frameworks.
- **Findings and Synthesis** – Presenting trends, challenges, and opportunities identified across the six industries analyzed.
- **Implications** – Discuss the broader relevance of these insights for advancing anticipatory design practices.

By combining methodological rigor with a focus on real-world applications, this chapter lays the groundwork for bridging theoretical constructs with practical innovations in anticipatory systems design. In doing so, it provides a systematic, evidence-based foundation for advancing the discourse on user-centered AI design within the anticipatory systems field.

Consequently, the PICo framework guides this scoping review. However, rather than reiterating the framework, this chapter operationalizes its components—Population, Interest, and Context—by integrating them into the review's structure and analysis. Here, "Population" refers to users and stakeholders of anticipatory systems across sectors, including education, healthcare, finance, and e-commerce. The "Interest" encompasses key dimensions of anticipatory systems, such as personalization, trust, and ethical considerations. "Context" focuses on real-world environments where these systems are deployed, spanning physical, digital, and hybrid spaces.

By integrating the PICo and PRISMA-ScR frameworks, this chapter establishes a rigorous foundation for understanding and advancing anticipatory design practices. The insights serve as a bridge between theoretical frameworks and practical applications, contributing to the broader discourse on user-centered AI design.

5.1.1 Methodology

This study employed a scoping review methodology to analyze anticipatory experiences across six frontrunner industries: education, healthcare, finance, retail, transportation, and entertainment. These sectors were selected due to their advanced adoption of anticipatory design principles, offering a rich landscape for comparative analysis. The research aimed to identify commonalities and distinctions among these industries concerning the data type utilized, focus of analysis, achieved outcomes, identified opportunities, pitfalls encountered, and areas for improvement.

The scoping review adhered to the PRISMA-ScR framework (Tricco et al. 2018; Aromataris and Munn 2017) to ensure transparency, rigor, and methodological consistency, following the staged process first established in scoping reviews (Levac et al. 2010)**.** The process involved six systematic steps, which are addressed in detail in the following subsections:

1. **Eligibility Assessment**: Sources were assessed against inclusion criteria based on the PICo framework (Aromataris and Munn 2017) to ensure relevance and rigor (see 5.1.1.1 Inclusion Criteria and PICo Framework).
2. **Identification and Screening**: Relevant sources were systematically identified and screened for eligibility through comprehensive data collection strategies (see 5.1.1.2 Data Collection and Search Strategy).
3. **Data Extraction**: Key information was systematically extracted and categorized for analysis, focusing on core dimensions like forecasting and backcasting approaches, outcomes, opportunities, pitfalls, and potential improvements (see 5.1.1.3 Data Extraction).
4. **Thematic Synthesis**: Extracted data were coded and analyzed to identify patterns, trends, and cross-industry comparisons (Tricco et al. 2018) (see 5.1.1.4 Thematic Synthesis).
5. **Reporting and Flow Diagram**: A PRISMA-ScR flow diagram visually represents the selection and screening process, underscoring methodological transparency and rigor (see 5.1.1.5 Findings and Relevance).

5.1.1.1 Inclusion Criteria and PICo Framework

The review integrated the PICo framework to define inclusion criteria:

- **Population (P):** Anticipatory systems deployed within identified industries, such as healthcare, education, transportation, retail, entertainment, and finance.
- **Interest (I):** Dimensions such as data types, the focus of analysis, outcomes, opportunities, pitfalls, and improvements in anticipatory design.

- **Context (Co):** Real-world implementations, emphasizing user interactions and system impacts in dynamic, industry-specific settings.

These criteria ensured that the review captured a diverse and representative sample of anticipatory systems across varying contexts.

5.1.1.2 Data Collection and search strategy

To comprehensively capture diverse perspectives and implementations of anticipatory systems, the search strategy encompassed both formal and informal data sources. This multi-faceted approach was necessary to ensure a robust and comprehensive dataset of anticipatory experiences, given the limited availability of formal academic research specifically addressing anticipatory design.

Searches conducted across platforms, including Google Scholar, ResearchGate, PubMed, IEEE Xplore, and others, between 2005 and 2024, using terms such as *'anticipatory design,' 'anticipatory systems in design,'* and *'proactive user experiences,'* yielded fewer than a dozen papers directly addressing anticipatory design. The majority of results were tangential, focusing on predictive modeling or user-centered AI without delving into the intricacies of market-specific applications of anticipatory systems. Much of the existing literature remained theoretical or about speculative design related to future studies, rather than examining practical applications or real-world implementations.

This revealed a significant gap: no dedicated studies or comprehensive academic investigations into the core principles or applications of anticipatory design were readily available. This absence of formal studies constrained the collection of formal academic sources, compelling this research to draw heavily on alternative, informal sources. These informal avenues—spanning real-world case studies, user reviews, and online forums—proved invaluable for uncovering practical insights into the strengths, limitations, and user experiences of anticipatory systems.

To address this gap and ensure a well-rounded analysis, the data collection process incorporated both formal and informal sources, as outlined below:

1) **Formal Sources**
    - Peer-reviewed journals, conference proceedings, industry white papers, and market research reports.
2) **Informal Sources**

- Reddit discussions: Subreddits focusing on technology, user experience, and specific industries were analyzed for user feedback and community discussions about anticipatory systems.
- YouTube reviews: Videos showcasing user interactions with anticipatory systems were studied to understand real-world applications and user sentiments.
- Online forums: Specialized forums provided insights into industry-specific challenges and user pain points.
- Product review websites: Platforms like Trustpilot and G2 were used to extract user feedback on the strengths and limitations of anticipatory services.

These informal sources provided critical, real-world perspectives on the usability, acceptance, and limitations of anticipatory systems. By incorporating user-generated content, the analysis captured practical nuances often overlooked in formal studies.

To ensure the inclusion of only relevant and high-quality sources, this scoping review employed tailored inclusion criteria. These criteria, specific to this study's context, are outlined in Table 7.

Table 7: Inclusion criteria for this scoping review.

Inclusion Criteria	Description
Relevance to Anticipatory Systems	a) Studies, reports, or discussions explicitly addressing anticipatory systems, their design principles, applications, or user interactions. b) Research focused on anticipatory design in the identified six industries (education, healthcare, finance, retail, transportation, and entertainment).
Alignment with Research Goals	Sources discussing dimensions of anticipatory systems such as data type, focus analysis (forecasting/backcasting), outcomes, opportunities, pitfalls, and improvements.
Date of Publication	Published within the last 10 years to ensure up-to-date insights, unless the source is a foundational or highly cited work in the field.
Language	Only English-language sources to maintain consistency in interpretation and analysis.
Types of Sources	a) Peer-reviewed articles, conference proceedings, industry white papers, and case studies. b) Informal sources like forums (e.g., Reddit), YouTube reviews, and product review websites, provided they offer unique user-centered perspectives.
Focus on Anticipatory Technology	Examples featuring AI-driven systems, personalized experiences, and decision-support tools explicitly designed to anticipate user needs.

Thematic Dimensions	Sources that address ethical considerations, user trust, explainability, or other critical themes tied to anticipatory systems.

5.1.1.3 Data Analysis

This section details the methodology employed to assess how various industries are leveraging anticipatory experiences, along with their associated challenges and opportunities. For each service analyzed, a consistent but multifaceted approach was adopted to gain a holistic understanding of its anticipatory experience (Table 8). The analysis centered on the following dimensions, extracted and categorized across the six industries:

Table 8: Variables assessed in each service.

Variable	Goal
Data Type	To predict the effectiveness and potential limitations of an anticipatory service, we start the analysis by meticulous understanding what type of data each services uses. Understanding the data foundation was crucial, as it directly impacts the quality of the service's outcomes.
Focus Analysis	We further analyzed the system's focus, determining whether it primarily relied on forecasting future events (forecast-driven), analyzing past events to inform predictions (backcast-driven), or employed a combination of both approaches.
Outcomes	We evaluate the core outcomes delivered by the anticipatory experience to the users. This analysis sheds light on the value proposition and user and social impact of the service.
Opportunities	By analyzing the service's outcomes, we identified opportunities to enhance the experience and optimize the anticipatory features. These insights can be used to refine existing services and inform the development of user interactions for our proposed framework.
Pitfalls	We identified potential pitfalls and challenges associated with the service's anticipatory experience. We loop up for limitations in data accuracy, ethical considerations, or user trust issues. Understanding these challenges was imperative to gather insights on problems to be addressed in the ADR Study 2.
Improvements	Finally, for each identified pitfall, we mapped potential solutions or mitigation strategies employed by the service. This analysis provides valuable insights into best practices for addressing common challenges in anticipatory design.

5.1.1.4 Thematic Synthesis

The data was analyzed using a thematic synthesis approach to uncover patterns and insights. Key steps included:

1) **Data Extraction:** Information relevant to each thematic dimension was systematically extracted from selected sources.
2) **Coding:** Data was coded into categories aligned with the six thematic dimensions.
3) **Cross-Source Validation:** Comparing findings from formal and informal sources to validate trends and uncover new insights.
4) **Cross-Industry Comparison:** Comparative analysis was performed to identify commonalities and unique characteristics among the six industries.

5.1.1.5 Findings and Relevance

This methodology enabled the identification of best practices and persistent challenges in designing anticipatory experiences. The analysis provided actionable insights into how different industries are driving or failing to utilize anticipatory systems to enhance user experiences while addressing domain-specific constraints.

By focusing on these aspects, this chapter establishes a foundation for understanding the broader implications of anticipatory design, highlighting opportunities for innovation and areas requiring ethical and practical considerations. In the end, the scoping review findings provide actionable insights into anticipatory systems' design and implementation. Key takeaways include:

- **Data Usage:** Understanding the foundational role of data in predicting user needs and optimizing system performance.
- **User-Centered Outcomes:** Strategies for aligning system goals with user expectations to enhance satisfaction and trust.
- **Ethical Considerations:** Addressing challenges in data privacy, bias, and transparency to build responsible AI systems.
- **Opportunities and Pitfalls:** Leveraging identified opportunities while mitigating challenges to improve anticipatory experiences.

5.1.2 PRISMA-ScR Flow Diagram Analysis

The PRISMA-ScR flow diagram (Figure 56) visually represents the selection and screening process of products and services, providing a transparent account of how data were identified, evaluated, and included in the scoping review (Tricco et al. 2018; Levac et al. 2010).

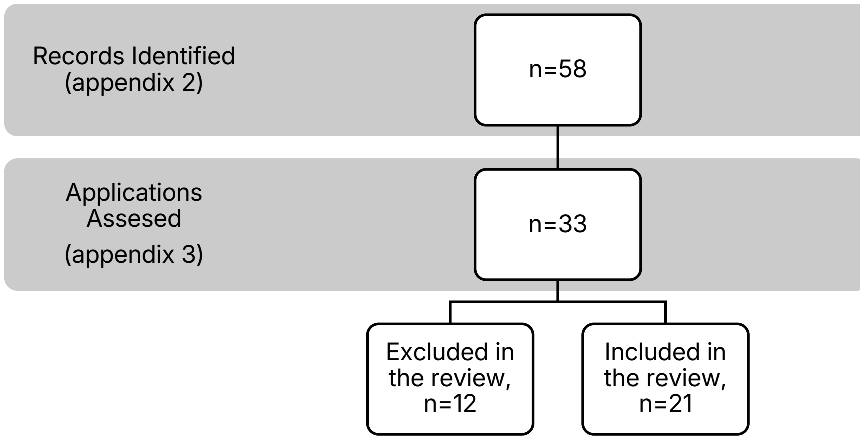


Figure 54: PRISMA-ScR Flow Diagram.

This process included the following steps:

- **Identification**: A total of 58 products and services were identified through formal and informal sources, including academic databases, but mostly from user-generated platforms.
- **Screening**: Of these, 33 products and services were screened for eligibility based on titles and abstracts.
- **Eligibility**: We excluded 12 that did not meet the defined criteria.
- **Inclusion**: Finally, 21 products and services were included in the review, forming the foundation for thematic synthesis and analysis.

5.1.2.1 Key Insights from the Flow Diagram

The flow diagram highlights the breadth of data sources explored, ensuring a comprehensive understanding of anticipatory systems across industries, consistent with best practices for scoping reviews (Aromataris and Munn 2017). The rigorous screening process reduced bias and maintained a focus on high-quality, relevant studies, while the iterative refinement of inclusion criteria reflects the dynamic and evolving scope of anticipatory systems research (Levac et al. 2010). By visualizing the process, the flow diagram underscores methodological transparency and rigor, ensuring that the findings are robust, actionable, and well-positioned to inform the development of a human-centered anticipatory design framework.

5.1.3 Findings: Current Landscape of Anticipatory Experiences

5.1.3.1 Overview of Key Industries and Applications

This scoping review analyzed anticipatory experiences across six key industries—finance, education, transportation, hospitality and travel, healthcare, and retail—chosen for their advanced adoption and implementation of anticipatory systems. These industries were selected to capture both diversity and maturity in implementation, reflecting guidance to ensure breadth in scoping review design (Tricco et al. 2018). They represent diverse applications of anticipatory design, ranging from personalized learning and predictive healthcare to automated financial advice and intelligent transportation solutions (Table 9).

Table 9: Six frontrunners' industries in the adoption of anticipatory experiences.

Industry	Service provided
Finance	Financial institutions have been utilizing anticipatory experiences to improve customer satisfaction and streamline processes. This includes features like personalized financial advice, automated budgeting and savings suggestions, fraud detection, and proactive customer support for financial transactions.
Education	The education industry is actively exploring the integration of anticipatory experiences to personalize learning, anticipate student needs, and provide tailored educational support for better outcomes.
Transportation	The transportation industry has adopted anticipatory technologies to enhance safety, efficiency, and convenience. This includes predictive traffic management, real-time route optimization, proactive maintenance of vehicles, and smart public transit systems that adapt to user demands.
Hospitality and Travel	The hospitality and travel sectors use anticipatory experiences to enhance customer satisfaction by offering personalized trip planning, dynamic pricing, proactive itinerary adjustments based on disruptions, and tailored recommendations for accommodations and experiences.
Healthcare	The healthcare industry has started embracing anticipatory experiences to provide proactive and personalized care. This includes technologies like remote patient monitoring, predictive analytics for disease prevention, smart health devices that provide real-time feedback, and personalized health recommendations.
Retail	Companies in the retail sectors have leveraged data analytics and machine learning to anticipate customer preferences and needs. They use techniques like personalized recommendations, predictive inventory management, and proactive customer service to enhance the shopping experience.

Across these industries, anticipatory systems aim to enhance user experiences by anticipating needs, reducing friction, and fostering proactive engagement. However, consistent with prior observations in foresight and anticipation studies (Poli 2017; 2019), the extent of adoption and success varies, with some sectors demonstrating more mature applications than others.

5.1.3.2 Specific Use Cases and Their Impact

In each industry identified in Table 9, we were able to identify 3 to 4 services to be analyzed, each showcasing unique applications of anticipatory experiences. While some have achieved significant market success, others are still in the early stages, indicating a market ripe for innovation and growth. These findings reflect broader patterns observed in behavioral design and responsible AI practices, where user trust, transparency, and contextual adaptation remain decisive factors in adoption (Shneiderman 2020; Beer et al. 2014).

Table 10 highlights specific companies and services analyzed within these industries, providing detailed examples of how anticipatory experiences are designed and implemented.

Table 10: List of companies and services analyzed.

Company	Service Description	Year Created
Finance		
Mint	Mint is a financial management tool that uses anticipatory design to help users track their personal finances, and budgets, and manage their financial accounts. Mint.com, a product of Intuit, operates by aggregating financial data from various sources to provide users with a comprehensive view of their financial situation. It categorizes and tracks expenses, income, and transactions across multiple bank accounts, credit cards, loans, and investment accounts. It can anticipate upcoming bills and expenses and provide personalized financial advice based on the user's spending habits and patterns.	2006
Betterment	Betterment is a robot-advisor platform that uses automation design to manage investments on behalf of users. Betterment uses algorithms to make investment decisions based on the user's risk tolerance, investment goals, and market trends. It uses a combination of user-provided data and financial market data to provide a personalized investing experience. Users do not need to make investment decisions themselves, as Betterment automates the process for them.	2008
Oportun	Oportun, formerly Digit, is a financial management app that uses anticipatory design to automate savings for users. It analyzes their spending habits and income to determine how much they can afford to save and automatically transfers the money to a savings account.	2015 (as Digit)
Wealthfront	Wealthfront is a robot-advisor platform that uses anticipatory design to automate investment management and financial planning. It uses algorithms and machine learning to analyze user data and make personalized investment	2011

	recommendations based on factors such as risk tolerance, time horizon, and financial goals. This system uses a combination of quantitative and user-provided data to provide anticipatory financial services to its users. Wealthfront also offers additional features such as a high-yield cash account and a stock-level tax-loss harvesting service to optimize returns and minimize taxes. The goal is to provide users with a tailored and proactive approach to managing their finances and investments.	
Education		
Dreambox Learning	Dreambox Learning is a math learning platform for students that uses anticipatory design to adapt to each student's learning style and pace. The platform uses AI to predict which concepts the student is struggling with and provides targeted instruction and feedback to help them master the material. DreamBox Learning uses a variety of data to provide its personalized learning experiences to users, primarily focusing on educational data.	2006
Knewton	Knewton is an adaptive learning platform that uses anticipatory design to personalize the learning experience for each student. The platform analyzes the student's learning style, behavior, and progress to predict what content they will need to master next and deliver it to them. Knewton's adaptive learning system uses sophisticated algorithms and machine learning to analyze and interpret this data. It then uses this analysis to dynamically adjust the learning experience for each user, providing personalized content, recommendations, and challenges to optimize the learning journey based on individual needs and progress. This adaptability is a key feature of Knewton's educational technology.	2008
Smart Sparrow	Smart Sparrow is an adaptive courseware platform that uses anticipatory design to provide personalized learning experiences for students. The platform uses data analytics and machine learning to predict each student's needs and adapt the course content to meet those needs. Smart Sparrow is an innovative educational platform that transforms learning experiences through anticipatory design. Its adaptive learning capabilities and personalized feedback make it a standout in the field of education, providing tailored learning paths and fostering student engagement.	2011
Transportation		
Waze	Waze is a navigation app that uses anticipatory design to suggest the best routes based on real-time traffic data and the user's preferred settings. It can also predict the user's destination based on their frequent locations and time of day. Waze's anticipatory experiences in the transportation sector focus on real-time updates, personalized recommendations, and community collaboration, ultimately leading to improved efficiency, reduced stress, and enhanced safety for users.	2006
BMW Connected Drive	BMW ConnectedDrive vehicle connectivity system anticipates users' needs by providing real-time traffic information, route recommendations, and other personalized services based on the user's location and driving habits. BMW	2008

	ConnectedDrive showcases anticipatory design in the automotive industry better than anyone. They offer proactive assistance and personalized recommendations to drivers. Its integration of sensors, connectivity, and data analysis enables a more seamless and anticipatory driving experience.	
Citymapper	Citymapper is a comprehensive urban transportation app that integrates various modes of transportation, including buses, trains, bikes, and ride-sharing services. The app provides real-time updates on transit schedules, route options, and disruptions. Citymapper also uses machine learning algorithms to anticipate user needs, such as suggesting optimal transit routes and notifying users of any service changes or delays Citymapper's anticipatory experiences in the transportation sector aim to provide users with comprehensive, real-time transit information, personalized route suggestions, and a more efficient, eco-friendly, and less stressful commuting experience.	2011
Hospitality and Travel		
Booking	Booking's website uses anticipatory design to predict the user's next steps and personalize their search results accordingly. E.g., it might suggest hotels or flights based on a user's past searches, their location, and the time of day.	1996
Hooper	Hopper is a mobile app that uses anticipatory design to help users find the best deals on flights. It can anticipate price changes and recommend the best time to book a flight, as well as suggest alternative travel dates or airports to help users save money. This app employs anticipatory design to analyze flight prices and provide personalized recommendations for users seeking the best deals. Its data-driven approach, combined with its user-friendly interface, has gained recognition in the travel industry as an innovative solution for proactive trip planning.	2007
Disney MagicBand	Disney MagicBand is a wearable device that uses anticipatory design to enhance the guest experience at Disney theme parks. It can anticipate the guest's needs and provide personalized recommendations for attractions, shows, and dining options based on factors such as past visits and interests. It goes beyond typical personalized recommendations and offers a comprehensive and immersive experience for theme park guests, integrating various aspects of their visit into a seamless and proactive system.	2013
Healthcare		
MyFitnessPal	MyFitnessPal is a health and fitness app that uses anticipatory design to track the user's diet and suggest personalized meal plans and calorie goals based on their preferences and nutritional needs. MyFitnessPal stands out as a leading health and fitness app that effectively utilizes anticipatory design to provide personalized recommendations and support for users' wellness goals. Its data-driven approach and user-centric design make it a popular choice among individuals looking for proactive health management.	2005
Medisafe	Medisafe is a medication management app that uses anticipatory design to remind users to take their medications at the right time and in the right dosage.	2012

	It can also predict potential drug interactions and suggest alternative medications if necessary.	
Lifesum	Lifesum is another health and fitness app that uses anticipatory design to suggest personalized meal plans and nutritional advice based on the user's goals, preferences, and progress. It can also predict potential health risks and suggest preventive measures.	2013
Ada Health	Ada Health is a symptom-checking app that uses anticipatory design to provide personalized health assessments and recommendations based on the user's symptoms and medical history. It can also predict potential health risks and suggest preventive measures.	2016
Retail		
Walmart	Walmart's anticipatory service is a customer-focused approach that utilizes data, technology, and predictive analytics to enhance the shopping experience. By analyzing factors like purchase history, online behavior, and location data, Walmart provides personalized product recommendations, anticipates replenishment needs, offers location-specific promotions, and utilizes weather forecasts for tailored suggestions. It also ensures efficient order tracking, integrates with smart home devices, optimizes inventory management, and provides proactive customer support. These efforts aim to create a seamless, convenient, and highly personalized shopping experience for customers, promoting loyalty and satisfaction. The goal is to provide a more personalized and convenient shopping experience.	1962
Amazon	Amazon is a pioneering force in the realm of anticipatory experiences, harnessing data analytics and ML algorithms to offer a personalized and efficient service. By analyzing user behavior and purchase histories, Amazon provides tailored product recommendations, making online shopping more convenient and engaging. Additionally, the company streamlines the checkout process, storing user information securely for swift, one-click purchases. Amazon Prime, one of its flagship services, epitomizes anticipatory design by delivering fast shipping options that meet users' desires for rapid deliveries. Amazon has been utilizing anticipatory experiences for some time, consistently enhancing its services to better comprehend and satisfy customer needs, thus fostering loyalty and driving substantial growth in sales.	1994
ASOS	ASOS, is a popular online fashion and clothing retailer, uses various types of data to provide a personalized and anticipatory experience to its users. These data types help ASOS make tailored product recommendations, improve the shopping experience, and anticipate customer needs.	2000
Easysize	Easysize is a service that specializes in providing personalized size recommendations for online shoppers in the fashion industry. By leveraging advanced data analytics and technology, Easysize takes into account a variety of factors, including a customer's past shopping behavior, garment measurements, brand-specific sizing, and individual body measurements to determine the most suitable size for a particular item. The aim is to reduce the	2014

common problem of ordering ill-fitting clothing online, which often leads to returns and customer dissatisfaction. Easysize's integration with online retailers offers a more tailored and user-friendly shopping experience, ultimately improving customer confidence and satisfaction while reducing return rates for both customers and retailers.

These use cases illustrate the tangible benefits anticipatory design can deliver, including improved user satisfaction, operational efficiency, and proactive problem-solving. However, they also reveal persistent challenges, particularly in managing user trust, ensuring data privacy, and addressing algorithmic biases—issues repeatedly emphasized in human–automation interaction and responsible AI literature (Parasuraman et al. 2000; Shneiderman 2020).

5.2 Results and Discussion

From the analysis, we can conclude that there are a few companies at the forefront of providing anticipatory experiences to their user and customers. In general, these companies highlight the core objectives of anticipatory experiences, which are to provide personalized, efficient, and proactive support that enhances user satisfaction, engagement, and outcomes. The result is a user experience that doesn't merely react to users' expressed preferences but understands and acts upon the deeper motivations and needs, leading to enhanced satisfaction and engagement (Garrett 2011; Fogg 2009; Thaler and Sunstein 2008).

5.2.1 Common Outcomes

Across the analyzed industries, several common outcomes emerged concerning the implementation of anticipatory experiences (Table 12).

Table 11: Outcomes of Anticipatory Experiences in Various Industries.

Outcomes	Description	Benefits
Personalization	Services tailor offerings to individual user needs, preferences, and objectives.	Increased user experience, engagement, and improved results.
Enhanced Efficiency & Convenience	Users receive timely recommendations, insights, and actionable information, streamlining processes.	Minimizes cognitive strain and makes complex tasks more manageable.
Enhanced Decision-Making	Data analytics and advanced ML support user decision-making with relevant information, reducing cognitive overload.	Users make well-informed choices with confidence.

Proactive Support	Services proactively outline potential challenges, opportunities, or risks, offering timely interventions and guidance.	Optimizes user outcomes and provides a proactive approach.
Engagement & Empowerment	Tailored recommendations and interactive elements promote user agency and involvement.	Deepens engagement and makes the experience more rewarding.
Data-Driven Insights	Sophisticated data analytics and predictive models inform continuous refinement and personalization.	Enables informed decision-making and delivery of truly personalized experiences.

These findings reveal a pronounced emphasis on personalization across all services. Consistent with prior research in persuasion and behavior design (Fogg 2009; Thaler and Sunstein 2008), services within these industries consistently prioritize tailoring their offerings according to the distinct needs, preferences, and objectives of individual users. This customization significantly elevates user experience, fostering increased engagement and improved results.

By leveraging data and predictive methodologies, users receive timely recommendations, insights, and actionable information that streamline processes and make complex tasks more manageable. This outcome aligns with broader discussions in human–automation interaction on minimizing cognitive strain through effective system support (Parasuraman et al. 2000; Shneiderman 2020).

This ties into the third outcome: enhanced decision-making. With the aid of data analytics and advanced machine learning, anticipatory experiences support users' decision-making capacities, equipping them with tools and insights to make well-informed choices confidently. These outcomes are consistent with observations about how digital systems reduce cognitive overload and structure decision contexts (Raisch and Krakowski 2020; Schwartz 2004).

Furthermore, anticipatory services stand out for their proactive support. By proactively outlining potential challenges, opportunities, or risks, they offer timely interventions, alerts, and guidance that optimize user outcomes. This proactive dimension is closely tied to foresight-informed approaches to anticipation (Poli 2017; 2019)**.**

This proactive approach dovetails with the fifth outcome: engagement and empowerment. Anticipatory experiences are designed to actively involve users, offering tailored recommendations and interactive elements that promote agency and involvement (Cerejo and Carvalhais 2020; Kleber 2016; Pezzulo and Butz 2008). This not only deepens engagement but also makes the experience more rewarding and empowering.

Finally, at the heart of these anticipatory experiences lies a foundation of data-driven insights. By leveraging sophisticated data analytics and predictive models, these services continuously collect valuable insights into user behaviors and patterns. This data-centric approach is pivotal, enabling refinement, informed decision-making, and the delivery of truly personalized experiences (Castellano et al. 2009; Beer et al. 2014).

5.2.1.1 Finance Outcomes

The examined financial services strive to empower users, improve their financial well-being, simplify their financial management, and guide them toward stability, security, and long-term financial prosperity. To achieve these goals, these services use data-driven insights and automation to provide various benefits to users (Table 13).

Table 12: Outcomes Description Benefits References.

Outcome	Description	Benefits
Financial Empowerment	Tailored recommendations and insights equip users to make informed financial decisions.	Improved financial well-being, stability, and security
Convenience & Efficiency	Automation and streamlining simplify financial management tasks.	Increased accessibility and time efficiency
Improved Financial Habits	Fosters regular savings, budgeting, and responsible investing.	Enhanced financial literacy and responsible behavior
Behavior Change & Habit Formation	Enables users to adopt more responsible financial behaviors.	Enhanced financial stability and resilience
Simplified Goal Tracking & Management	Users can set, track, and achieve financial goals.	Achievement of financial goals (savings, retirement, debt reduction)
Risk Management	Users receive guidance on investment strategies, tax optimization, and risk mitigation.	Increased financial awareness and informed decision-making
Tax Efficiency	Services implement strategies to reduce users' tax obligations.	Substantial long-term financial savings
Continuous Monitoring	Financial profiles, investments, and goals are monitored to adapt to changing circumstances.	Ensures strategies evolve for long-term financial health

Financial Education	Users gain access to educational resources and insights.	Improved financial judgment and ability to navigate complex financial situations

In this sector, anticipatory experiences instill a profound sense of *financial empowerment* in users. Tailored recommendations and predictive insights equip individuals with the knowledge needed to make informed decisions about their financial goals and operations, reinforcing the broader principle that proactive systems can extend user agency when designed with transparency and reliability in mind (Parasuraman et al. 2000; Shneiderman 2020).

This empowerment is complemented by the unprecedented convenience and efficiency offered through automation. By streamlining financial tasks such as budgeting, bill payment, and portfolio monitoring, anticipatory systems reduce friction and cognitive strain, making financial management more accessible and time efficient (Poli 2019). The resulting simplification fosters improved financial habits and literacy, including regular savings, prudent budgeting, and disciplined investing.

Furthermore, these financial services facilitate genuine *behavior change and habit formation*, enabling users to adopt more responsible financial behavior, and fostering proactive and goal-oriented behavior (Pezzulo and Butz 2008; Fogg 2009). This, in turn, leads to enhanced *financial stability*, as users become better equipped to build savings, optimize investments, and reduce unnecessary expenses, enhancing their resilience against unforeseen financial challenges.

Another significant outcome is simplified goal tracking and management. By enabling users to set, pursue, and monitor financial goals—whether for retirement planning, debt reduction, or major purchases—anticipatory systems align personal objectives with adaptive monitoring that supports long-term outcomes. These functions illustrate how foresight can be operationalized at the micro-level of individual behavior (Poli 2017).

Risk management also emerges as a central focus. Anticipatory financial services provide strategic guidance for navigating risks, ensuring that portfolios align with user-defined tolerances while integrating optimization strategies such as tax efficiency. These affordances contribute to heightened financial awareness, giving users a holistic understanding of income, expenses, and investment performance as the foundation for informed decision-making (Raisch and Krakowski 2020).

Moreover, tax efficiency is emphasized, with predictive analytics employed to reduce obligations and deliver long-term savings. Continuous monitoring ensures that users' financial profiles, investments, and goals evolve in response to personal and market changes, reflecting the principle of adaptive system design (Beer et al. 2014).

Finally, users benefit from financial education resources, which offer structured knowledge to strengthen financial judgment and enhance their ability to navigate increasingly complex financial ecosystems. In this sense, anticipatory systems not only provide immediate functionality but also contribute to long-term literacy, reinforcing trust and sustainable engagement with technology (Schwartz 2004).

5.2.1.2 Education Outcomes

Overall, educational platforms that employ anticipatory experiences aim to enhance the learning journey of their students. These platforms share common outcomes that reflect the positive impact of personalized and adaptive learning (Table 14).

Table 13: Outcome Description Benefits References.

Outcome	Description	Benefits
Personalized Learning	Tailored content and challenges based on individual needs, comprehension levels, and learning styles.	Increased engagement, caters to individual learning trajectories
Improved Learning Outcomes	Students demonstrate better comprehension and mastery of concepts.	Achievement of learning goals
Data-Driven Insights	Platforms collect data on student learning pathways to inform personalized instruction.	Improved pedagogical strategies and interventions for educators
Reduced Student Frustration	Educational content is calibrated to avoid discouragement and maintain interest.	More gratifying learning experience
Confidence Building	Students overcome challenges tailored to their readiness, fostering confidence in their abilities.	Enhanced learning disposition
Time Savings for Educators	Automation of learning processes and evaluation frees up educator time.	More effective learning environment through focused planning and personalized assistance

In the realm of education, anticipatory experiences have been transformative, leading to remarkable outcomes. The main emphasis is on *personalized learning*. All three analyzed services (Smart Sparrow, Knewton, and Dreambox learning) champion an individualized learning paradigm, meticulously crafting content and challenges that resonate with each student's distinct needs, comprehension levels, and learning velocities. This enhanced personalization aligns with established arguments that adaptive design can reduce cognitive strain and improve motivation (Fogg 2009; Thaler and Sunstein 2008). By providing content that is both pertinent and calibrated to the right degree of complexity, students find themselves more vested in the learning process. This increased engagement invariably translates to active participation, timely completion of assignments, and a deeper sense of learning ownership.

Consequently, these actions often lead to *improved learning outcomes*. Students demonstrate better comprehension and mastery of concepts when introduced to new ideas and concepts at a moment in their learning trajectory. Such outcomes highlight how foresight principles applied at the micro-level can scaffold learning progressions effectively (Poli 2017; 2019). Another basis of these services is their reliance on data-driven insights. By continually collecting data on student pathways, platforms can identify both strong areas and those requiring reinforcement. This process benefits not only learners but also educators, who can refine pedagogical strategies and interventions to deliver more impactful teaching (Ljubica 2023; Zamenopoulos and Alexiou 2020).

Furthermore, anticipatory experiences play a pivotal role in managing student frustration. By ensuring that content is neither overly simplistic nor overwhelmingly complex, these systems reduce the risk of disengagement or discouragement (Schwartz 2004). This outcome is critical for sustaining motivation and resilience, echoing broader findings on calibrated trust and reliance in human–automation systems (Parasuraman et al. 2000; Beer et al. 2014).

This dovetails with another crucial outcome: confidence building. Academic success, particularly when tasks are well-matched to readiness, acts as a confidence booster. As students consistently overcome challenges tailored to their preparedness, they cultivate a stronger belief in their capabilities, enhancing their overall learning disposition.

Additionally, anticipatory experiences generate time savings for educators. By automating repetitive tasks such as content delivery and evaluation, these platforms free educators to focus on higher-value activities like instructional design and personalized assistance. This redistribution of effort supports the development of richer learning environments and aligns with discussions on the augmentation of human roles through AI (Daugherty and Wilson 2018; Yang 2017; Shneiderman 2020).

5.2.1.3 Transportation Outcomes

In the transportation sector, anticipatory experiences have emerged as revolutionary, producing a range of innovative outcomes (Table 15).

Table 14: Outcomes of Anticipatory Experiences in Transportation

Outcome	Description	Benefits
Real-Time Information	Services deliver timely traffic updates and personalized recommendations using crowd-sourced data.	Informed decision-making for users
Proactive Navigation	Personalized recommendations for alternative routes based on traffic predictions.	Enhanced user experience and city efficiency
User-Centric Personalization	Services tailor information to user location, driving behaviors, and preferences.	Safer and more efficient travel choices
Crowd-Sourced Data Integration	Services leverage user-reported information for real-time updates.	User-centric design and improved data accuracy
Efficiency & Safety Optimization	Services optimize routes, reduce congestion, and proactively alert users of hazards.	Safer transit and reduced travel time
Multi-modal Integration	Seamlessly combines various transportation options (buses, trains, bikes, ride-sharing).	Flexible and diverse travel planning for users
User Engagement for Improved Data	Users contribute by reporting incidents and refining data for platform accuracy.	Enhanced user experience through collaborative data management
Empowered Decision-Making	Users gain access to accurate, real-time information for all transit modes.	Improved decision-making for navigating transportation
Adaptive & Intelligent Systems	Platforms leverage ML and real-time data for dynamic and optimized solutions.	Efficient and swift travel experiences
Evolving User Interaction Design	Focus shifts from efficiency to a user-centric, fluid interaction adapting to changing conditions.	Enhanced user experience through adaptable design

A standout feature across the analyzed services is the provision of real-time information. Platforms such as Waze and Citymapper consistently deliver timely traffic updates and personalized services, effectively exploiting crowd-sourced data to provide instant alerts and transit-related updates. This ensures that users are equipped with up-to-the-minute information for informed decision-making, reducing uncertainty in complex mobility environments (Poli 2017; Beer et al. 2014).

Anticipatory capabilities are particularly evident in proactive navigation. Services employ predictive modeling and ML to suggest alternative routes, dynamically adapting to traffic scenarios. This proactive support enhances both individual user experience and systemic efficiency at the city level, echoing broader discussions on how automation can augment human decision-making under time pressure (Parasuraman et al. 2000; Dietterich 2000).

Personalization remains a cornerstone of these services. By tailoring information to users′ location, driving behavior, and preferences, anticipatory systems foster safer and more efficient travel. This aligns with anticipatory design’s central promise: reducing cognitive strain and enabling users to act more effectively with minimal effort (Fogg 2009; Kleber 2016).

Another defining strength lies in the integration of crowd-sourced data. User-generated inputs—such as hazard reports or congestion updates—are not only essential to improving accuracy but also exemplify the shift toward collective anticipatory practices (Zamenopoulos and Alexiou 2020; Morrison et al. 2021). This collective contribution reflects a participatory design ethos, where users actively shape the quality of the anticipatory experience.

Prioritizing *efficiency and safety*, each service is committed to elevating transportation standards. They focus on optimizing routes to reduce travel time and ease congestion, while proactively delivering alerts about potential road hazards to foster safer transit. Notably, these services excel in their *multi-modal integration*, seamlessly combining various transportation options, including buses, trains, bicycles, and ride-sharing services, offering users a wide array of choices to plan their commutes effectively.

Moreover, *user engagement* is critical for these platforms, actively encouraging users to contribute to the platform's accuracy by reporting incidents, refining data, and enhancing the overall user experience. Collectively, these services empower users towards *enhanced decision-making* by supplying accurate, real-time information, whether they are driving or utilizing public or private transportation. We are witnessing the development of intelligent and adaptive systems designed to respond to contextual possibilities and influence user behavior based on the situation (Dove et al. 2017; Fischer 2002; Van Allen 2017).

These services combine ML and real-time data to create living, dynamic, optimized solutions for swift travel (Daugherty and Wilson 2018, 6–7). Design is evolving into a new context, an evolving, negotiated, inconsistent, improvised, serendipitous interaction that does not easily resolve task accomplishments, efficiency, certainty, ROI, customer expectations, or for that matter, one user’s experience (Van Allen 2017, 431).

Together, these developments illustrate how transportation services are evolving into intelligent and adaptive systems, capable of responding to contextual possibilities and influencing user behavior in situ. This trajectory supports a shift in interaction design away from static efficiency and certainty, toward fluid, negotiated, and user-centric experiences that adapt dynamically to changing urban conditions (Morrison et al. 2021; Van Allen 2017).

5.2.1.4 Hospitality and Travel Outcomes

Within the hospitality and travel sector, anticipatory experiences have emerged as a game-changer, helping in a series of remarkable outcomes for users (Table 16).

Table 15: Outcomes of Anticipatory Experiences in Hospital and Travel.

Outcome	Description	Benefits
Increased Convenience	Services simplify product discovery, expedite procedures, and offer fluid interactions.	Seamless user experience with reduced time and effort.
Enhanced Efficiency	AI facilitates quick and precise decision-making, reducing decision fatigue.	Time conservation and amplified productivity
Personalized Recommendations	Services tailor suggestions based on user data, preferences, and interests.	Increased user satisfaction and engagement
Cost Savings	Platforms identify best deals, anticipate price fluctuations, and recommend ways to save money.	Maximized financial savings for users
Improved Decision-Making Confidence	Users receive data-backed insights and forward-looking projections, fostering confidence in choices.	More thoughtful and well-informed decision-making
Enhanced User Experience	Streamlined operations, facilitated interactions, and a focus on user delight contribute to a rewarding experience.	Improved user journey through user-centric design and proactive guidance

Convenience is a primary outcome across this sector. Services highlight user ease by simplifying discovery processes and reducing the time and effort traditionally expended in decision-making (Schwartz 2004; Chernev et al. 2015). Users are presented with meticulously personalized suggestions, expedited procedures, and fluid interactions, translating into a truly seamless experience.

These services also enhance efficiency. AI-driven platforms provide users with timely and relevant data, enabling quick, precise decision-making and reducing the risk of decision fatigue or analysis paralysis. Such outcomes echo findings in behavioral science, where too many choices or poorly structured information environments can impair decision quality (Hirshleifer et al. 2019; Vohs et al. 2008).

Like other services from different industries, at the heart of these services lies an inherent commitment to *personalization*. Exploiting the power of anticipatory experiences, they secure recommendations and interactions, meticulously crafted to resonate with the user's individual predilections and needs. By incorporating insights from users' historical data, preferences, and interests, these platforms ensure an experience that amplifies user contentment and engagement. This outcome aligns with broader discussions on personalization and intent-aware anticipatory design (Kleber 2016; Kaneko et al. 2017; Cerejo and Carvalhais 2020). By providing targeted, relevant recommendations, these systems increase satisfaction and engagement while reducing friction in the travel planning process.

Additionally, a significant benefit for users is the *cost savings* these services facilitate. Employing sophisticated predictive algorithms, they accurately spot the best deals, anticipate pricing oscillations, and extend recommendations, all geared towards ensuring users maximize their financial savings.

Another important outcome is improved confidence in decision-making. Equipped with forward-looking projections and data-backed insights, users report greater certainty and trust in their travel-related decisions. This confidence reflects the role of transparency and explainability in fostering calibrated trust in AI systems (Amershi et al. 2019a; Shneiderman 2020).

Cumulatively, these features contribute to an enhanced user experience. By eliminating pain points, streamlining operations, and facilitating service interactions, anticipatory hospitality and travel platforms deliver user journeys that are both rewarding and engaging. With their focus on proactive guidance and user-centric design, they exemplify how anticipatory systems can transform everyday decision-making into seamless, confidence-building experiences (Zamenopoulos and Alexiou 2020; Morrison et al. 2021).

5.2.1.5 Healthcare Outcomes

In the health sector, anticipatory experiences have been responsible for a transformative approach to care (Table 17).

Table 16: Outcomes of Anticipatory Experiences in Healthcare.

Outcome	Description	Benefits
Personalized Care	Experiences are tailored to user needs, health conditions, and data.	Improved user experience and health outcomes

Improved Health Outcomes	Users receive preventive strategies, tailored insights, and support for long-term health management.	Overall health improvement and disease prevention
Enhanced Health Education & Awareness	Users gain access to educational content, fostering health literacy and informed decision-making.	User empowerment and ability to manage health
Behavior Change & Habit Formation	Services provide feedback, reminders, and suggestions to encourage healthier habits (diet, exercise, medication adherence).	Improved health behaviors and overall well-being
User Empowerment & Engagement	Users receive tailored information, recommendations, and support, fostering a sense of control and accountability.	Increased user motivation and active participation in health management
Simplified Tracking & Management	Services streamline health tasks like medication tracking, goal monitoring, and progress assessment.	Reduced complexity and improved organization for managing health

Like most of the other industries, at the forefront is the profound emphasis on *personalization*. Contemporary healthcare services are committed in delivering experiences meticulously tailored to align with a user's distinct needs, objectives, and prevailing health conditions. Users are encouraged to personalized evaluations, suggestions, notifications, warnings, and reminders, all meticulously crafted based on their data and needs. This amplified personalization dovetails into clearly *improved health outcomes.* The core tenet of these anticipatory experiences is to reinforce overall health results, especially in the long term. By equipping users with tailored insights, supported by custom preventive strategies. This personalization echoes anticipatory design’s intent to go beyond reactive care by proactively structuring experiences around user intent and context (Garrett 2011; Cerejo and Carvalhais 2020).

Furthermore, a significant thrust area for these services is *health education and awareness*. Anticipatory experiences in healthcare are determined in extending educational content, insights, and resources, all assembled towards amplifying users' health literacy. This ensures that users possess a clear understanding of their health metrics, symptoms, and medical conditions (Zamenopoulos and Alexiou 2020; Ljubica 2023).

These services allow preventive strategies, thereby enabling users to make rational choices and assume command of their health. Additionally, a relevant outcome of these experiences is the support they provide for *behavior change and habit formation*. By tailoring suggestions, reminders, and feedback, these platforms play a crucial role in pushing users toward cultivating healthier habits. This aligns with broader theories of decision-making and anticipatory action in shaping user behavior (Pezzulo and Butz 2008; Schwartz 2004).

Equally important is *user empowerment and engagement*. By offering access to tailored information, recommendations, and support, they cultivate a robust sense of user engagement and awareness. This not only fosters active participation but also encourages a sense of accountability in users as they navigate their health journeys. This increased engagement translates to users feeling an inherent sense of control, motivation, and companionship. The anticipatory qualities of these interactions highlight the shift toward negotiated, adaptive experiences that evolve with user needs (Fischer 2002; Van Allen 2017; Dove et al. 2017).

Finally, *simplified tracking and management* plays a crucial role. They endeavor to streamline health-centric tasks, be it tracking medication, orchestrating meal plans, monitoring goals, or assessing progress. By offering consolidated overviews, reminders, and alerts, they ensure users remain both organized and informed, thereby easing the complexities traditionally associated with managing health-centric endeavors. The use of predictive models and continuous monitoring ensures evolving strategies remain aligned with user needs (Castellano et al. 2009; Daugherty and Wilson 2018).

5.2.1.6 Retail Outcomes

In the retail sector, anticipatory experiences have revolutionized the shopping landscape, leading to a new length of unique outcomes for users. The common outcome in this sector is to leverage anticipatory experiences to create more customer-centric and satisfying interactions, benefiting both users and service providers. These outcomes elevate customer engagement, foster loyalty, and contribute to business success (Table 18).

Table 17: Outcomes of Anticipatory Experiences in Retail.

Outcome	Description	Benefits
Personalized Recommendations	Data analysis personalizes product discovery, streamlines shopping, and boosts user satisfaction.	Improved user experience and product discovery
Convenience & Time Savings	Reduced need for extensive searches and decisions leads to a more efficient shopping experience.	Enhanced user experience

Improved Customer Satisfaction	Personalized experiences and streamlined processes boost customer satisfaction and loyalty.	Increased customer retention and loyalty
Reduced Returns	Personalized recommendations minimize product dissatisfaction and returns, impacting sustainability.	Reduced environmental impact and operational costs for retailers (E.g., Easysize)
Valuable Business Insights	User behavior data informs business decisions.	Competitive advantage and informed decision-making
Customer-Centric Shopping Experience	Personalized experience and efficient shopping benefit both customers and retailers.	Increased customer satisfaction and business success

One key element is *personalized recommendations*, where data analytics and user behavior analysis enhance product discovery, streamline shopping processes, and boost user satisfaction. Moreover, *convenience and time savings* are at the forefront of anticipatory experiences across these platforms, as they aim to reduce the need for extensive searches and decision-making, ultimately enhancing the overall user experience. This personalization reduces the effort required to find relevant items and minimizes decision fatigue, making shopping more convenient and rewarding (Schwartz 2004; Garrett 2011; Cerejo and Carvalhais 2020).

The anticipatory features go hand in hand with *improved customer satisfaction*, providing a more personalized and relevant experience, which in turn boosts customer satisfaction and loyalty. These platforms also bring *streamlined processes*, ensuring users benefit from more efficient and straightforward procedures, whether it's simplified checkout processes or optimized inventory management.

Anticipatory experiences excel in *enhancing engagement*, motivating users to spend more time on these platforms and return for future interactions. By offering personalized recommendations and services, these platforms aim to achieve a *reduction in returns*, reducing the likelihood of customers returning products due to dissatisfaction. An action that has a tremendous impact on the sustainability of our planet. According to Easysize, nearly 30 to 40% of all online fashion is returned due to the wrong size and fit. This translates into worldwide spending of $32 billion on handling size-related returns annually. This represents a substantial logistic effort and cost for brands, given that the items must move around from one place to another.

Another outcome is the *enhancement of customer engagement*. By encouraging longer interactions and repeat visits, these services cultivate deeper bonds with users. Engagement is also reinforced by data-driven processes that ensure interactions remain relevant, proactive, and adaptive to evolving user needs (Schwartz 2004).

Finally, anticipatory systems in retail generate valuable *behavioral insights*. The data collected enables platforms to better understand user needs and preferences, translating into improved inventory management, optimized supply chains, and more strategic business decisions. In this way, anticipatory design not only delivers superior customer experiences but also equips retailers with a competitive edge, strengthening their position in increasingly saturated markets (Castellano et al. 2009).

Collectively, these outcomes demonstrate how anticipatory experiences in retail deliver a more customer-centric, efficient, and sustainable shopping experience, simultaneously driving user satisfaction, loyalty, and business success.

5.2.2 Common Opportunities

Incorporating anticipatory experiences into business strategies offers a multifaceted opportunity for substantial growth, enhanced customer satisfaction, and market differentiation (Cerejo and Carvalhais 2019). These opportunities are the cornerstones of a compelling argument for embracing anticipatory design and transforming digital interactions (Van Allen 2017). The services in the analysis explore a set of common opportunities (Table 19).

Table 18: Benefits of Anticipatory Experiences in Business Strategies.

Outcome	Description	Benefits
Enhanced User Engagement & Satisfaction	Personalized experiences, convenience, and proactive services improve user satisfaction and loyalty.	Increased customer retention, loyalty, and positive word-of-mouth referrals (Cerejo & Carvalhais, 2019)
Market Differentiation	Unique, innovative services with proactive recommendations and personalized features set companies apart from competitors.	Competitive edge attracting customers who value enhanced experiences (Van Allen, 2017)
Expansion & Integration	Partnerships and collaborations with other companies enhance capabilities and offer users more comprehensive experiences.	Growth and increased market reach
Data-Driven Insights	User data analysis informs business decisions, service refinement, trend identification, and data-driven strategies.	Improved decision-making and service optimization

Scalability & Expansion	Adaptability to different contexts and user segments allows for exploring new markets and customer bases.	Broadened audience, maximized reach, and industry collaboration
Continuous Improvement & Innovation	Refinement, innovation, and adaptation to emerging technologies ensure relevance and effectiveness.	Staying at the forefront of the field
Contextual Awareness & Real-Time Adaptation	Recommendations based on location, time, weather, and user activities increase user engagement and satisfaction.	Enhanced user experience and personalization
Gamification & Rewards	Challenges, achievements, and personalized rewards motivate users, sustain positive behaviors, and foster long-term engagement.	Increased user engagement and goal achievement
Advanced ML & AI Algorithms	Continuously learning algorithms provide more refined recommendations based on individual variations and changing circumstances.	Increased accuracy and effectiveness of anticipatory experiences
User Experience Enhancement, Data Insights, Collaboration & Technology	Integration of these elements strengthens business strategies and positions companies at the forefront of innovation.	Transformative growth, heightened user satisfaction, and market differentiation

This analysis shows that anticipatory experiences aim to *enhance user engagement* and satisfaction by providing personalized, convenient, and proactive services. By delivering tailored recommendations, real-time information, and seamless interactions, these experiences significantly impact *customer loyalty*. Through the delivery of value, convenience, and personalized solutions, they surpass user expectations, fostering unwavering loyalty. This loyal user base leads to increased retention rates and fosters positive word-of-mouth referrals, thereby expanding a company's reach and influence. Furthermore, *partnerships and collaborations* with other companies and organizations unlock opportunities for expansion and integration. By extending services and integrating with complementary platforms, these collaborations enhance the anticipatory capabilities of businesses, offering users comprehensive and seamless experiences. All of this is only possible by *data-driven insights*, enabling businesses to anticipate user needs and preferences. The collection and analysis of user data empower companies to refine their algorithms, enhance services, identify trends, and make data-driven decisions aligned with their business objectives. Ultimately, anticipatory experience allows a singular *market differentiation and competitiveness*. They set companies apart from competitors by offering unique, innovative services driven by proactive recommendations, personalized features, and advanced technologies. This distinctiveness establishes a competitive edge that attracts customers to value these enhanced experiences.

Moreover, *scalability and expansion* are fundamental elements of anticipatory design, empowering companies to explore new markets, industries, and customer segments. This adaptability enables the adaptation of services to different contexts, facilitates collaboration with industry peers, and broadens the audience, maximizing the reach and impact of the business. Supported by *continuous improvement and innovatio***n**, anticipatory design allows for remaining at the forefront of this field's demands with continuous refinement, innovation, and adaptation to emerging technologies and user preferences. Companies must invest in research and development, gather user feedback, and evolve their offerings to maintain relevance and effectiveness. Incorporating *contextual awareness and real-time adaptation* further enhances anticipatory experiences. Considering factors like location, time of day, weather, and user activities allows businesses to provide more relevant and timely recommendations, increasing user engagement and satisfaction. This strategy sometimes is also aligned with the introduction of *gamification and reward* elements adding an engaging and enjoyable dimension to anticipatory experiences. Challenges, achievements, and personalized rewards motivate users to achieve their goals, sustain positive behaviors, and foster long-term engagement.

Finally, the development of *advanced ML and AI algorithms* significantly enhances the accuracy and effectiveness of anticipatory experiences. These algorithms continually learn from user behavior and outcomes, adapting to provide more refined recommendations that consider individual variations and changing circumstances. This technological sophistication is pivotal in ensuring the value and efficacy of anticipatory design in contemporary digital landscapes. In conclusion, these common opportunities across industries are bridging user experience enhancement, data-driven insights, collaboration, and advanced technologies, collectively forming a compelling argument for the integration of anticipatory experiences into business strategies. Companies that capture these opportunities position themselves at the forefront of innovation, setting the stage for transformative growth, heightened user satisfaction, and market differentiation in an ever-evolving digital landscape.

5.2.2.1 Finance Opportunities

The financial sector stands on the brink of transformation, embracing anticipatory experiences through a range of strategic opportunities because advancements in ML and AI algorithms can amplify personalization and user insights. By analyzing intricate user data, these technologies enable tailored recommendations that align precisely with individual financial objectives and preferences. This sector has the potential to expand service offerings. Financial institutions can offer comprehensive financial planning services, covering retirement, tax optimization, and estate planning. These holistic services empower users with guidance that harmonizes with their long-term financial aspirations. To promote responsible financial conduct and user engagement, gamification and reward elements incentivize positive financial behaviors, motivating users to achieve financial milestones and meet their goals (Table 20).

Table 19: Opportunities for Anticipatory Experiences in Finance Services.

Outcome	Description	Benefits
Financial Education Resources	Interactive tools and content educate users on financial concepts, enabling informed decisions.	Enhanced financial literacy
Integration of External Accounts	Ability to link mortgages, loans, and external investments for a holistic view.	Comprehensive financial management
Real-Time Financial Data	Integration of real-time transaction data, market indicators, and economic news.	Up-to-date information and anticipatory insights
Partnerships & Ecosystem Expansion	Collaboration with fintech companies, banks, or investment firms to expand service offerings.	Increased range of financial services available to users
Tax Strategy Optimization	Refined algorithms and features for maximizing after-tax returns and aligning with long-term goals.	Improved financial outcomes
Application of Behavioral Finance	Insights address common cognitive biases and emotional pitfalls for better decision-making.	More prudent financial choices
Robust Security Measures	Staying at the forefront of cybersecurity protects user data and fosters trust.	Enhanced user trust and data protection
User Control over Automation & Customization	Empowerment over financial planning tools leads to a sense of control.	Compelling user experience and user trust
Heightened User Satisfaction & Market Differentiation	Improved users experience positions financial institutions as innovation leaders.	Transformative growth and market differentiation

Financial institutions can contribute to enhancing users' financial literacy by investing in comprehensive *financial education resources*. Interactive tools and content enlighten users about complex financial concepts, enabling them to make well-informed financial decisions. To equip users with a comprehensive view of their financial landscape, the *integration of external financial accounts* is crucial. Users should have the flexibility to link various financial elements, including mortgages, loans, and external investments. Plus, incorporating *real-time financial data* is key for providing users with the most current information. Collaborations with financial institutions offer real-time transaction data while integrating external sources like market indicators and economic news enhances anticipatory insights. There is also an opportunity for *partnerships and ecosystem expansion* through strategic partnerships with fintech companies, banks, or investment firms to expand the range of financial services available to users.

Moreover, *optimizing tax strategies* is a compelling opportunity. By refining tax optimization algorithms and offering detailed tax planning features enables users to maximize after-tax returns, aligning their decisions with long-term financial goals. The application of *behavioral finance insights* aids users in making prudent financial decisions, addressing common cognitive biases and emotional pitfalls.

Ensuring *robust security measures* is pivotal, in safeguarding user trust and data integrity. Staying at the forefront of cybersecurity advancements protects user data from emerging threats. Empowering users with *control over automation and customization* in their financial planning offers a sense of choice, culminating in a compelling case for anticipatory design in the financial sector. This approach not only promises heightened user satisfaction but also positions financial institutions at the forefront of innovation, setting the stage for transformative growth and market differentiation in an ever-evolving financial landscape.

5.2.2.2 Education Opportunities

The education sector holds the promise of transformative change through anticipatory experiences, with a range of strategic opportunities at its core (Table 21).

Table 20: Opportunities for Anticipatory Experiences in Education.

Outcome	Description	Benefits

Personalized Learning & User Insights	Services cater to individual needs, interests, and learning styles.	Tailored guidance and support for students, potentially leading to improved learning outcomes.
Improved Learning Outcomes	Targeted interventions, immediate feedback, and adaptive content lead to better knowledge retention and mastery.	Students grasp concepts more effectively.
Increased Engagement & Reduced Frustration	Interactive and immersive learning experiences boost engagement and motivation, while appropriate difficulty levels minimize discouragement.	More engaged learning community and reduced student frustration.
Data-Driven Insights for Educators	Student performance data informs teaching strategies, enabling effective guidance and improved learning outcomes.	Educators can tailor support and interventions based on student needs.
Time Savings for Educators	Automation of lesson planning and assessment frees up educator time for instructional strategies.	Streamlined administrative tasks and more time for quality teaching.
Personalized Learning & User Insights	Services cater to individual needs, interests, and learning styles.	Tailored guidance and support for students, potentially leading to improved learning outcomes.
Improved Learning Outcomes	Targeted interventions, immediate feedback, and adaptive content lead to better knowledge retention and mastery.	Students grasp concepts more effectively.
Increased Engagement & Reduced Frustration	Interactive and immersive learning experiences boost engagement and motivation, while appropriate difficulty levels minimize discouragement.	More engaged learning community and reduced student frustration.
Data-Driven Insights for Educators	Student performance data informs teaching strategies, enabling effective guidance and improved learning outcomes.	Educators can tailor support and interventions based on student needs.
Time Savings for Educators	Automation of lesson planning and assessment frees up educator time for instructional strategies.	Streamlined administrative tasks and more time for quality teaching.

Personalization and user insights are the core opportunities. All educational services can provide highly personalized learning experiences that cater to individual student needs, interests, and learning styles. This level of personalization can revolutionize education, ensuring that students receive tailored guidance and support that aligns with their unique requirements. Therefore, there is a potential to *improve the learning outcomes*. Anticipatory experiences can significantly enhance learning outcomes by offering targeted interventions, immediate feedback, and adaptive content. This approach fosters better knowledge retention and mastery, ensuring that students grasp concepts effectively.

Increased engagement and frustration reduction are vital in educational settings. Incorporating interactive and immersive learning experiences can boost student engagement and motivation. Engaged students are more likely to participate actively in their learning journey, making anticipatory approaches a powerful tool for fostering a more engaged learning community. Furthermore, these approaches can help reduce student frustration by delivering content at the appropriate difficulty level, thus preventing discouragement.

Data-driven insights empower educators to tailor teaching strategies based on student performance data, ensuring effective guidance and improved learning outcomes. Educators can connect these insights to tailor their teaching strategies and support, leveraging a deep understanding of student performance data. This not only ensures that educators provide the best possible guidance and resources but also enables them to make precise and targeted interventions to help students thrive in their learning journey. *Time savings* is another valuable opportunity. By automating aspects of lesson planning and assessment, these services can save educators time, freeing them to focus on instructional strategies. This not only streamlines administrative tasks but also allows educators to invest more in the quality of their teaching, creating a more enriching learning experience for students.

In conclusion, these opportunities make a strong case for integrating anticipatory design in education, promising personalized learning, improved outcomes, higher engagement, valuable insights for educators, and time savings, benefitting learners and educators.

5.2.2.3 Transportation Opportunities

The opportunities for transportation services to enhance their anticipatory experiences and services are vast and diverse, bridging various aspects of technology, user engagement, and industry partnerships (Table 22).

Table 21: Opportunities for Anticipatory Experiences in Transportation.

Outcome	Description	Benefits

Data Analytics & Machine Learning	Utilize historical and real-time data to improve predictive models, personalization, and recommendations.	Enhanced user experience, improved efficiency, and more accurate recommendations.
Integration with Emerging Technologies	Connect with smart home devices, electric vehicles, autonomous vehicles, and smart city initiatives.	Expanded service offerings, improved efficiency, and enhanced user experience.
Partnerships & Collaborations	Collaborate with mapping providers, mobility services, smart device manufacturers, cities, and businesses.	Innovation, integration opportunities, and revenue generation.
Personalization & User Experience	Personalize journey planning, provide alerts, offer intuitive interfaces, and enable offline functionality.	Improved user satisfaction, increased engagement, and user-friendliness.
Environmental Sustainability	Promote eco-friendly options, offer eco-friendly routing, and collaborate for sustainable transportation systems.	Reduced environmental impact and alignment with sustainability goals.
Global Expansion	Expand services to new cities, regions, and international markets.	Address global demand and achieve market penetration in new areas.
Community Engagement & Crowdsourcing	Build user communities, gather feedback, and leverage crowdsourced data.	Fosters sense of belonging, improves data quality, and enhances service quality.
Safety & Security	Implement safety features, provide real-time hazard information, and protect user data.	Builds trust, ensures user safety, and protects privacy.

In the rapidly evolving landscape of transportation services, common opportunities emerge across the analyzed services. Leveraging advanced *data analytics and ML* techniques stands as a cornerstone, enabling the refinement of anticipatory capabilities by analyzing vast troves of historical and real-time data to offer more accurate and personalized recommendations. Integration with emerging technologies, be it smart home devices, electric scooters, or autonomous vehicles, extends the realm of possibilities, fostering seamless transitions between various modes of transportation and enhancing overall user experiences. *Partnerships and collaborations* with industry players, municipalities, and businesses unlock new avenues for innovation and integration, amplifying the services' reach and capabilities. Furthermore, a concerted focus on *personalization and user-centric design*, coupled with an emphasis on *environmental sustainability*, underscores a commitment to delivering not just efficient but also socially responsible transportation solutions. As these services *expand globally, community engagement and crowdsourcing* efforts become vital in fostering user loyalty and improving service quality, while concurrently prioritizing *safety and security* to ensure trust and reliability in an ever-connected world of mobility. In essence, the convergence of these opportunities heralds a transformative era in transportation, where technological innovation, collaborative partnerships, and user-centric approaches converge to redefine the way we navigate our increasingly interconnected urban landscapes.

5.2.2.4 Hospitality and Travel Opportunities

The analysis highlighted common opportunities overflow in this sector in their pursuit of anticipatory experiences (Table 23).

Table 22: Opportunities for Anticipatory Experiences in Hospitality and Travel.

Outcome	Description	Benefits
Continuous Improvement & Data Utilization	Leverage guest feedback and data analytics to refine capabilities and personalize experiences.	Enhanced user experience, improved personalization, and more relevant recommendations.
Integration with Digital Platforms	Seamless access to information and personalized recommendations through mobile apps or online portals.	Increased user engagement, convenience, and improved overall user experience.
Expansion & Partnerships	Explore offerings beyond core services and partner with other brands to enrich user experience. (e.g., MagicBand beyond parks, Hopper with travel businesses).	Enhanced user experience, comprehensive travel solutions, and access to new offerings.
Monetization & Revenue Generation	Utilize platform capabilities to generate revenue through partnerships, exclusive deals, commissions, and targeted advertising.	Improved business performance and additional revenue streams.
Customer Loyalty & Market Differentiation	Build loyalty and differentiate through personalized recommendations and anticipating user needs.	Fosters trust, user loyalty, and drives business growth.
Data Insights for Strategic Decisions	Analyze user data to understand consumer trends and market dynamics.	Informs strategic decisions, service improvements, and innovation for long-term success.

All the services emphasized the importance of *continuous improvement fueled by feedback and data analytics*. By meticulously analyzing user preferences and behaviors, they can refine their anticipatory capabilities, ensuring that recommendations are increasingly personalized and relevant, thereby fostering higher user satisfaction and loyalty.

Furthermore, *integration with digital platforms* emerges as a pivotal strategy to enhance convenience and engagement. Through seamless access to personalized recommendations and information via mobile apps or online portals, users can enjoy a more streamlined and immersive experience, thereby solidifying their bond with the service. *Expanding beyond current offerings presents* another avenue for growth, whether it's Disney contemplating extending the MagicBand experience to resorts or cruises, or Hopper forging strategic partnerships with airlines and travel-related businesses to offer comprehensive travel solutions. This expansion not only broadens their market reach but also enriches the user experience by providing a wider array of services. *Monetization and revenue generation* opportunities also signals exclusive deals, commissions, referral fees, and targeted advertising as avenues to capitalize on their anticipatory design capabilities. By harnessing these revenue streams, they enhance their competitive edge in the market. Furthermore, *customer loyalty and market differentiation* appear strong on their strategic radar, these services carve out a distinct identity by providing invaluable, personalized experiences that resonate deeply with their users.

Through proactive solutions and keen anticipation of user needs, they seek to forge lasting connections with their users, thus reinforcing their position as industry leaders. Lastly, the amount of *data insights* at their disposal offers valuable insights into consumer trends and market dynamics, empowering them to make informed decisions, drive innovation, and continually elevate the quality of their services. In essence, these common opportunities underscore a shared commitment to leveraging data, technology, and user-centric approaches to chart a course toward a future of unparalleled anticipatory experiences and services.

5.2.2.5 Healthcare Opportunities

Healthcare services in this space shared a common commitment to leveraging data-driven insights, predictive analytics, partnerships, user engagement strategies, and continuous improvement efforts to deliver anticipatory experiences that empower users to take proactive steps toward better health and well-being (Table 24).

Table 23: Opportunities for Anticipatory Experiences in Healthcare.

Outcome	Description	Benefits

Personalization & Tailored Recommendations	Consider individual preferences, health history, lifestyle factors, and contextual cues to deliver personalized recommendations and interventions for improved health outcomes and user satisfaction.	Improved health outcomes and user satisfaction through tailored interventions and recommendations
Data Utilization & Integration	Leverage data from wearables, health apps, and user feedback to understand user behavior and health patterns.	More accurate recommendations, improved user experiences, and better health outcomes (all services)
Predictive Capabilities & Anticipatory Experiences	Use machine learning and predictive analytics to anticipate needs, offer proactive suggestions, and personalize recommendations for preventive care and medication management.	Enhanced preventive care, improved medication management, and overall well-being
Partnerships & Collaborations	Collaborate with healthcare providers, pharmacies, wellness platforms, and health professionals for data integration, access to resources, and a more comprehensive health experience.	Seamless data integration, access to additional resources and expertise, and a more effective anticipatory experience
User Engagement & Gamification	Utilize gamification elements, rewards, challenges, and social features to create interactive experiences that encourage healthy behaviors and long-term engagement.	Increased user engagement, fostered sense of community, and long-term adherence to health goals
Continuous Learning & Improvement	Continuously refine algorithms, expand knowledge bases, and incorporate user feedback for up-to-date services, improved diagnostic accuracy, and effective anticipatory experiences.	Staying current with advancements, enhanced diagnostic accuracy, and relevant and effective services

Personalization and tailored recommendations lie at the heart of healthcare anticipatory services. By considering individual preferences, health history, lifestyle factors, and contextual cues, they aim to deliver tailored recommendations and interventions that meet the unique needs of each user, ultimately contributing to improved health outcomes and user satisfaction.

This opportunity is significantly leveraged by the *utilization and integration of data*. These services recognize the wealth of insights that can be collected from sources such as wearables, health apps, and user feedback. By harnessing this data, they can paint a comprehensive picture of user behaviors, preferences, and health patterns. This allows for more accurate and personalized recommendations, whether it's providing precise diagnostic assessments, offering tailored nutrition plans, or managing medication regimens with greater efficacy. Central to these anticipatory experiences is the deployment of *advanced predictive analytics*. By continuously learning from user interactions and outcomes, these services aim to anticipate user needs and behaviors. Whether it's predicting potential health risks, suggesting preventive measures, or identifying medication adherence challenges in advance, these anticipatory capabilities are poised to drive proactive interventions and improve health outcomes.

Furthermore, *partnerships and collaborations* play a pivotal role in enhancing the comprehensiveness and effectiveness of these services. By collaborating with healthcare providers, pharmacies, and wellness platforms, these services can seamlessly integrate data and access additional resources and expertise. This not only facilitates a more holistic approach to healthcare but also ensures a smooth transition from digital platforms to professional medical services when needed. *User engagement and gamification* lies at the core of these anticipatory experiences, and strategies such as rewards and social features are employed to foster adherence to healthy behaviors and drive long-term engagement. By creating interactive and enjoyable experiences that encourage community engagement and progress tracking, these platforms aim to empower users to take ownership of their health journey.

Continuous learning and improvement are also emphasized, with a commitment to refining algorithms, expanding knowledge bases, and incorporating user feedback. By staying well-informed of the latest medical advancements and leveraging behavioral insights, these services ensure that their anticipatory experiences remain relevant and effective in meeting the evolving needs of users. In essence, the convergence of data-driven insights, predictive analytics, partnerships, user engagement strategies, and continuous improvement efforts represents a paradigm shift in healthcare services. By harnessing the power of anticipatory experiences, these services are poised to empower individuals to take proactive steps towards better health and well-being, ultimately transforming the way healthcare is delivered and experienced.

5.2.2.6 Retail Opportunities

The common patterns observed in the analysis of retail service opportunities underscore a shared commitment to leveraging data-driven insights, integrating technology, prioritizing personalization and customization, expanding globally, fostering partnerships, promoting sustainability, and driving continuous improvement and innovation to enhance anticipatory experiences and services for customers worldwide (Table 25).

Table 24: Opportunities for Anticipatory Experiences in Retail.

Outcome	Description	Benefits
Advanced Data Analytics & Machine Learning	Utilize advanced data analytics, machine learning, and AI to understand customer behavior and preferences.	More accurate predictions, personalized recommendations, and enhanced customer satisfaction and engagement.
Integration of Technology	Integrate voice assistants, IoT devices, and wearable tech into the shopping experience.	Real-time data collection, intuitive shopping experiences, and personalized services that anticipate customer needs.
Personalization & Customization	Offer customized subscription services and product recommendations based on individual preferences.	More relevant and individualized experiences that resonate with customers.
Global Expansion & Market Adaptation	Expand into international markets, adapt services to cultural contexts, and cater to diverse body types.	Consistent and inclusive shopping experiences for customers globally.
Partnerships & Collaborations	Collaborate with retailers, technology providers, and other companies to enrich services.	Expanded reach, access to additional resources, and more innovative services for customers.
Sustainability & Ethical Practices	Promote eco-conscious products, reduce waste, and support sustainable fashion initiatives.	Align with consumer values and contribute to a more sustainable and ethical retail industry.
Continuous Improvement & Innovation	Continuously refine algorithms, incorporate user feedback, and stay at the forefront of technology.	Stay agile and responsive to evolving customer needs and preferences.

Retail giants and specialized services alike are embarking on a journey towards revolutionizing the shopping experience. Central to these efforts is the utilization of *advanced data analytics and ML* technologies. Across platforms, there's a shared recognition of the immense value in mining customer data to gain deeper insights into behaviors, preferences, and trends. By leveraging these insights, retail services can deliver more accurate predictions, personalized recommendations, and tailored experiences that resonate with individual customers on a deeper level. The integration of advanced analytics is key to driving customer engagement and loyalty.

Moreover, the *integration of technology* is exposing an all-new world of opportunities. From voice-activated shopping to integration with IoT devices, there's a concerted effort to leverage emerging technologies to enhance the shopping journey. By collecting real-time data and offering intuitive, seamless experiences, retailers aim to anticipate and fulfill customer needs more effectively. This integration not only streamlines the shopping process but also creates opportunities for innovation, such as the exploration of wearable tech for personalized style recommendations.

Personalization and customization emerge as a focal point of anticipatory retail experiences. Across these services, there's a commitment to providing tailored services that cater to individual preferences and needs. Whether is customized subscription services or enhanced personalization algorithms, retailers are striving to create more relevant and individualized experiences that resonate with customers on a personal level. By delivering personalized recommendations and offerings, retailers can foster stronger connections with customers and drive repeat business.

Furthermore, there's a concerted effort towards *global expansion and market adaptation*. Recognizing the diverse needs and preferences of customers worldwide, retailers are expanding their reach and adapting their services to different cultural contexts. There is a commitment to creating a consistent and inclusive shopping experience for customers globally. By catering to diverse markets and adapting to local preferences, retailers can strengthen their global presence and appeal to a broader customer base. No surprise that *partnerships and collaborations* emerge as another strategic approach to enhancing anticipatory retail experiences. By collaborating with other companies, retailers can access additional resources, expand their reach, and offer customers even more innovative and relevant services. Whether it's partnering with technology providers to enhance predictive algorithms or collaborating with retailers to integrate services into e-commerce platforms, partnerships play a crucial role in enriching the shopping experience and driving customer engagement.

Moreover, there's a growing emphasis on *sustainability and ethical practices* in anticipatory retail experiences. From promoting eco-conscious product recommendations to reducing waste through predictive inventory management, retailers are aligning with consumer values and contributing to a more sustainable and ethical retail industry. By integrating sustainability initiatives into anticipatory services, retailers can appeal to environmentally conscious consumers and position themselves as socially responsible brands. Finally, there's a commitment to *continuous improvement and innovation*. Whether it's through refining predictive algorithms, incorporating user feedback loops, or staying at the forefront of fashion technology, these platforms aim to stay agile and responsive to evolving customer needs and preferences. The future of retail lies in harnessing anticipatory experiences to enhance customer engagement and satisfaction. By leveraging data, technology, personalization, global expansion, partnerships, and sustainability initiatives, retailers can create more seamless, intuitive, and personalized shopping experiences that anticipate and meet customer needs proactively. As the retail landscape continues to evolve, anticipatory experiences will play an increasingly pivotal role in shaping the future of retail and driving business success in the digital age.

5.2.3 Common Pitfalls

As mentioned previously, anticipatory experiences have emerged as powerful tools to streamline decision-making and enhance user experiences across various domains (Zamenopoulos and Alexiou 2007; 2020). From personalized recommendations to predictive analytics, these services leverage data, and algorithms to anticipate user needs and preferences. However, among high potential benefits comes also high pitfalls that must be addressed to ensure the effectiveness, ethicality, and acceptance of anticipatory experiences (Table 26).

Table 25: Challenges of Anticipatory Experiences.

Challenge	Description	Impact
Data Privacy & Security	Large data volumes raise privacy concerns about handling and misuse of user information.	Potential breaches, loss of trust, and legal repercussions.
Accuracy & Reliability	Inaccurate predictions or failure to adapt to changing circumstances reduces user trust.	Reduced value for users and frustration with the system.
User Reliance & Overconfidence	Overconfidence on automation diminishes user responsibility and engagement.	Reduced sense of control and potential negative impact on decision-making skills.
Limited Customization & Control	Limited ability for users to personalize recommendations based on unique needs.	Frustration with irrelevant suggestions and a feeling of lack of control.
Ethical Considerations	Biases, lack of fairness, unclear communication, and potential spread of misinformation.	Loss of user trust, ethical dilemmas, and potential harm to users.
Technical Challenges & Reliability	System downtime, glitches, or reliance on third-party services can disrupt user experience.	Reduced service reliability and user frustration.
User Engagement & Acceptance	Users may prefer more control or be skeptical of automated recommendations.	Reduced user engagement and potential rejection of the service.
Balancing Automation & Human Interaction	Overreliance on automation can diminish the value of human expertise and interaction.	Reduced user satisfaction and potential for missed opportunities for personalized service.

User Education & Communication	Lack of transparency about limitations and data usage can lead to distrust.	Unrealistic expectations, user frustration, and potential misuse of the service.

The analysis shows that anticipatory experiences come with their share of common pitfalls that need careful consideration. *Data privacy and security* are crucial, requiring robust measures to safeguard sensitive information from unauthorized access or breaches. *Accuracy and reliability* are also essential for user satisfaction, highlighting the importance of maintaining precise predictions and adaptable recommendations. While *user reliance* on anticipatory services can simplify decision-making, there's a *risk of overconfidence*, diminishing users' sense of personal responsibility.

Seeking a balance between *customization and standardization* poses a challenge, as some users' unique preferences may not fully align with the system's capabilities. *Ethical considerations*, such as addressing biases and promoting transparency, are crucial for fostering user trust. *Technical challenges*, like system downtime or glitches, can *affect reliability*, emphasizing the need for designing for failure, meaning foreseeing all the possible scenarios that can go wrong in the service and designing safety mechanisms to support user control and accountability over the system. *User engagement and acceptance* may vary, with some users preferring more control or expressing skepticism toward automated recommendations. *Balancing automation with human interaction* is vital, ensuring that personalized expertise isn't overshadowed by automated processes. Lastly, clear *user education and communication* are also relevant, informing users about service limitations, data usage, and the importance of seeking professional advice when needed, thereby fostering trust and managing expectations effectively.

5.2.3.1 Finance Pitfalls

In the finance sector, anticipatory experiences encounter several common pitfalls that demand careful attention (Table 27).

Table 26: Challenges of Anticipatory Experiences in Finance.

Challenge	Description	Impact
Data Privacy & Security Concerns	Sensitive financial data collection raises concerns about breaches and mishandling.	Loss of trust, legal repercussions, and severe consequences for users.
Algorithmic Bias and fairness	Biases in algorithms can lead to unfair financial outcomes for users.	Unequal access to financial opportunities and potential harm to users.

User Understanding & Education	Users may not fully understand the service or risks, leading to uninformed decisions.	Misuse of the service, unrealistic expectations, and potential financial losses.
Overconfidence on Technology	Overreliance on automation can diminish financial literacy and personal judgment.	Poor financial decisions and a lack of preparedness for unforeseen circumstances.
Market Volatility & Economic Events	Predicting market behavior is difficult during volatile times, impacting recommendations.	Reduced effectiveness of the service and potential user frustration.
Technical Challenges & Reliability	System outages, glitches, or inaccurate data disrupt the user experience.	Reduced trust, inconvenience, and potential financial losses for users.
Regulatory Compliance	Navigating complex financial regulations while offering innovative services can be challenging.	Legal issues, service disruptions, and operational challenges.
Loss of Personal Touch	Users may feel a lack of control over their finances due to automation.	Reduced user satisfaction and a potential disconnect from personalized financial advice.
Ethical Considerations	Ensuring investment recommendations align with user values and ethics can be challenging.	Potential for unethical practices and negative impact on user well-being.
Managing User Expectations	High user expectations can lead to disappointment if limitations and ongoing financial assessment are not communicated clearly.	User frustration, loss of trust, and potential misuse of the service.

One primary concern revolves around *data privacy and security*, as all financial services collect and analyze sensitive user financial data. Instances of data breaches or mishandling can severely damage user trust, requiring robust data protection measures and encryption protocols. Additionally, the reliance on algorithms introduces the risk of *algorithmic bias and fairness*, potentially leading to unfair financial outcomes. Regular auditing and adjustments to algorithms are imperative to mitigate biases. Moreover, ensuring *user understanding and education* is crucial, as users may not grasp the workings or risks associated with anticipatory financial services. Providing clear explanations and educational resources becomes paramount. There's also a risk of *overconfidence in technology*, where users may neglect personal financial literacy and judgment, emphasizing the need for continued user engagement in financial planning. Anticipatory experiences may face challenges during *market volatility and economic events*, requiring adaptive strategies and effective management of user expectations. Technical challenges, regulatory compliance, maintaining a personal touch, addressing ethical considerations, and managing user expectations all contribute to the complex landscape of anticipatory experiences in the finance sector.

5.2.3.2 Education Pitfalls

In the education sector, anticipatory experiences encounter a spectrum of common pitfalls that may need careful consideration (Table 28).

Table 27: Challenges of Anticipatory Design in Education.

Challenge	Description	Impact
Data Privacy & Security Concerns	Balancing personalized learning with data protection and complying with regulations.	Potential student data breaches, loss of trust, and legal repercussions.
Algorithmic Bias and Fairness	Educational algorithms perpetuating existing inequalities through biased recommendations.	Unequal learning experiences and unfair educational outcomes for students.
Overconfidence on Technology	Students becoming overly dependent on platforms, diminishing critical thinking and creativity.	Hindered development of essential skills and a potential disconnect from human interaction in learning.
Teacher Preparedness	Lack of training and support for educators to effectively integrate these services.	Ineffective utilization of technology, hindering potential benefits for student learning.
User Engagement	Students disengaging from impersonal or irrelevant platforms.	Reduced effectiveness of the services and potential frustration for users.
Regulatory Compliance	Navigating a complex landscape of regulations across different regions.	Legal issues, service disruptions, and potential operational challenges.
Students' Well-being	Prolonged screen time and technology use can impact students' well-being.	Can negatively impact students' physical and mental health and social interactions.

Common to all industries, one of the leading challenges revolves around *data privacy and security*, as the collection and handling of student data demand robust measures to safeguard privacy while adhering to regulations. Ensuring transparency and compliance is essential to uphold user trust. Additionally, *algorithmic bias and fairness* pose a significant concern, requiring meticulous design and frequent audits to mitigate biases and ensure equitable learning outcomes. There's also a risk of *overconfidence in technology*, potentially diminishing students' problem-solving skills and creativity. Balancing technology's role with human interaction is crucial to prevent dependency on automation. Sustaining *user engagement and acceptance* is fundamental for the efficacy of these services, requiring strategies to maintain student interest. Ethical considerations, such as transparent data practices, are also a concern. Moreover, while *adaptive learning* is powerful, its limitations must be recognized to ensure a balanced educational approach. Finally, ensuring student *health and well-being* among increased screen time underscores the importance of balancing technology-based learning with physical activities for holistic development. Addressing these challenges is key to exploiting the potential of anticipatory experiences in education.

5.2.3.3 Transportation Pitfalls

In the transportation sector, anticipatory experiences encounter countless common pitfalls that require careful evaluation (Table 29).

Table 28: Challenges of Anticipatory Design in Transportation.

Challenge	Description	Impact
Data Privacy & Security	User data collection necessitates robust safeguards and regulatory compliance to maintain trust.	Potential privacy breaches, legal issues, and loss of user trust.
Data Accuracy & Connectivity Reliance	Disruptions in data sources or connectivity can impair the accuracy and reliability of features.	Frustrated users due to unreliable or inaccurate recommendations.
User Acceptance & Trust	Concerns about data usage and intrusiveness necessitate transparent communication.	Reduced user engagement and potential rejection of the service.
Balancing Personalization & Control	Striking a balance between personalized recommendations and user control is crucial.	Overwhelmed or alienated users due to lack of control over recommendations.
Maintenance and Updates	Ongoing attention is required to ensure optimal performance amidst evolving technologies and user expectations.	Outdated systems with reduced effectiveness and potential user frustration.
Regulatory Compliance	Navigating intricate local and international regulations is crucial to avoid legal issues.	Legal entanglements, service disruptions, and operational challenges.

Firstly, *data privacy and security* emerge as a main concern, as the collection and analysis of user data demand robust safeguards to preserve privacy and obey regulations, ensuring user trust remains intact. Additionally, the *reliance on accurate data* and connectivity poses a significant risk, as disruptions in data sources or connectivity can impair the accuracy and reliability of anticipatory features, potentially frustrating users and, ultimately, posing risks to their physical well-being. *User acceptance and trust* are fundamental, as anticipatory experiences may cause concerns about data usage and invasiveness, imposing transparent communication to moderate user hesitations.

Furthermore, the challenge lies in *adapting to diverse user preferences*, seeking a balance between personalized recommendations and user control to avoid overwhelming or alienating users with varying preferences. The need for *maintenance and updates* is key, with anticipatory systems requiring ongoing attention to ensure optimal performance among evolving technologies and user expectations. Lastly, *regulatory compliance* presents a formidable obstacle, as navigating complex local and international regulations demands meticulous adherence to avoid legal entanglements. By addressing these common pitfalls, anticipatory experiences in the transportation sector can maximize their efficacy and utility for users.

5.2.3.4 Hospitality and Travel Pitfalls

The travel industry is on the edge of a revolution. Anticipatory travel experiences, powered by AI and big data, promise to transform the way we plan and experience voyages. However, this exciting vision comes with a set of challenges that the hospitality and travel sector must navigate to ensure smooth and successful experiences, not just for their technology but for their customers as well. Therefore, in this sector, anticipatory experiences confront a multitude of common pitfalls that demand careful attention and strategic mitigation (Table 29).

Table 29: Challenges of Anticipatory Design in Hospitality and Travel.

Challenge	Description	Impact
Data Collection & Analysis	Massive data handling with concerns about data integrity, scalability, and user privacy.	Data breaches, inaccurate recommendations, and potential legal issues.
Predicting User Behavior	Refining machine learning (ML) algorithms and incorporating user feedback for accurate predictions.	Irrelevant recommendations, user frustration, and decreased user engagement.
Adapting to Change	Keeping recommendations relevant as user preferences and market dynamics evolve.	Outdated recommendations missed opportunities for personalization, and potential loss of customers.
Privacy & Security	Implementing strong data privacy measures and complying with regulations to protect user information.	Privacy breaches, loss of user trust, and potential legal repercussions.
Personalization vs. Control	Balancing personalized recommendations with user autonomy and control over preferences.	Feeling overwhelmed by recommendations or a lack of

		personalization, leading to user dissatisfaction.
Bias & Fairness	Monitoring and mitigating biases in algorithms to ensure fair and non-discriminatory recommendations.	Unfair or discriminatory recommendations, exacerbating existing inequalities, and potential legal issues.
Transparency & Trust	Communicating data usage and the basis of recommendations clearly and transparently to build user trust.	Lack of trust, user apprehension, and decreased adoption of services.
Unforeseen Events	Adapting to disruptions (e.g., weather, travel restrictions) that can impact travel plans and pricing.	Outdated or irrelevant recommendations, user inconvenience, and potential loss of bookings.
Regulatory Compliance	Ensuring data protection and privacy compliance, especially in regions with varying regulations (e.g., GDPR).	Legal repercussions, operational limitations, and potential damage to brand reputation.

One of the biggest challenges lies in *data collection and analysis*. These services rely on vast amounts of user data, from past travel choices to online browsing habits. While this data is crucial for personalization, ensuring data integrity, scalability, and most importantly, user privacy, is hard and complicated. Data breaches can be devastating, not only for the service's reputation but also for user trust. Robust security measures, coupled with transparency about data usage, are essential to building a foundation of trust with customers.

Another challenge lies in *predicting user behavior*. ML and big data algorithms power these services, but refinement and adaptation are key. Imagine a system that keeps recommending ski trips despite your newfound passion for scuba diving. Continuously refining algorithms based on user feedback and incorporating real-time data are essential for ensuring recommendations remain relevant and engaging. Travelers are not static entities, and *adapting to changing user preferences and market dynamics* is another hurdle. Imagine a service stuck recommending the same family-friendly resort after your children have grown up. The ability to adapt recommendations to evolving preferences and keep pace with market changes is crucial for remaining competitive. *Privacy and security concerns* are a constant worry. While personalization requires data collection, users are increasingly wary of how their information is used. Compliance with regulations like GDPR is not just a legal requirement, but a key factor in building user trust.

Finding the *balance between personalization and user control* is another challenge. Users still desire autonomy and control over their travel experience. The ability to customize preferences and control over unwanted recommendations is essential for user satisfaction.

Algorithm bias and fairness must also be addressed. Imagine a system consistently recommending luxury hotels that are out of your budget range. Algorithmic biases can lead to unfair or discriminatory recommendations. Regularly assessing algorithms for unintended biases and taking corrective measures is crucial for ensuring equitable travel experiences for all. *Transparency and user trust* go hand in hand. Imagine a service suggesting destinations with no explanation for the recommendation. Building trust requires clear communication about how data is used and the rationale behind recommendations. Users deserve to understand the "why" behind the suggestions they receive.

The travel industry is also subject to *unforeseen events* like weather disruptions or travel restrictions. Imagine a service recommending a beach vacation during a hurricane. The ability to adapt recommendations in real time based on unforeseen circumstances is essential for ensuring user safety and satisfaction. Finally, *regulatory compliance* with data protection and privacy regulations such as GDPR[12], especially when operating in multiple jurisdictions, is a complex but necessary effort. Staying up-to-date on evolving regulations and investing in ongoing compliance efforts are essential for avoiding legal issues and maintaining a positive brand reputation.

5.2.3.5 Healthcare Pitfalls

The future of healthcare is glowing with potential. Anticipatory experiences promise a new era of personalized care, predicting and preventing health issues before they arise. However, this exciting vision comes with a set of challenges that healthcare providers must navigate to ensure patient safety, trust, and ethical practices (Table 31).

Table 30: Challenges of Anticipatory Design in Healthcare.

Challenge	Description	Impact
Data Privacy and Security	User data collection and analysis are essential for personalized experiences but raise concerns about privacy breaches and loss of trust.	Breaches can expose sensitive data, leading to legal issues and eroded user trust.
Accuracy and Limitations of Recommendations	Recommendations rely on data analysis and algorithms, which can be inaccurate, lack individual context, and miss unforeseen circumstances.	Inaccurate or irrelevant recommendations can lead to poor decision-making and negative health outcomes.

[12] Europe General Data Protection Regulation

User Reliance and Overconfidence	Services can heavily influence user decisions, potentially leading to a loss of personal control and responsibility for health.	Overconfidence can delay or prevent users from seeking professional advice they may need.
Ethical Use of Data	Data misuse, such as a lack of user consent, inadequate anonymization, and biased algorithms, can lead to inequitable and unfair recommendations.	Biased recommendations can widen health disparities and negatively impact individual health outcomes.
Managing User Expectations	High expectations created by the services can lead to unrealistic beliefs about their capabilities.	Disappointment with limitations can discourage users from using the service or impact treatment adherence.
Technical Challenges and Reliability	Technical glitches, system failures, and dependence on technology can disrupt user experience and lead to dissatisfaction.	System downtime can disrupt service access and negatively impact user trust.
Regulatory Compliance	Non-compliance with data protection regulations can result in legal violations and loss of user trust.	Legal repercussions and fines can damage the service's reputation and limit its operation.

One of the most pressing concerns is *data privacy and security*. Anticipatory experiences rely heavily on collecting and analyzing personal health information. While this data is crucial for effective recommendations, data breaches can have devastating consequences, exposing sensitive medical information and eroding patient trust. Robust security measures, along with clear communication regarding data usage and anonymization practices, are essential to building a foundation of trust.

Another challenge lies in the *accuracy and limitations of recommendations*. Algorithms power these services, but they are not infallible. Inaccurate or incomplete data, coupled with limitations in capturing individual complexities, can lead to misguided recommendations. Imagine a system overlooking a crucial family history detail due to incomplete data, potentially delaying a necessary diagnosis. Regular updates, real-time data analysis, and incorporating professional human-in-the-loop feedback cycles are all crucial for improving accuracy and ensuring recommendations are relevant and actionable.

User reliance and overconfidence on these services present another hurdle. Patients trusting automated recommendations implicitly could diminish their own responsibility for their health. Imagine someone delaying a doctor's visit due to a reassuring app notification, potentially missing a critical window for intervention. Balancing automated guidance with user input and promoting the importance of consulting healthcare professionals is key to empowering patients to make informed decisions. *Ethical use of data* is another obstacle. Obtaining informed consent, anonymizing data whenever possible, and addressing potential biases within algorithms are all crucial to ensuring fair and equitable recommendations. Imagine a biased algorithm overlooking a certain symptom in a specific demographic, potentially delaying diagnosis for a segment of the population. Prioritizing ethical data practices is essential to avoid exacerbating existing health disparities. Therefore, *managing user expectations* is critical. Anticipatory experiences can create unrealistic expectations about their capabilities. Imagine a patient neglecting important lifestyle changes because they believe an app will prevent any health issues. Clear communication regarding the limitations of the services and the importance of a holistic approach to healthcare is vital for setting appropriate expectations. *Technical challenges and reliability* can also disrupt user experience. Technical glitches, system failures, and dependence on technology can all lead to frustration and a decline in trust. Investing in robust technical infrastructure, ensuring scalability and reliability, and having a rapid response system for technical issues are all crucial for maintaining user satisfaction.

Finally, *regulatory compliance* with data protection laws is essential. Failure to comply with regulations like the Health Insurance Portability and Accountability Act (HIPAA) and GDPR can result in legal repercussions and erode user trust. Healthcare providers must stay up-to-date on evolving regulations and invest resources in ongoing compliance efforts.

In conclusion, anticipatory experiences in healthcare can offer a glance into a future of personalized care, but it's a future that requires careful consideration of the challenges outlined above. By prioritizing data security, ethical practices, clear communication, and accessibility, healthcare providers can harness the power of these technologies to create a future where patients are empowered partners in their own well-being.

5.2.3.6 Retail Pitfalls

The future of retail is personalized. Anticipatory experiences promise a shopping experience tailored to individual needs and desires. But with great power comes great responsibility. While these technologies offer undeniable benefits, they also present a unique set of challenges that retailers must navigate to ensure long-term success (Table 32).

Table 31: Challenges of Anticipatory Design in Retail.

Challenge	Description	Impact

Data Privacy & Security	Extensive user data collection raises privacy concerns and necessitates robust security measures to prevent breaches.	Potential for data breaches, user privacy violations, and loss of trust.
Algorithmic Bias and fairness	Flawed algorithms may perpetuate inequalities or lead to inaccurate recommendations.	Unfair or irrelevant recommendations, exacerbating social biases and hindering customer experience.
Overconfidence on Automation	Overreliance on automation can diminish the human touch in shopping experiences.	Lack of personalization, reduced customer engagement, and a sterile shopping environment.
Invasive Marketing Tactics	Invasive marketing tactics can overwhelm users with unwanted recommendations.	User frustration decreased brand loyalty, and disengagement from the platform.
Accuracy Limitations	Predictions and recommendations may be inaccurate due to limitations in technology.	User frustration missed opportunities for sales, and potential damage to brand reputation.
Regulatory Compliance	Compliance with data protection regulations can be complex and challenging.	Legal repercussions, fines, and operational limitations if regulations are not met.
User Resistance	Some users may resist data collection or be skeptical of personalized recommendations.	Difficulty in user adoption and potential for lower engagement with the technology.

One of the biggest struggles is ensuring *data privacy and security*. Extensive data collection, the foundation of personalization, raises concerns about user privacy. Data breaches can be devastating, breaking users' trust and potentially leading to legal repercussions. Retailers must prioritize robust security measures, transparent data practices, and strict adherence to regulations like GDPR to maintain user confidence. Another challenge lies in *algorithmic bias and fairness*. Flawed algorithms can perpetuate social inequalities or deliver inaccurate recommendations. Imagine a system recommending beauty products that cater to a specific skin tone, potentially excluding users outside that demographic. This can not only be frustrating for users but also reinforce existing biases. Retailers need to invest in fair and unbiased algorithms, as well as communicating that a user may be a potential outlier from their training set, to bring more transparency to the service.

The human touch is a vital part of the shopping experience, and *overconfidence on automation* can have a negative impact. This lack of human guidance can lead to user disengagement.

Retailers should strive for a balance, leveraging automation for efficiency while maintaining opportunities for human interaction and customer service. Similarly, *invasive marketing tactics* can backfire. The premise of anticipatory experiences is to reduce de user cognitive effort by streamlining overload of information. Bombarding users with irrelevant recommendations can quickly turn this principle off. The key is to personalize marketing messages while respecting user preferences. Finding this balance allows retailers to promote products effectively without overwhelming their customer base.

Accuracy limitations may become another hurdle. Predictive algorithms are not foolproof, and inaccurate recommendations can lead to user frustration and missed sales opportunities. Retailers need to continuously refine their algorithms based on user feedback and real-time data to improve accuracy and ensure a positive customer experience. *Regulatory compliance* adds another layer of complexity. Data protection regulations are constantly evolving, and staying compliant can be challenging. However, failing to do so can result in hefty fines and operational limitations. Retailers must invest in resources to ensure they understand and adhere to all relevant regulations. *User resistance* can also be a barrier to adoption. Some users may be hesitant to share personal data or may simply prefer a more traditional shopping experience. Retailers need to build trust and offer clear value propositions to encourage user participation with these technologies.

In conclusion, the future of retail is undoubtedly personalized, but achieving this vision requires a delicate balancing act. By addressing these challenges and prioritizing user privacy, trust, and ethical practices, retailers can harness the power of anticipatory technologies to create a win-win situation for both businesses and customers.

5.3 Strategies to Overcome Pitfalls

As a result of the previous analysis, we understand now that anticipatory experiences have been manifested in myriad applications, from personalized recommendations to predictive analytics, across multiple industries. However, the substantial potential benefits are counterbalanced by notable pitfalls that must be meticulously addressed to ensure the effectiveness, ethicality, and acceptance of anticipatory experiences.

Key challenges include ensuring data privacy and security, maintaining the accuracy and reliability of predictions, preventing over-reliance on automated recommendations, providing sufficient customization options, addressing ethical considerations, managing technical reliability, fostering user engagement and acceptance, balancing automation with human interaction, and effectively educating and communicating with users. To navigate these challenges, it is essential to adopt a strategic approach that aligns with a robust anticipatory design framework. The following Table 33 presents a comprehensive set of strategies designed to mitigate these general challenges. By adopting these strategies, organizations can create anticipatory experiences that are secure, accurate, user-centric, and ethically responsible, ultimately building and maintaining user trust and satisfaction.

Table 32: Strategies to overcome general challenges in anticipatory experiences.

Challenges	Strategies to Overcome Challenges
Data Privacy & Security	- Implement robust encryption and access controls. - Conduct regular security audits and vulnerability assessments. - Adhere to data protection regulations (e.g., GDPR, CCPA). - Educate users on data privacy policies and practices.
Accuracy & Reliability	- Use high-quality, diverse datasets for training algorithms. - Continuously update and validate models to reflect current data. - Implement feedback loops to improve system performance.
User Reliance & Overconfidence	- Encourage users to verify automated recommendations. - Provide decision support tools rather than fully automated solutions. - Through design, educate users on the importance of critical thinking.
Limited Customization & Control	- Allow users to adjust recommendation settings and provide feedback. - Develop user-friendly interfaces for customization. - Offers opt-out options for personalized experiences.
Ethical Considerations	- Ensure transparency in algorithmic processes and decision-making. - Regularly audit algorithms for biases and fairness. - Establish ethical guidelines and governance frameworks. - Communicate clearly about the ethical implications of the systems.
Technical Challenges & Reliability	- Implement failover mechanisms and redundancy. - Regular maintenance and updates of technical infrastructure are conducted. - Monitor systems continuously for performance issues.
User engagement & Acceptance	- Provide clear, accessible information about how systems work and their benefits. - Solicit and incorporate user feedback to improve system design. - Ensure transparency about data usage and limitations.
Balancing Automation & Human Interaction	- Integrate human oversight in automated processes when critical. - Encourage human interaction and support in customer service. - Design systems that enhance rather than replace human expertise.
User Education & Communication	- Develop comprehensive user guides and educational resources. - Communicate system limitations and encourage seeking customer support when needed.

	- Maintain open channels for user queries and support.

These strategies can be a starting point to propose an Anticipatory Design framework. By systematically applying principles such as understanding user intent, forecasting, backcasting, integrating into the design process, and implementing and monitoring, organizations can develop anticipatory systems that embody robustness in security, reliability, user-centricity, and ethical integrity.

To effectively tackle the potential of the anticipatory design framework in addressing the challenges outlined in this analysis, it is essential to align strategic initiatives that synergistically complement the core principles of anticipation, user-centricity, and iterative refinement. Table 34 presents a structured compilation of strategies meticulously aligned with the proposed anticipatory design framework. By seamlessly incorporating these strategies into the stages of understanding user intent, forecasting future trends, backcasting desired outcomes, integrating them into the design process, and implementing and monitoring solutions, organizations can enhance the resilience, reliability, and ethical grounding of anticipatory systems.

Table 33: Strategies aligned with anticipatory design framework.

Challenges	Strategies to Overcome Challenges	Anticipatory Design Framework
Data Privacy & Security	- Implement robust encryption and access controls. - Conduct regular security audits and vulnerability assessments. - Adhere to data protection regulations (e.g., GDPR, CCPA). - Educate users on data privacy policies and practices.	▪ Forecasting (Data Collection and Analysis) ▪ Implement and Monitor (Automation Tools, Performance Metrics)
Accuracy & Reliability	- Use high-quality, diverse datasets for training algorithms. - Continuously update and validate models to reflect current data. - Implement feedback loops to improve system performance.	▪ Forecasting (Predictive Modeling) ▪ Integrate into the Design Process (User Feedback Loops) ▪ Implement and Monitor (Continuous Improvement)

User Reliance & Overconfidence	- Encourage users to verify automated recommendations. - Provide decision support tools rather than fully automated solutions. - Through design, educate users on the importance of critical thinking.	▪ Understand User Intent (User Research) ▪ Integrate into Design Process (Design Thinking, User Feedback Loops)
Limited Customization & Control	- Allow users to adjust recommendation settings and provide feedback. - Develop user-friendly interfaces for customization. - Offers opt-out options for personalized experiences.	▪ Integrate into Design Process (Design Thinking, User Feedback Loops)
Ethical Considerations	- Ensure transparency in algorithmic processes and decision-making. - Regularly audit algorithms for biases and fairness. - Establish ethical guidelines and governance frameworks. - Communicate clearly about the ethical implications of the systems.	▪ Understand User Intent (User Research) ▪ Forecasting (Predictive Modeling) ▪ Integrate into the Design Process (User Feedback Loops)
Technical Challenges & Reliability	- Implement failover mechanisms and redundancy. - Regular maintenance and updates of technical infrastructure are conducted. - Monitor systems continuously for performance issues.	▪ Implement and Monitor (Automation Tools, Performance Metrics, Continuous Improvement)
User engagement & Acceptance	- Provide clear, accessible information about how systems work and their benefits. - Solicit and incorporate user feedback to improve system design. - Ensure transparency about data usage and limitations.	▪ Understand User Intent (User Research ▪ Integrate into Design Process (User Feedback Loops)
Balancing Automation & Human Interaction	- Integrate human oversight in automated processes when critical. - Encourage human interaction and support in customer service. - Design systems that enhance rather than replace human expertise.	▪ Integrate into Design Process (Design Thinking, Agile Methodologies, User Feedback Loops)
User Education & Communication	- Develop comprehensive user guides and educational resources. - Communicate system limitations and encourage seeking customer support when needed.	▪ Understand User Intent (User Research ▪ Integrate into Design Process (User Feedback Loops) ▪ Implement and Monitor (Continuous Improvement)

	- Maintain open channels for user queries and support.	

Each strategy is strategically crafted to navigate through the complexities of data privacy, user trust, customization needs, and ethical considerations, ensuring that anticipatory experiences not only meet but exceed user expectations while adhering to stringent ethical standards. This cohesive alignment underscores the transformative potential of anticipatory design frameworks in fostering innovation and sustainable growth across diverse sectors.

5.4 Developing Heuristics for Anticipatory Systems

This exercise of delineating challenges and aligning them with the anticipatory design framework can open the door to a set of valuable heuristics for guiding the development and evaluation of anticipatory experiences. A heuristic, in this context, refers to a practical approach or methodological guideline used to assess and improve the effectiveness of anticipatory systems based on established principles and best practices.

According to Nielsen and Molich (1990), heuristics are "rules of thumb" that help designers identify usability problems in user interfaces by leveraging prior knowledge and established design principles. These principles are adapted in the context of anticipatory experiences to ensure they effectively meet user needs and expectations (Jakob Nielsen 1994).

Heuristics are essential in providing structured evaluation criteria that ensure anticipatory systems are robust, reliable, and user-centric. They encompass methods for understanding user intent, forecasting future trends, backcasting desired outcomes, integrating anticipatory processes into design methodologies, and implementing continuous monitoring and improvement mechanisms. By adhering to these heuristic principles, organizations can enhance the resilience, reliability, and ethical integrity of anticipatory systems.

However, it is crucial to recognize that while these proposed heuristics offer a structured framework, additional empirical studies and testing within real-world business contexts are imperative to further validate their applicability and effectiveness. This empirical validation is essential for establishing the scientific validity and practical utility of these proposed heuristics in enhancing anticipatory systems.

In the realm of user experience design, Nielsen's 10 usability heuristics have long served as a foundational framework for evaluating and improving the usability of interactive systems.

Developed by Nielsen and Molich (1990), these heuristics provide practical guidelines for identifying usability issues within user interfaces, focusing on aspects such as visibility of system status, user control and freedom, and error prevention, among others.

Today, as we delve into the realm of anticipatory design — where systems proactively predict user needs and behaviors — it becomes imperative to rethink and align Nielsen's heuristics with the unique challenges and opportunities presented by anticipatory experiences. This adaptation will not only ensure that anticipatory systems meet usability standards but also address critical challenges such as data privacy, accuracy, and user reliance effectively.

To achieve this alignment, we propose mapping each of Nielsen's heuristics to specific strategies aimed at overcoming the challenges inherent in anticipatory design. By doing so, we aim to enhance the resilience, reliability, and ethical integrity of anticipatory systems, ensuring they not only meet users' expectations but also empower them with intuitive and efficient interactions.

The following Table 35 presents a structured approach to integrating Nielsen's heuristics with anticipatory design challenges, thereby facilitating a comprehensive evaluation framework that guides the development and assessment of anticipatory systems. This integration underscores the importance of usability principles in fostering user acceptance and satisfaction in the era of proactive digital experiences.

Table 34: Aligning Nielsen's heuristics with anticipatory design evaluation challenges.

Nielsen's Heuristic	Proposed Heuristics	Description	Strategy
Visibility of system status	Keep users informed	Ensure users are continuously aware of the anticipatory system's current status and operations.	**Data Privacy & Security:** Educate users on data privacy policies and practices. **Accuracy & Reliability:** Implement feedback loops to improve system performance.
Match with user expectations	Align with mental models	Anticipatory systems should use language, concepts, and predictions that align with users' expectations and mental models.	**User Reliance & Overconfidence:** Through design, educate users on the importance of critical thinking.
User control and freedom	Allow user intervention	Provide users with control over anticipatory interactions,	**Limited Customization & Control:** Allow users to adjust

		allowing them to adjust or override recommendations easily.	recommendation settings and provide feedback.
Consistency and standards	Maintain design coherence	Maintain consistency in design elements and interaction patterns across anticipatory features.	**Accuracy & Reliability:** Continuously update and validate models to reflect current data.
Error prevention	Minimize anticipatory errors	Anticipatory systems should include mechanisms to prevent erroneous predictions and actions.	**Accuracy & Reliability:** Use high-quality, diverse datasets for training algorithms.
Recognition rather than recall	Reduce cognitive load	Present information and recommendations in anticipatory interfaces in context, minimizing the need for users to remember or anticipate system behavior.	**User engagement & Acceptance:** Provide clear, accessible information about how systems work and their benefits.
Flexibility and efficiency of use	Cater to user proficiency	Anticipatory systems should be flexible to accommodate both novice and expert users efficiently.	**Balancing Automation & Human Interaction:** Integrate human oversight in automated processes when critical.
Aesthetic and minimalist design	Present information cleanly	Anticipatory interfaces should be designed in a clean and uncluttered manner, focusing on essential information.	**User Education and Communication:** Development comprehensive user guides and educational resources.
Error recovery	Assist users in error resolution	Help users understand and recover from errors encountered in anticipatory interactions.	**Technical Challenges & Reliability:** Implement failover mechanisms and redundancy.
Help and documentation	Provide user assistance	Offer accessible help and documentation that guides users through anticipatory functionalities effectively.	**User Education & Communication:** Maintain open channels for user queries and support.

Aligning Nielsen's usability heuristics with anticipatory design evaluation challenges offers a structured approach to enhancing the effectiveness and user-centricity of anticipatory systems. By integrating established usability principles with strategies tailored to overcome specific challenges such as data privacy, reliability, user engagement, and ethical considerations, organizations can foster robust and trustworthy anticipatory experiences. This alignment not only provides a comprehensive framework for evaluating anticipatory systems but also promotes continuous improvement through iterative refinement and user feedback. Moving forward, empirical validation and real-world testing will be essential to further substantiate the applicability and effectiveness of these aligned heuristics, ensuring their relevance in advancing the field of anticipatory design.

5.4.1 Proposing an Anticipatory Design Heuristic Checklist

Designing effective anticipatory experiences requires a structured approach that adheres to established heuristics while addressing the unique challenges of predictive systems. The checklist presented here synthesizes Nielsen's heuristics with the proposed anticipatory design heuristics checklist (Table 36) to guide designers and developers in creating user-centered anticipatory systems. By focusing on visibility, user control, error prevention, and flexibility, among other principles, this checklist ensures that anticipatory systems are transparent, intuitive, and aligned with user needs. It serves as a practical reference, bridging the gap between theory and application, and equips teams with actionable steps to create systems that empower users while minimizing cognitive overload, errors, and ethical concerns.

Table 35: Proposed anticipatory design heuristics checklist.

Keep Users Informed Ensure transparency by keeping users aware of system operations, predictions, and underlying processes.	☐ **Provide real-time feedback:** Ensure the system clearly communicates its status and current operations (e.g., predictions in progress, actions being taken).
	☐ **Educate users on data privacy:** Include visible and easy-to-access information about data privacy and system security practices.
	☐ **Implement feedback loops:** Regularly update users on how their feedback has improved system performance.
Align with Mental Models Design anticipatory systems to align with users' expectations and familiar workflows.	☐ **Use intuitive language:** Ensure the system uses terminology and interaction patterns familiar to the target audience.
	☐ **Align with mental models:** Verify that the system's predictions and recommendations align with user expectations and behaviors.
	☐ **Promote critical thinking:** Integrate design elements that encourage users to evaluate system predictions critically.
Allow User Intervention Provide mechanisms for users to customize, adjust, or override system recommendations	☐ **Enable override options:** Provide users with clear ways to adjust or reject system recommendations.
	☐ **Allow customization:** Include settings for users to tailor the system's behavior to their preferences (e.g., level of automation, notification preferences).
	☐ **Provide feedback channels:** Allow users to provide input on the system's predictions and actions.

Maintain design coherence Ensure consistency in design elements and interaction patterns across all anticipatory features.	☐ **Maintain design coherence:** Ensure consistent design elements across all anticipatory features (e.g., colors, fonts, button placements).
	☐ **Validate models regularly:** Update models to reflect current and accurate data, ensuring predictions remain relevant.
Minimize Anticipatory Errors Incorporate safeguards to reduce the likelihood of erroneous predictions or recommendations.	☐ **Minimize erroneous predictions:** Use diverse and high-quality datasets to train algorithms.
	☐ **Test system robustness**: Conduct thorough testing to identify potential biases or inaccuracies in predictions.
	☐ **Provide preemptive warnings:** Notify users about potential inaccuracies or limitations in predictions.
Reduce Cognitive Load Present anticipatory information in ways that minimize the mental effort required from users.	☐ **Contextualize recommendations:** Present recommendations in a way that connects to the user's current context, reducing cognitive load.
	☐ **Explain predictions clearly:** Include explanations of why certain predictions or actions are being suggested.
	☐ **Highlight system benefits:** Provide accessible, clear information about how the system benefits users.
Cater to User Proficiency Design systems to accommodate both novice and expert users.	☐ **Accommodate diverse users:** Ensure the system is usable by both novice and expert users with different levels of technical proficiency.
	☐ **Balance automation and control:** Integrate human oversight into critical automated processes.
	☐ Streamline workflows: Design anticipatory processes that enhance user efficiency without introducing unnecessary complexity.
Present Information Cleanly Ensure the anticipatory interface is aesthetically pleasing and focused on delivering essential insights.	☐ **Focus on essential information:** Present recommendations and system feedback in a clean and uncluttered manner.
	☐ **Prioritize clarity**: Avoid overwhelming users with excessive or irrelevant details.
	☐ **Use visual hierarchy:** Ensure important elements stand out visually while maintaining a cohesive design.
Assist Users in Error Resolution Provide mechanisms to help users understand and recover from errors in anticipatory interactions.	☐ **Provide recovery options:** Offer users clear pathways to resolve errors caused by the anticipatory system.
	☐ **Implement failover mechanisms:** Ensure system reliability by adding redundancy to critical processes.
	☐ **Guide users during errors:** Include step-by-step instructions for resolving common errors.
Provide User Assistance	☐ **Make help accessible:** Include a dedicated help section with detailed documentation on anticipatory system features.

Offer accessible help and documentation to guide users through anticipatory functionalities effectively.	☐ **Provide contextual assistance:** Offer help or tips relevant to the user's current interaction within the system.
	☐ **Maintain support channels:** Ensure users can easily reach out to customer support or submit feedback.

6 Designing for Anticipatory Experiences

6.1 Introduction

Anticipatory design represents a paradigm shift in human-computer interaction, moving beyond reactive systems to create proactive solutions that address both immediate and evolving user needs. Building upon the theoretical foundations established in Chapter 2 and 3, and the empirical insights from Chapter 5's scoping review, this chapter introduces a structured framework that synthesizes foresight methodologies, predictive analytics, and behavioral science principles into anticipatory systems design.

The framework aims to address a critical gap identified in current literature: the absence of systematic approaches for integrating anticipatory capabilities into user-centered design practice (Morrison et al., 2021; Celi & Colombi, 2020). While existing design methodologies excel at addressing current user needs, they lack the forward-looking mechanisms necessary for anticipatory systems that must adapt to changing contexts and emergent behaviors.

Central to this framework is the integration of behavioral science principles that inform ethical anticipatory design. Drawing from nudge theory (Thaler and Sunstein 2008), and the Transtheoretical Model (Prochaska & DiClemente, 1983), the framework ensures that anticipatory systems enhance rather than manipulate user decision-making. This ethical imperative distinguishes anticipatory design from predictive systems that merely forecast user actions without considering broader implications for user autonomy and well-being.

The framework employs strategic foresight methodologies—including scenario planning, environmental scanning, and the Delphi Method—to enable designers to navigate uncertainty and align short-term predictions with long-term goals (Poli, 2019; Voros, 2017). Unlike traditional forecasting that extrapolates current trends, foresight broadens design scope by considering alternative possibilities and their implications for user experience.

To manage the inherent complexity of anticipatory design , this chapter structures the framework around the concept of *UX chunks*, inspired by George A. Miller’s (1956) cognitive load theory. This chunking approach organizes complex anticipatory design processes into manageable, interconnected components that designers can systematically address without cognitive overload. Miller's work established that the average person could process only 7 (plus or minus 2) items in their working memory. This approach is informed by principles from:

- **Cognitive Load Theory**: Reducing mental effort by organizing information into manageable chunks to support user focus.
- **Interaction Design**: Structuring workflows into smaller steps, such as progressive disclosure or multi-step processes, to improve usability.
- **Information Architecture**: Organizing content hierarchically or categorically to enhance navigation and comprehension.

By structuring the framework into meaningful, manageable components, this chapter aims to create anticipatory systems that are not only predictive but also deeply user-centered. This commitment to innovation, ethical responsibility, and user empowerment ensures that anticipatory systems elevate, rather than undermine, the human experience. The proposed framework is designed to navigate complexity while maintaining coherence, adaptability, and a user-first perspective, laying a foundation for both theoretical insight and practical application.

6.2 Foundations of the Framework

The proposed framework addresses limitations identified in current anticipatory design practice through empirical analysis of 21 case studies across six industries (Chapter 5). Key challenges included a lack of systematic approaches, insufficient consideration of long-term user goals, and inadequate integration of behavioral science principles. Therefore, the proposed framework aims to balance human control and AI automation, ensuring that anticipatory systems are not only effective but also ethical and aligned with user values. Drawing from behavioral science, foresight methodologies, and real-world case studies, it provides actionable steps for designing adaptive, transparent, and user-centered anticipatory experiences.

6.2.1 Core Principles of Anticipatory Design

As established in Chapter 2, anticipatory design requires a multi-dimensional approach that incorporates temporal methods (forecasting, backcasting, and foresight), human-centered principles, and ethical considerations. Consequently, this framework is chunked around three key phases: *Anticipating Directions of Change*, *Imagining Alternative Scenarios*, and *Shaping Choices* (Figure 56). Each phase includes actionable steps, supported by real-world examples and theoretical foundations to guide designers in building adaptive, transparent, and user-centered systems.

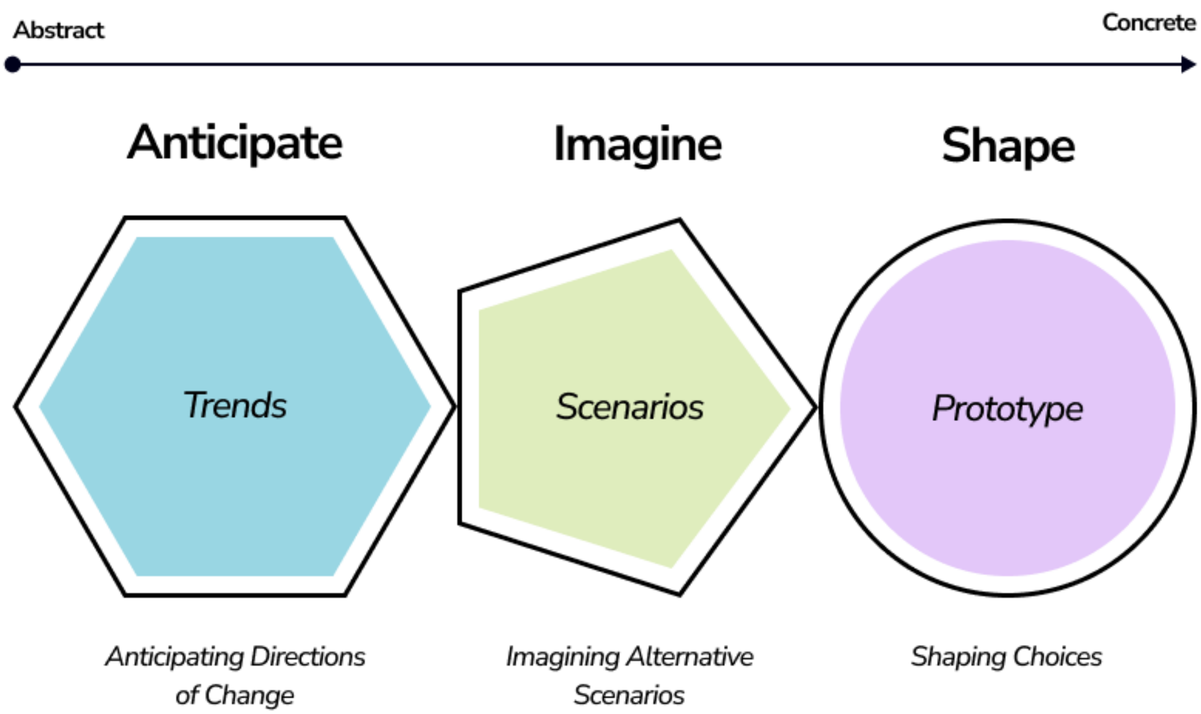


Figure 55: Our proposed framework for anticipatory design.

By breaking down anticipatory design processes into a concise set of chunks, each module contains specific yet adaptable procedures. The framework aims to guide professionals along a structured and less ambiguous path. This modular approach aims to simplify the design process, making it more linear and manageable. By organizing the workflow into meaningful, streamlined phases, professionals can more easily address, understand, and recall each step, enhancing both the efficiency and clarity of their work in creating anticipatory systems.

The framework rests on three evidence-based principles derived from the literature synthesis and case study analysis:

1. **User Intent as a Central Focus**:
    - Anticipatory systems must align with users' goals and motivations, as discussed in Section 2.5.1 on mental models. Anticipatory systems must align with users' explicit and latent goals, as demonstrated by successful implementations like Nest's thermostat system (Shapiro, 2015). This principle draws from Norman's (2013) user-centered design principles and extends them to anticipatory contexts where user intent must be inferred from behavioral patterns and contextual cues.

2. **Temporal Integration**:
    - Effective anticipatory systems synthesize multiple temporal perspectives: forecasting (data-driven predictions), backcasting (goal-oriented planning), and foresight (scenario exploration) (Poli, 2017). This integration addresses the limitation of single-temporal approaches identified in failed systems like Digit and Vi Sense headphones (Chapter 4).

3. **Behavioral Science as a Guide**:
    - Behavioral frameworks, like the Transtheoretical Model (Section 3.5.1.1) and Nudge Theory (Section 3.5.1.2), inform the design of interventions that resonate with users' cognitive and emotional states. The framework incorporates established behavioral frameworks—Fogg's Behavior Model (B=MAP), the Transtheoretical Model, and Nudge Theory—to ensure interventions resonate with users' cognitive and emotional states while maintaining autonomy (Fogg, 2009; Thaler & Sunstein, 2008).

6.3 A Framework for Anticipatory Design

As shown in Figure 56, this research proposes a three-phase framework—**Anticipate, Imagine, Shape**—providing a structured methodology for integrating foresight, predictive modeling, and behavioral science principles into the design process. Traditional UX design often follows a linear process of research, design, development, testing, and iteration based on user feedback (Norman 1986; Cross 2008; Geneva: International Organization for Standardization 2019). While iterative design is valuable, it's inherently reactive, addresses problems only after they have been identified.

Anticipatory design, by contrast, aims to incorporate predictive and proactive capabilities, leveraging data analysis, trend forecasting, and behavioral science to understand not just current user needs but also their likely future needs and behaviors (Shapiro 2015; Poli 2017; 2019). In essence, the framework seeks to enables professionals to create systems that are not only user-friendly today but also remain relevant and intuitive as user needs and technology evolve. Exisitng design frameworks rarely address the specific anticipatory design requirements of dynamic contexts, where user needs and socio-technical environments shift continuously over time (Hassenzahl and Tractinsky 2006; Carroll and Rosson 2003).

Adopting an anticipatory approach requires more than just a shift in mindset. It necessitates the integration of new tools and techniques, explored in Chapters 2, 3, and 4. Moreover, anticipatory design is not a one-time process but an iterative journey. As user needs and technology evolve, system must adapt accordingly through continuous monitoring, feedback gathering, and refinement (Amershi et al. 2019b; Shneiderman 2020).

The three-phase framework detailed in this chapter provides a structured yet flexible approach for implementing anticipatory design. As illustrated in Figure 56, the framework unfolds as follows:

- **Phase 1: Anticipate Directions of Change**—focuses on identifying emerging trends, user motivations, and contextual shifts through methods such as horizon scanning and behavioral analysis (Voros 2017; Poli 2017).
- **Phase 2: Imagine Alternative Scenarios**—leverages scenario planning and backcasting to develop plausible future scenarios and align them with user desired outcomes (Rohrbeck 2008; Poli 2017).
- **Phase 3: Shape Our Choices—**guides the iterative design process, emphasizing agile development, user feedback integration, and ethical considerations to refine the system's design in light of foresight insights (Amershi et al. 2019b).

The goal of this framework is to establishe a continuous improvement process that ensures that systems remain relevant, efficient, enjoyable, and desirable to the user over time—Ultimatly enhancing satisfaction and fostering sustained engagement. In doing so, acknowledges the ever-changing nature of technology and human behavior for sustainable business growth.

Throughout this chapter, the practical application of the framework highlights the importance of user control, transparency, and alignment between system goals and user aspirations (Shneiderman 2020). The core philosophy is to design systems that anticipate user needs rather than simply respond to them, creating a more intuitive and user-centric digital experience.

The framework also promotes a collaborative design process that empowers designers and non-designers to create technology that integrates automation seamlessly into everyday life (Amershi et al. 2019b). By continually monitoring user behavior, technological advancements, and societal shifts, designers can adapt and refine the system to remain relevant and effective in evolving contexts.

To navigate these complexities, the three-phase framework integrates forecasting, backcasting, and human-centered design principles (Poli 2017; Voros 2017; Geneva: International Organization for Standardization 2019), offering a foundation for anticipatory systems that balance predictive power with user agency, ethics, and adaptability.

6.3.1 Phase 1: Anticipate

The first phase (Figure 57), *anticipating directions of change*, is about understanding the present while projecting possible futures. It involves rigorous research to identify current user needs and behaviors, combined with trend analysis and forecasting techniques to explore how these may evolve (Voros 2017; Poli 2017). This phase draws on both qualitative and quantitative data, leveraging tools and methodologies to pinpoint emerging user needs and anticipate potential disruptions (Rohrbeck 2008).

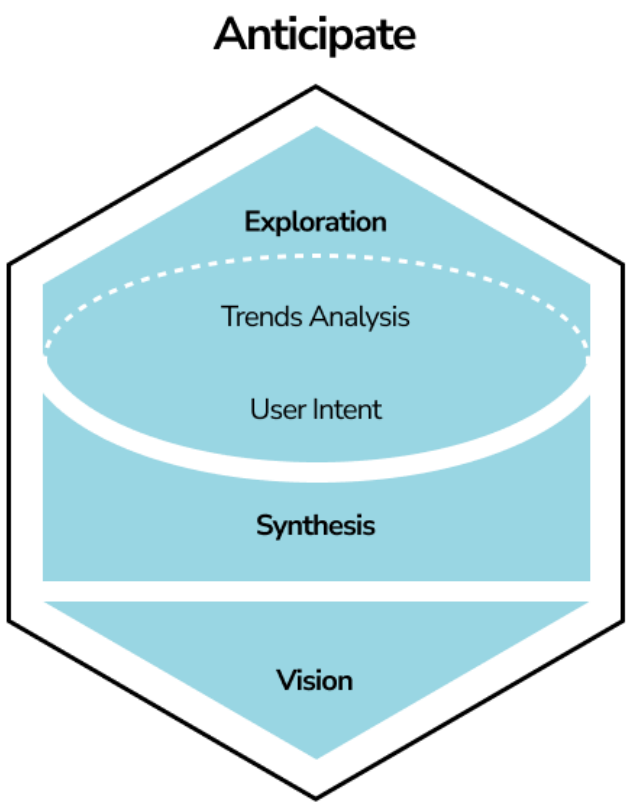


Figure 56: Our proposed sub-chunk for the anticipation phase.

At its core, this phase emphasizes understanding **user intent** and aligning anticipatory systems with their goals, motivations, and pain points. Approaches like *Jobs-to-be-Done (JTBD)* help uncover the underlying drivers behind user actions and behaviors, ensuring that designs address both immediate and aspirational needs (Fogg 2009; Thaler and Sunstein 2008). For instance, a ride-sharing service might analyze demographic shifts, transportation infrastructure changes, and evolving environmental concerns to anticipate future demand and optimize its offerings.

Predictive analytics serves as a cornerstone for this phase. Historical user data, combined with contextual signals such market trends or economic conditions, enables the identification of patterns and the formulation of forecast about potential behaviors (Shapiro 2015; Poli 2019). For example, anticipating a surge in demand during a specific event, or adjusting pricing models based on predicted changes in fuel costs, are proactive measures that emerge from robust data analysis. To strengthen accuracy, diverse data points must be incorporated, thereby minimizing bias and enhancing adaptability (Amershi et al. 2019b; Shneiderman 2020).

Objective

The objective of this phase is to identify major trends and forces shaping the future landscape of user needs, motivations, and technological possibilities. By synthesizing behavioral insights, predictive models, and foresight methodologies, this phase ensures anticipatory systems are grounded in user intent while remaining agile in the face of change (Voros 2017; Poli 2017). It creates a foundation for designing adaptive systems that effectively anticipate and respond to evolving user expectations.

6.3.1.1 Anticipation Sub-Chunks

1. **Exploration**

   Focus: Run in-depth research to uncover emerging trends, user intent, and behavioral motivations.

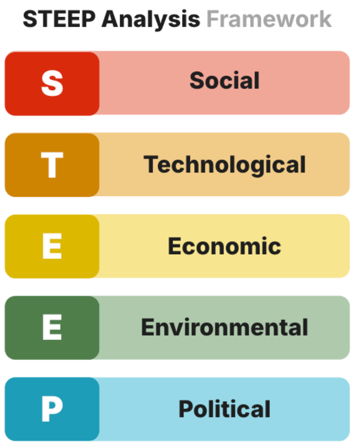
Components

A. **Trend Analysis:**

   Objective: Identify external forces (technological, social, economic) influencing user needs.

   Methods: Use tools like STEEP analysis (Figure 58), Horizon Scanning[13] (Figure 59), and expert panels to detect emerging trends and weak signals.

[13] Horizontal scanning is a foresight method for identifying early signals of change. It's a systematic, proactive approach that empowers organizations to not only anticipate and respond to future trends but to actively shape them. Via https://www.futuresplatform.com/blog/how-to-horizon-scanning-guideline



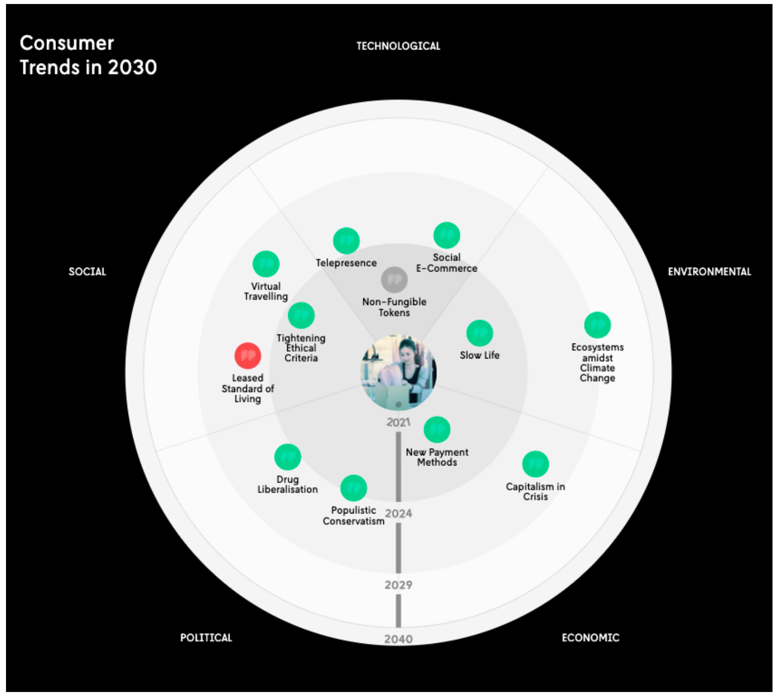


Figure 57: STEEP analysis framework

Figure 58: A foresight radar for horizon scanning

B. User Intent:

Objective: Deepen understanding of users' mental models, pain points, and aspirations.

Methods:

- Empathy Mapping: Visualize user emotions, behaviors, and goals.
- Jobs-to-be-Done (JTBD): Clarify underlying user needs and broader contexts.
- Automation vs. Augmentation Mapping: Define the spectrum of user autonomy and collaboration with AI.

Activities

- Organize trend workshops with interdisciplinary teams to explore societal, technological, and environmental shifts.
- Conduct user research using interviews, surveys, and observational studies.
- Develop empathy maps and autonomy maps to capture diverse user perspectives.

2. Synthesis

Focus: Combine insights from research into actionable models and hypotheses.

Components

- **Insight Mapping:**
  - **Objective:** Identify patterns and interconnections between trends and user needs.
  - **Methods:** Use affinity diagrams or mind mapping to group research findings.
- **Personas:**
  - **Objective:** Create detailed personas and context-based scenarios that reflect real-world diversity.
  - **Methods:** Use data from user research to build personas capturing long-term goals and aspirations.

Activities

- Facilitate workshops to cluster qualitative and quantitative insights.
- Develop personas emphasizing users' needs, pain points, and interaction goals.
- Align personas and scenarios with identified trends and emerging contexts.

3. Vision

Focus: Articulate a clear, ethical, and actionable vision for future user experiences.

Components

- **Foresight Visioning:**
  - **Objective:** Define a forward-looking vision based on synthesized insights.
  - **Methods:**
    - **Backcasting:** Map pathways from desired future states to present actions according to user intent.
    - **Delphi Method:** Gather consensus among stakeholders on critical design directions.
- **Ethical Considerations:**
  - **Objective:** Ensure alignment between system goals and ethical principles like transparency, inclusivity, and trust.
  - **Methods:**
    - **Stakeholder Alignment:** Collaborate with ethicists, designers, and engineers to define shared principles.

- **Ethical Impact Assessment:** Anticipate potential unintended consequences of proposed solutions.

Activities

- Develop vision boards or roadmaps that represent long-term goals and strategies.
- Conduct Delphi workshops to align team perspectives on ethical and user-centered priorities.
- Integrate ethical guidelines into design principles for anticipatory systems.

6.3.2 Phase 2: Imagine

The second phase (Figure 58), *imagine alternative scenarios*, focuses on exploring a diverse range of potential futures to guide impactful design decisions. Moving beyond simple prediction, this phase embraces scenario planning and backcasting techniques to ensure that designs remain resilient, adaptable, and aligned with long-term goals (Poli 2017; Voros 2017). By accounting for societal shifts, technological advancements, and unforeseen challenges, this phase fosters a proactive approach to building anticipatory systems that can evolve alongside users and their contexts.

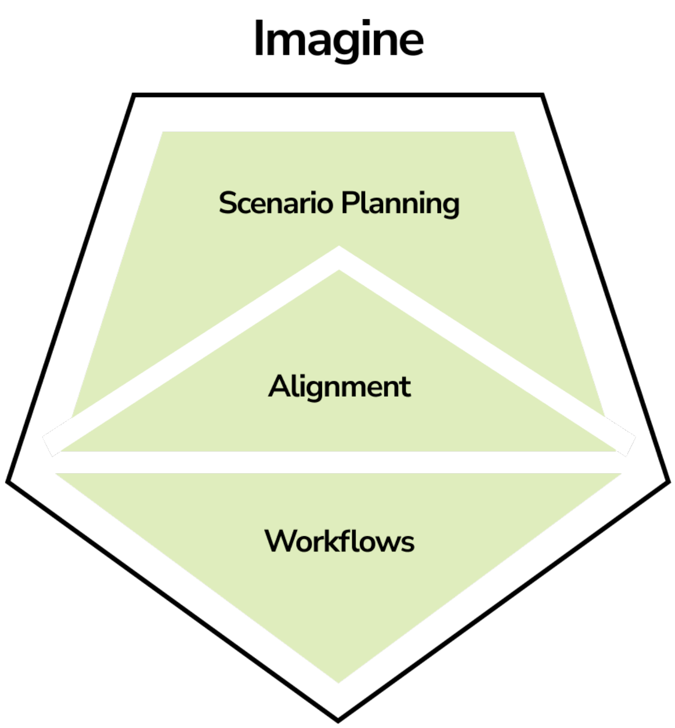


Figure 59: Our proposed sub-chunk for the imagine phase.

Rather than seeking a single “correct” future, this phase investigates multiple plausible and preferable futures to develop systems that can thrive across a variety of contexts (Voros 2017; Poli 2019). Methods such *STEEP analysis* (Figure 60) provide a structured way to consider social, technological, economic, environmental, and political forces, while backcasting helps identify the steps needed to reach a desirable vision of the future (Poli 2017). For instance, if the desired future involves significantly reduced carbon emissions, a transportation app could backcast to determine the design features and user incentives necessary to encourage more sustainable mobility choices.

The diversity of scenarios explored in this phase ensures that design decisions are not unduly influenced by a single, potentially inaccurate, forecast. Instead, anticipatory systems are prepared to adapt across a range of contexts and challenges. By embedding foresight practices into the design process, this phase strengthens adaptability while promoting systems that actively shape better outcomes for both users and society (Shapiro 2015; Poli 2019).

Objective

The objective of this phase is to explore a diverse range of plausible and desirable futures to inform adaptive and impactful design decisions. Rather than predicting a singular outcome, the goal is to enhance user control and agency by providing customization options and transparent communication of system decisions (Amershi et al. 2019b; Shneiderman 2020). Ethical safeguards such as privacy, fairness, and accountability are integral, alongside the integration of behavioral techniques like nudges and feedback mechanisms (Thaler and Sunstein 2008; Fogg 2009) that guide users toward achieving their goals.

6.3.2.1 Imagine Sub-Chunks

1. **Scenario Planning**

   Focus: Develop a set of plausible, diverse future scenarios based on external and internal drivers. Assess potential impacts on user needs and how systems could respond to those shifts.

Components

- **Scenario Development**
    - **Objective**: Design a set of plausible, probable, and preferable scenarios that account for potential system failures, disruptions, and recovery strategies. These scenarios should reflect real-world challenges and ensure that the system can recover without undermining user autonomy.

- **Methods**:
  - Combine previously uncovered trends from STEEP and behavioral insights from horizon scanning to identify key factors that could lead to system challenges or failures in user context-based scenarios.
  - **Failure Scenarios:** Generate multiple scenarios that include both expected and unexpected failures, designing responses that allow systems to recover without user frustration or loss of trust.
  - **Design for Failure**: Explore how different system failures or errors might impact user behaviors and goals, ensuring that users can still control or easily navigate recovery mechanisms.

- **Scenario Analysis**
  - **Objective**: Analyze how the proposed scenarios impact long-term user needs and motivations stages.
  - **Methods**:
    - **Scenario Impact Assessment**: Assess each scenario's impact on user motivations, behaviors, and interactions.
    - **Long-Term User Needs**: Map long-term user motivations and behaviors in each scenario and ideate nudges that address these needs.

- **Failure Recovery Design**
  - **Objective:** Plan strategies for system failure recovery, ensuring the system maintains user trust and autonomy during failures. This includes anticipating the ways the system should recover from errors without overwhelming users.
  - **Methods:**
    - **User Recovery Protocols:** Design clear pathways for recovery that users can easily follow, maintaining a sense of control and minimizing cognitive load during failure events.
    - **Error vs. Failure Communication:** Define how the system will differentiate between system errors and system failures, and design transparent communication strategies to distinguish between the two to avoid users' confusion and frustration and define types of explanations.

Activities

- Conduct workshops to generate and analyze a range of plausible, probable, and preferable scenarios.
- Ideate how each scenario would influence the design, focusing on the adaptability of the system to each context.
- Develop a scenario matrix to visually compare how scenarios differ and interact.
- Analyze failure points within different scenarios, designing pathways for user support and system recovery.

2. Alignment

Focus: Start from an ideal future state and backcast to identify the steps required to achieve those outcomes. Ensure that the system design anticipates user needs and recovery processes, focusing on maintaining user autonomy and providing transparent pathways during failures.

Components

- **Backcasting: Designing from the Desired Future**
    - **Objective**: Articulate long-term user-centered goals to shape design directions.
    - **Methods**:
        - **Backcasting Workshops**: Co-create future goals with stakeholders (users, designers, technologists). Focus on articulating clear, attainable outcomes.
        - **Desired Future States**: Define the 'ideal' state for users in multiple scenarios and understand their long-term motivations.
- **Use Visioning Planning**
    - **Objective**: Develop a vision of the future that emphasizes user empowerment, autonomy, and resilience in the face of failure.
    - **Methods**:
        - **Co-Creation**: Use collaborative brainstorming sessions with stakeholders to visualize future systems that allow users to navigate potential failures with clarity and control.
        - **Future Success Models**: Define what a successful user experience looks like, ensuring that the user's autonomy, and trust are central to the processes.

        - Emphasize ethical considerations and user empowerment along the journey to respect user autonomy, privacy, and inclusivity, avoiding manipulative tactics.
- **Identify Steps to Reach Goals**
    - **Objective**: Reverse-engineer the user journey from the desired future state to identify steps toward achieving those goals.
    - **Methods**:
        - **User Journey Mapping**: From the desired future state, map the steps backward to present-day interactions.
        - **Backcasting Milestones**: Identify critical milestones along the journey and how they relate to system failure recovery, ensuring that users are not overwhelmed at any stage.

Activities

- Conduct workshops with cross-disciplinary teams to co-create and validate the vision for the future system, focusing on user autonomy and failure recovery.
- Map out clear steps to reach desired future outcomes, emphasizing transparency and control during failure events.
- Develop roadmaps that include failure recovery touchpoints and ethical guidelines.

3. Workflows

Focus: Design the user experience by focusing on feedback loops, autonomy protocols, and system explanations. This ensures that the system fosters trust, clarity, and positive engagement while adapting to diverse futures.

Components

- **Feedback Loops**
    - **Objective**: Ideate adaptive systems that respond to user input over time, building trust through continuous feedback.
    - **Methods**:
        - **Ideate Feedback Systems**: Map and design feedback systems that allow the system to evolve based on user inputs and changing contexts.

        - **Continuous Improvement**: Develop a feedback system that evolves over time based on user input, helping to mitigate future failures and improving system reliability. Based on feedback from users and other stakeholders.
- **User Autonomy Protocols**
    - **Objective**: Trust calibration. Establish an adaptive design that supports user control without overwhelming them.
    - **Methods**:
        - **Autonomy Mapping**: Identify decision points and user autonomy levels, ensuring that users maintain control without cognitive overload.
        - **User-Centric Protocols**: Design supporting features (e.g., opt-out choices, transparency, user-driven data management).
- **Reward Functions and Explainability**
    - **Objective**: Foster engagement and trust by defining reward functions that incentivize desired behaviors and by designing transparent system explanations.
    - **Methods**:
        - **Explainability Framework**: Define and implement clear explanation mechanisms across all system touchpoints. Explain the rationale behind system decisions and provide levels of detail based on user needs.
        - **Behavioral Incentives**: Create reward structures that encourage positive engagement while maintaining transparency and ethical considerations.

Activities

- Ideate adaptive feedback systems that notify users of failure events and guide them through recovery.
- Design user workflows that integrate failure recovery and user autonomy, ensuring that users can act with clarity and confidence.
- Run a workshop with data scientists and data engineers to validate how different reward functions and explainability affect user trust and satisfaction.

6.3.3 Phase 3: Shape

The third phase (Figure 61), *shape our choices*, transforms the insights from previous phases into tangible, user-centered design solutions. This stage focuses on iterative development, drawing on agile methodologies and continuous user feedback to refine and adapt anticipatory systems (Norman 1986; Cross 2008; Geneva: International Organization for Standardization 2019). The aim is to deliver systems that not only address predicted user needs but also adapt dynamically to evolving contexts and behaviors.

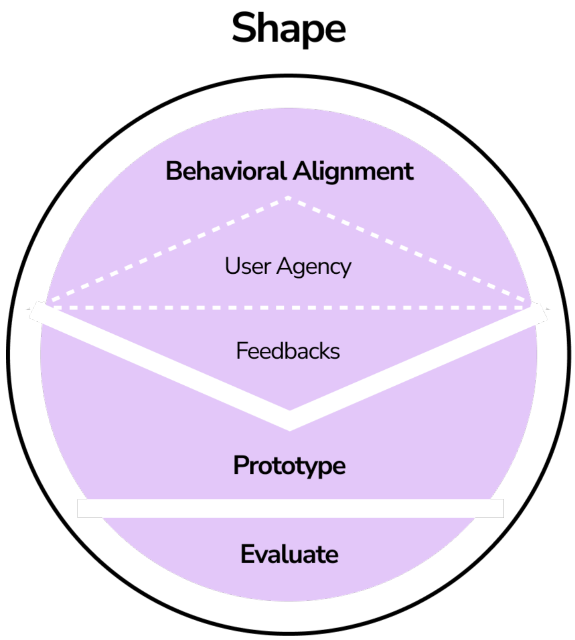


Figure 60: Our proposed sub-chunk for the shape phase.

At its core, this phase involves testing, refinement, and ethical vigilance. It guides the iterative design process, emphasizing agile development, user feedback integration, and the incorporation of ethical considerations to refine the system's design in light of scenario insights (Amershi et al. 2019b; Shneiderman 2020). Systems are evaluated against the imagined scenarios developed in Phase 2 to ensure their resilience, adaptability, and long-term relevance. For example, disaster relief systems may undergo simulations to assess performance under a variety of crisis conditions, ensuring preparedness for multiple contingencies (Poli 2017; Voros 2017).

Ethical considerations remain paramount to prevent bias, foster equity, and build trust through transparency and accountability (Shneiderman 2020). Behavioral science principles such as Nudge Theory (Thaler and Sunstein 2008) and the Transtheoretical Model (Fogg 2009) (as applied to digital behavior change) guide the design of interventions that resonate with users, supporting engagement and long-term adoption.

This phase not only accounts for technological advancement but also foregrounds **human-centered design principles** to ensure that the final product is functional, intuitive, and enjoyable to use (ISO 9241-210, 2019).

Objective

Leverage scenario insights to inform iterative design decisions, ensuring systems are adaptive, ethical, and aligned with long-term user goals. This phase focuses on enhancing user control, embedding ethical safeguards, promoting positive behavior change, and ensuring systems are both transparent and responsive. Continuous refinement and ethical vigilance are core to the process, enabling anticipatory systems to evolve resposibly over time.

6.3.3.1 Shape Sub-Chunks

1. **Behavioral Alignment**

   Focus: Design for alignment between the system's behavior and user goals, emphasizing trust, autonomy, and adaptability in the face of changing contexts.

Components

- **User Control**
  - **Objective:** Prototype interaction control protocols that offer varying levels of autonomy, ensuring users can modify system behaviors as needed without losing trust.
  - **Methods:**
    - Design interaction protocols for customization of system decisions and automated recommendations.
    - Establish clear communication pathways about the user's control options and transparency around system actions.

- **Designing Feedback**
  - **Objective:** Create robust feedback loops to ensure users understand the system's state and can act accordingly.
  - **Methods:**
    - Prototype system responses that deliver meaningful feedback on user actions.
    - Design recovery mechanisms that are easily accessible, ensuring users retain control during errors and failures.

Activities

- Prototype systems with varying levels of user control, from simple adjustments to more advanced customizations.
- Design adaptive feedback loops, focusing on error recovery and communication of system failures.
- Test user control protocols to ensure users can easily modify the system based on real-time contexts.

2. Prototyping

Focus: Build dynamic, personalized prototypes that foster trust and empowerment through clear, responsive interactions.

Components

- **Personalization**
  - **Objective:** Develop prototypes that emphasize dynamic personalization and provide users with clear settings for customization.
  - **Methods**:
    - Design onboarding experiences that focus on user preferences and customization options.
    - Create adaptive loading states, updates, and system responses that reflect the user's motivations and goals.
- **Building Trust**
  - **Objective**: Develop prototypes of feedback systems and test them in different scenarios to ensure users feel confident and in control of the system.
  - **Methods**: Implement features that reinforce trust, such as transparency in data usage, explanation of system behaviors, and accessible failure recovery.

Activities

- Develop and test prototypes with clear trust-building elements like user settings, preference management, and error handling.
- Design onboarding interactions that set the tone for transparency and user agency throughout the service lifecycle.

- Test prototypes for user engagement and confidence in system behaviors, ensuring ease of recovery during failures.

3. Interactive Evaluation

Focus: Use real-time feedback to evaluate and iterate system performance, focusing on evolving user needs, transparency, and explainability.

Components

- **Continuous Testing**
    - **Objective**: Engage in usability testing and gather real-time feedback to iterate and refine the system based on diverse user contexts.
    - **Methods**:
        - Run A/B tests, surveys, and usability studies to understand how users interact with the system and where improvements are needed.
        - Continuously monitor system performance, addressing issues that impact user trust and satisfaction.
- **Explainability**
    - **Objective**: Audit if the proposed system explanations are clear and context-sensitive to promote trust and transparency.
    - **Methods**:
        - Test explainability features, ensuring that the system clearly communicates the rationale behind automated decisions and offers comprehensible explanations, empowering users to understand and trust the system.
        - Focus on providing layered explanations based on user preferences and cognitive load.

Activities

- Conduct usability testing and A/B testing to iterate and refine user interfaces, workflows, and system behaviors.
- Implement and test system explanation features that clearly communicate the rationale behind automated decisions.
- Continuously evaluate the system’s ability to adapt to emerging user needs and goals, ensuring it stays relevant and effective over time.

- Regularly evaluate system performance against KPIs (accuracy, engagement, user satisfaction) and iterate based on these insights.

6.4 Navigating the Future of Anticipatory Design

Anticipatory design offers immense potential to enhance user experiences by predicting and addressing needs before they arise. However, success depends on balancing automation with user control, fostering trust, and aligning designs with both short-term and long-term user goals.

This framework contributes to anticipatory design discourse by providing a structured methodology that bridges theoretical insights with practical implementation challenges. However, several limitations must be acknowledged:

- **Implementation Complexity:** The framework's comprehensive nature may present adoption challenges for organizations with limited resources or expertise in foresight methodologies.
- **Validation Requirements:** Empirical testing across diverse contexts is necessary to establish the framework's effectiveness and identify refinement needs.
- **Contextual Adaptation:** Different industries and user populations may require framework modifications that have not yet been systematically explored.

Future research should focus on empirical validation through controlled studies and real-world implementations, development of industry-specific adaptations, and integration with emerging technologies such as generative AI and advanced machine learning systems.

The framework represents a foundation for systematic anticipatory design practice, but its ultimate value will be determined through practical application and iterative refinement based on empirical evidence and user outcomes.

7 Conclusion and Future Work

7.1 Evaluation and Reflection

This chapter set out to explore how anticipatory can be conceptualized and implemented within AI-driven user experiences. The central contribution has been the development of a framework that treats anticipatory design as a method rather than a loosely defined vision. By approaching anticipation methodologically, the research provides a structured way to interrogate design processes that aim not only to predict but also to shape interactions with evolving user needs.

Rather than describing anticipatory design as a technological promise, this research positions it as a methodological practice**.** It is defined as a design method that integrates foresight with predictive capabilities, allowing systems to adapt to uncertainty rather than merely replicate past behaviors (Celi and Colombi 2020; Poli 2017). Moreover, the findings demonstrate that anticipatory design must be distinguished from personalization. While personalization relies primarily on predictive modeling of past behavior (Gomez-Uribe and Hunt 2016; Yuan and Hernandez 2023), anticipation requires foresight methods that consider intent, context, and future uncertainty (Celi and Colombi 2020; Poli 2017). Anticipation, however, requires a broader perspective: it involves connecting user intent, contextual dynamics, and foresight methods to proactively shape interaction possibilities (Cerejo and Carvalhais 2020).

This distinction is crucial for AI-driven experiences. Systems that rely only on personalization risk over-automation, misinterpretation of intent, and user alienation. By contrast, anticipatory design—understood as a method—opens space for adaptability, reflection, and alignment with user goals. This reframing moves the discussion beyond industry hype and positions anticipation as a scholarly and practical contribution to design research.

The framework presented here positions anticipation as an integrative practice, balancing forecasting with foresight to avoid the over-automation and misalignment risks commonly seen in predictive-only systems.

7.1.1 Primary Research Contributions

This dissertation presents a comprehensive investigation into anticipatory design as a methodology for reducing cognitive overload in human-computer interaction while maintaining user autonomy and ethical integrity. Through systematic analysis of theoretical foundations, empirical examination of existing systems, and development of a structured design framework, this research makes significant contributions to the intersection of human-centered AI, behavioral science, and interaction design.

1. **Theoretical Framework Development**

This research establishes the first comprehensive theoretical framework integrating Rosen's anticipation theory (1985), human-centered AI principles (Shneiderman, 2020), and behavioral science models within a unified design methodology. The framework bridges the gap between abstract anticipation concepts and practical design application through three interconnected phases: Anticipate Directions of Change, Imagine Alternative Scenarios, and Shape Our Choices.

The theoretical contribution extends existing literature by:

- Connecting biological anticipation principles to interactive system design
- Integrating foresight methodologies with user experience design
- Establishing behavioral science as a foundational component of anticipatory systems
- Providing operational definitions for anticipatory design terminology

2. **Empirical Industry Analysis**

The scoping review of 21 anticipatory systems across six industries provides the first systematic analysis of real-world anticipatory implementations. This empirical work reveals consistent patterns in successful anticipatory design while identifying recurring challenges and failure modes. Key findings include:

- Universal emphasis on personalization as a core anticipatory capability
- Critical importance of user control mechanisms for maintaining trust
- Systematic challenges in balancing automation with transparency
- Industry-specific adaptation requirements for anticipatory features

3. **Methodological Innovation**

The research introduces a novel methodological approach combining:

- Systematic literature synthesis across multiple disciplines
- Industry case study analysis using structured evaluation criteria

- Framework development through iterative design processes
- Validation methodology incorporating expert review and practical application

This methodological contribution addresses the multidisciplinary nature of anticipatory design while providing replicable processes for future research.

7.2 Framework Evaluation and Validation Challenges

The evaluation of the framework revealed how difficult it is to validate anticipatory approaches empirically. Anticipation deals with open-ended futures, emergent intent, and evolving contexts, which resist the controlled testing environments commonly used in HCI or UX evaluation. Therefore, the ongoing effort to deploy the framework in real-world projects or organizational contexts remains one of its primary limitations. Without empirical testing in practical settings, its utility and adaptability have yet to be proven. This underscores the need for industry partnerships to evaluate how the framework performs under dynamic and unpredictable conditions. Validation was attempted through case studies, expert feedback, and literature alignment, but these methods highlighted the same underlying challenge: anticipatory frameworks cannot be fully tested through short-term or isolated studies. Their effectiveness depends on longitudinal observation and adaptation over time.

Another significant limitation lies in the absence of a robust academic baseline for comparison, a gap that reflects the emerging state of anticipatory design as a field rather than any shortcoming of this research. The lack of comprehensive case studies and anticipatory design reports is a broader challenge facing the community, not an individual responsibility. Consequently, this research relied on informal sources to bridge the gap. While these sources offered valuable insights into real-world practices, they may unintentionally bias the framework toward specific demographics, industries, or contexts due to the absence of consistent selection criteria. This limitation highlights the pressing need for the academic community to expand its efforts, developing a more extensive body of work that encompasses diverse case studies and industries to ensure broader applicability and a stronger foundation for comparison.

Another challenge is the interdisciplinarity of anticipatory design. The framework spans design studies, foresight, behavioral science, cognitive psychology, and artificial intelligence. This wide scope strengthens the conceptual depth of the work, but it also produces a sense of incompleteness, since no single discipline provides sufficient tools for comprehensive validation. Merging behavioral science, foresight, and user-centered design risks oversimplifying complex theories or creating a methodology that lacks coherence across diverse applications. Moreover, as the field evolves, new insights may emerge that refine or contradict the assumptions underlying this framework, necessitating continual updates to remain relevant.

Despite these challenges, the framework contributes to design research in several ways: it clarifies the conceptual foundations of anticipatory design; it distinguishes anticipation from personalization; it links foresight methods with layers of design practice; and it exposes the limitations of existing design processes when applied to AI-driven contexts.

7.2.1 Research Success metrics

Despite its limitations, the proposed framework demonstrates several strengths that align with its objectives. Ethically, it addresses significant concerns by promoting transparency, empowering users, and mitigating risks associated with manipulative behavioral interventions. By emphasizing algorithmic transparency, the framework fosters trust, making complex AI systems more comprehensible and accessible to users. Additionally, it aims to enhance equity by addressing inclusivity gaps and preventing the marginalization of underrepresented groups.

The framework's user-centered outcomes also validate its theoretical strengths. By focusing on reducing cognitive load, aligning predictive insights with user aspirations, and fostering engagement, the framework enhances user experience. Its iterative structure supports adaptability, enabling designers to refine solutions based on feedback and changing contexts. This adaptability positions the framework as a practical and versatile tool for designing anticipatory systems.

Moreover, the framework integrates equity considerations into the design process, addressing gaps that might marginalize underrepresented groups. This emphasis on inclusivity, combined with its alignment with ethical design principles, highlights the framework's potential to navigate complex societal challenges while remaining grounded in user-centered values.

7.3 Limitations and Stability of Research Questions

Several limitations temper the contributions of this research. First, the literature review was restricted by the methodological choice of a scoping review (Hilary and O'Malley 2005; Levac et al. 2010; Tricco et al. 2018). This approach allowed for breadth but not exhaustive coverage, which inevitably left out relevant academic sources.

Second, the research did not fully integrate data privacy concerns. Given the reliance of anticipatory systems on personal and behavioral data, privacy issues represent an important constraint for both design and implementation (Barocas and Selbst 2016). Future work must therefore account for how data protection and user trust shape the boundaries of anticipation.

Third, the project was heavily influenced by its multidisciplinary scope. Drawing on design studies, cognitive science, foresight, and artificial intelligence enriched the discussion, but it also created a sense of partiality. Each disciplinary lens illuminated aspects of anticipation, yet none alone provided sufficient coverage. This reinforces the need for collective, cross-disciplinary efforts.

Finally, a reflection concerns the stability of research questions versus the shifting nature of anticipatory design. Certain theoretical anchors, such as the role of foresight in decision-making (Poli 2017; Miller 2007) or the cognitive mechanisms underlying anticipation (Johnson-Laird 1980; Suddendorf and Corballis 2007), proved relatively stable throughout the research. In contrast, the specific questions evolved as anticipatory design was confronted with practical AI contexts, leading to reformulations of scope and focus. This dynamic illustrates why anticipatory design should not be approached as a static solution, but rather as a field in motion.

7.4 Future Work

Future research should continue the work of clarifying, testing, and expanding the anticipatory design framework. Several directions stand out as priorities.

1. **Framework validation:** Anticipatory design requires evaluation methods that capture long-term adaptation rather than short-term performance. Future studies should explore longitudinal research and cross-disciplinary collaborations capable of testing the framework in real-world environments.
2. **Integration with heuristics:** The framework would benefit from alignment with existing evaluation criteria in HCI and AI design (Amershi et al. 2019b; Shneiderman 2020). While Nielsen and Norman heuristics offered a familiar foundation, more tailored heuristics for intelligent systems provide opportunities for stronger validation.
3. **Cognitive foundations:** Further work should connect anticipatory design to research in cognitive psychology and behavioral science, including studies of mental models, decision fatigue, and foresight capacity (Johnson-Laird 1980; Baumeister et al. 1998; Anderson 2003). This would ground design methods in a clearer understanding of how people actually anticipate and decide.
4. **Design fiction and speculative methods:** Anticipatory design could be strengthened by speculative approaches that test frameworks through counterfactual scenarios and

fictional prompts (Light 2021; Celi and Colombi 2020)(Light 2021; Celi and Colombi 2020). These methods offer ways to evaluate anticipation when empirical validation is constrained.

5. **Ethics and governance:** Anticipatory systems should be further studied in relation to transparency, accountability, and privacy. Anticipation is not only a technical matter but also a governance question: how systems anticipate, and for whom, must be critically examined (Barocas and Selbst 2016).

7.5 Closing Thoughts

This thesis has positioned anticipatory design not as a technological guarantee but as a methodological practice. By distinguishing anticipation from personalization and by linking foresight methods with design processes, it contributes to strengthening the conceptual foundations of anticipatory design research.

Anticipatory design represents a paradigm shift in user-centered AI, offering the potential to create systems that predict and fulfill needs before they are articulated. However, the gap between theory and practical applications poses significant challenges. This research contributes to bridging this gap by proposing a structured, user-centered methodology that synthesizes behavioral science, foresight, and predictive analytics with user-centered principles.

The framework proposed here is necessarily provisional. Its value lies less in providing final answers than in framing anticipatory design as an open and evolving method. The research highlights that anticipation is both an opportunity—to reduce cognitive overload, to align design with intent, to extend foresight into practice—and a challenge, requiring careful validation, ethical reflection, and multidisciplinary collaboration.

In conclusion, the success of anticipatory design lies in its ability to enhance, rather than replace, the human experience. By navigating the complexities of prediction and foresight, anticipatory design has the potential to shape a future where technology seamlessly integrates with users' lives, delivering systems that are not only efficient but also meaningful and empowering.

In this sense, this research should be read as a step toward establishing anticipatory design as a research domain in its own right: one that connects technological systems, human intent, and societal futures in a shared inquiry into how we design for what lies ahead.

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APPENDIXES

Appendix 1— Components of PRISMA-ScR Analysis

Table. PRISMA-ScR Checklist

Section	Item	PRISMA-ScR Checklist Item
Title	1	Identify the report as a scoping review.
Abstract		
Structured summary	2	Provide a structured summary that includes (as applicable) background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.
Introduction		
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.
Methods		
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).
Summary measures	13	Not applicable for scoping reviews.
Synthesis of results	14	Describe the methods of handling and summarizing the data that were charted.
Risk of bias across studies	15	Not applicable for scoping reviews.
Additional analyses	16	Not applicable for scoping reviews.
Results		
Selection of sources of evidence	17	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.
Characteristics of sources of evidence	18	For each source of evidence, present characteristics for which data were charted and provide the citations.
Critical appraisal within sources of evidence	19	If done, present data on critical appraisal of included sources of evidence (see item 12).
Results of individual sources of evidence	20	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.
Synthesis of results	21	Summarize and/or present the charting results as they relate to the review questions and objectives.
Risk of bias across studies	22	Not applicable for scoping reviews.
Additional analyses	23	Not applicable for scoping reviews.
Discussion		
Summary of evidence	24	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.
Limitations	25	Discuss the limitations of the scoping review process.
Conclusions	26	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.
Funding	27	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.

Appendix 2—Services and Companies Assess During the Scope Review

Personalized Recommendations

1. **Netflix** - Tailored movie/show recommendations.
2. **Spotify** - "Discover Weekly" and "Daily Mixes" music predictions.
3. **Amazon** - Predictive product recommendations.
4. **YouTube** - Personalized video suggestions.
5. **ASOS** - Predicts clothing recommendations based on style preferences.
6. **Easysize** - Uses AI to recommend correct clothing sizes.

Smart Assistants

7. **Google Assistant** - Context-aware reminders and proactive suggestions.
8. **Apple Siri** - Predicts calendar prompts, travel times, and shortcuts.
9. **Amazon Alexa** - Proactive notifications, routines, and smart home integrations.
10. **Samsung SmartThings** - Automates smart home functions based on user behavior.

Smart Home Technologies

11. **Nest Thermostat** - Learns temperature preferences and adjusts automatically.
12. **Philips Hue** - Adapts lighting to user routines.
13. **Ring Doorbell** - Predicts security alerts for visitors or motion.

Healthcare

14. **Fitbit** - Proactive health insights from activity and sleep data.
15. **Apple Health** - Predictive fitness goals and health nudges.
16. **Ada Health** - Symptom checker with predictive insights.
17. **Lifesum** - Suggests food and activity choices to meet health goals.
18. **MyFitnessPal** - Anticipates meals and exercise needs.
19. **Medisafe** - Proactively reminds users to take medications.

Finance

20. **Mint.com** - Tracks expenses and predicts budgeting needs.
21. **Oportun (formerly Digit)** - Automates savings by analyzing spending patterns.
22. **Betterment** - Predicts optimal investment strategies.
23. **Wealthfront** - Offers automated financial planning.
24. **Robinhood** - Provides data-driven investment insights.

Education

25. **Duolingo** - Suggests personalized lessons and practice reminders.
26. **Knewton** - Adaptive learning platform offering tailored lesson plans.
27. **Dreambox** - Predicts and adapts math education for students.
28. **Smart Sparrow** - Provides personalized education experiences.

Travel & Hospitality

29. **Google Maps** - Predicts commute and travel times.
30. **Waze** - Suggests optimal traffic routes.
31. **Citymapper** - Offers real-time transit suggestions.
32. **Disney MagicBand** - Enhances theme park experiences by predicting user needs.
33. **Hopper** - Predicts optimal times for booking flights.
34. **Booking.com** - Recommends hotels and activities based on past searches.
35. **Expedia** - Suggests travel packages tailored to user preferences.
36. **Airbnb** - Recommends accommodations based on user behavior.

Retail and E-Commerce

37. **Walmart** - Predictive restocking and product recommendations.
38. **Starbucks App** - Anticipates frequent orders for faster checkout.
39. **Sephora** - Predicts makeup and skincare needs based on user history.
40. **Zara** - Uses AI to recommend clothing trends.

Work Productivity Tools

41. **Google Workspace** - Smart suggestions for email replies and calendar entries.
42. **Microsoft Outlook** - Focus time suggestions and meeting insights.
43. **Slack** - Highlights relevant channels and threads.
44. **Notion/Trello** - Predicts workflows or templates for streamlined organization.
45. **Salesforce** - Automates and predicts sales leads using AI.
46. **Marketo** - Proactively optimizes marketing campaigns.

Social Media

47. **Facebook/Meta** - Predicts connections, groups, and relevant content.
48. **Instagram** - Curates Explore content based on interaction history.
49. **TikTok** - Provides highly tailored video recommendations.

Transportation

50. **Tesla** - Predicts driver behavior and adjusts autopilot features.
51. **BMW ConnectedDrive** - Anticipates navigation and entertainment preferences.

Logistics and Delivery

52. **Uber Eats** - Anticipates frequent orders for faster checkout.
53. **Amazon Prime** - Predicts regular purchases for subscription-like services.
54. **FedEx** - Offers delivery timing insights.

Emerging Applications

55. **Grammarly** - Predicts and corrects grammar errors while suggesting tone adjustments.
56. **Lemonade** - Simplifies insurance claims with predictive questions.
57. **Xero** - Offers proactive financial tools for small businesses.
58. **Headspace** - Predicts meditation needs based on stress levels.

Scoping Review Dataset of Anticipatory Solutions

The following dataset compiles anticipatory solutions identified during the scoping review, structured by industry, channel, type of data, anticipatory approach (forecast/backcast), and key outcomes. This dataset provided the empirical grounding for the analysis presented in Chapters 3 and 4. The table below summarizes the anticipatory solutions collected and analyzed.

Company: Booking **Industry:** Hospitality and Travel **Channel:** Desktop

Criteria	Analysis
Solution	Booking.com's website uses anticipatory design to predict the user's next steps and personalize their search results accordingly. For example, it might suggest hotels or flights based on a user's past searches, their location, and the time of day.
Type of Data	User search history (previous bookings, reviews, and saved lists), User location, Time of day (as it may impact their seacrh intent and preference), user behavior on the website (including which pages they visit, how long they stay on each page, and what actions they take such as clicking on specific search filters). Booking also uses collective data like popular destinations, events, and activities to make recommendations to users.
Forecast <> Backcast	Is primarily based on a forecast service. Booking.com utilizes user data, such as past search history, location, and time of day, to predict and anticipate the user's needs and preferences for their upcoming travel. By analyzing this data, the platform can forecast potential accommodations or flights that align with the user's preferences and provide personalized recommendations. The forecast aspect comes into play as Booking.com predicts the user's future travel needs and preferences based on their historical data and current context. The system looks for patterns, trends, and correlations in the data to anticipate what options and recommendations would be most relevant and appealing to the user.

Outcomes	Booking.com increased convenience, efficiency, and personalization. Anticipatory experiences can make it easier for users to find what they're looking for, reduce the time and effort required to make decisions, and provide personalized recommendations that better meet their needs and preferences.
Pitfalls	1 - Collecting and analyzing vast amounts of data: Implement robust data infrastructure and analytics capabilities to handle the immense volume of user data collected. Ensure data is effectively stored, processed, and analyzed to generate meaningful insights while maintaining data integrity and scalability. 2 - Predicting user behavior accurately: Continuously refine machine learning algorithms to improve the accuracy of predicting user preferences, needs, and travel behavior. Leverage advanced data modeling techniques, user feedback, and historical patterns to enhance the system's predictive capabilities. 3 - Dealing with changing user preferences: Develop algorithms and models that can adapt to changing user preferences, travel trends, and evolving market dynamics. Regularly update and calibrate the system to reflect emerging preferences and shifts in user behavior, ensuring that recommendations remain relevant and aligned with user expectations. 4 - Ensuring data privacy and security: Implement stringent data privacy measures to protect user information and comply with applicable regulations. Securely store and handle sensitive user data, including personal and financial details, using encryption, access controls, and data anonymization techniques. 5 - Balancing personalization and choice: Strive to strike a balance between personalized recommendations and user choice. While anticipatory experiences aim to streamline decision-making, provide users with control and options to customize their preferences, filters, and search criteria to cater to individual preferences and ensure a sense of autonomy. 6 - Addressing biases and fairness: Continuously monitor and address biases in the system's recommendations to ensure fairness and prevent discrimination. Regularly assess the algorithms for any unintended biases and take corrective measures to promote unbiased and inclusive user experiences. 7 - Transparency and disclosure: Provide clear and transparent communication to users about the use of their data and the basis of recommendations. Explain the anticipatory design approach, the data sources used, and how the system makes predictions to enhance user trust and understanding. 8 - Responsiveness and adaptability: Maintain agility in the system's responsiveness to user feedback and evolving needs. Regularly gather user input, conduct usability tests, and iterate on the anticipatory features to deliver a user experience that is responsive, adaptable, and continually improving.

Company: Disney MagicBand **Industry:** Hospitality and Travel **Channel:** In-person

Criteria	Analysis
Solution	Disney MagicBand is a wearable device that uses anticipatory design to enhance the guest experience at Disney theme parks. It can anticipate the guest's needs and provide personalized recommendations for attractions, shows, and dining options based on factors such as past visits and interests. It goes beyond typical personalized recommendations and offers a comprehensive and immersive experience for theme park guests, integrating various aspects of their visit into a seamless and proactive system.
Type of Data	Disney MagicBand utilizes a variety of data to provide anticipatory experiences to its users. Some of the key types of data it may use include:

	1 - Guest profile data: This includes information provided by guests when creating their MagicBand accounts, such as personal preferences, interests, and demographic information. 2 - Past visit data: MagicBand can leverage data from guests' previous visits to Disney theme parks, including ride preferences, dining choices, and attractions they have previously experienced. 3 - Location data: MagicBand tracks guests' location within the park, allowing it to understand their proximity to various attractions, shows, and dining options. 4 - Real-time data: The device can gather real-time data on wait times for attractions, crowd levels, and show schedules, enabling it to make proactive recommendations based on current conditions. 5 - In-park interactions: MagicBand can capture data on guests' interactions with various elements within the park, such as scanning for entry at attractions or making purchases, to further personalize their experiences. 6 - Guest feedback: Disney may also collect feedback from guests about their experiences, preferences, and satisfaction levels, which can inform the anticipatory recommendations provided by MagicBand.
Forecast <> Backcast	The Disney MagicBand service is primarily based on backcast properties. Rather than forecasting future needs or preferences, it leverages historical data and guest profiles to make proactive recommendations and enhance the guest experience in real-time. By analyzing guests' past visits, preferences, and interactions, the MagicBand system can anticipate their needs and provide personalized suggestions for attractions, shows, and dining options during their current visit. It utilizes the knowledge of guests' previous behaviors to create a seamless and immersive experience in the present, tailoring recommendations to their specific interests and preferences.
Outcomes	Overall, the main outcomes of Disney MagicBand's anticipatory experiences are a personalized, seamless, and engaging theme park visit that optimizes time, enhances convenience, and creates memorable experiences for users that can include: 1 - Personalized recommendations: MagicBand offers personalized recommendations for attractions, shows, and dining options based on guests' past visits, preferences, and interests. This leads to a more tailored and enjoyable experience, saving guests time and effort in planning their park activities. 2 - Seamless and convenient experience: By leveraging anticipatory design, MagicBand streamlines various aspects of the guest experience. It allows for contactless entry to parks, fast pass access to attractions, and cashless transactions for purchases. This enhances convenience and reduces friction, making the overall park experience more seamless and enjoyable. 3 - Time optimization: MagicBand helps guests optimize their time in the park by providing real-time information on wait times for attractions, show schedules, and crowd levels. With this information, guests can make informed decisions on which experiences to prioritize and how to navigate the park efficiently. 4 - Enhanced engagement: The anticipatory experiences provided by MagicBand enhance guest engagement and immersion in the theme park environment. By tailoring recommendations and interactions based on guests' interests, it fosters a deeper connection to the attractions and characters, enhancing the overall sense of magic and enjoyment. 5 - Memories and personalization: MagicBand contributes to the creation of lasting memories by capturing guest interactions and preferences. It allows for personalized interactions with Disney characters, customized greetings, and even photo opportunities that can be linked to guests' accounts. This personalization adds to the overall experience and helps guests create special moments during their visit.
Pitfalls	While Disney MagicBand offers numerous benefits and innovative features, there are also potential pitfalls to consider:

	1 - Data privacy concerns: The extensive collection of guest data, including personal preferences and interactions, raises privacy concerns. Disney must ensure that appropriate data protection measures are in place to safeguard guest information and address any potential data breaches or misuse. 2 - Technical glitches and system reliability: MagicBand relies on complex technology systems, including RFID, wireless communication, and data analytics. Technical glitches or system failures could result in guest inconvenience, such as issues with park entry, fast pass access, or transactions. Ensuring system reliability and quick resolution of technical issues is crucial to maintain a positive guest experience. 3 - Accuracy of recommendations: While MagicBand aims to provide personalized recommendations, there is a risk of inaccuracies or misinterpretations. Relying solely on historical data and algorithms may not always capture the evolving preferences or immediate context of guests. Regular updates, real-time data analysis, and guest feedback integration are necessary to improve the accuracy of recommendations. 4 - Guest dependency and loss of control: MagicBand's anticipatory experiences may create a dependency on the system, where guests rely heavily on the recommendations and suggestions provided. This can result in a loss of personal control and decision-making. It is important for Disney to strike a balance between offering helpful recommendations and allowing guests to maintain their autonomy and freedom of choice. 5 - User experience challenges: Some guests may find the extensive use of technology, such as wearing a wearable device or relying on digital platforms, to be intrusive or overwhelming. Ensuring a user-friendly and intuitive interface, providing clear instructions, and offering alternative methods for those who may not prefer or have access to technology are essential to address user experience challenges. 6 - Accessibility considerations: The MagicBand system should be designed to accommodate guests with disabilities or special needs. This includes considerations for those who may have difficulty using wearable devices, accessing digital platforms, or following the system's recommendations. Ensuring inclusivity and accessibility for all guests is crucial.

Company: Hopper **Industry:** Hospitality and Travel **Channel:** Mobile

Criteria	Analysis
Solution	Hopper is a mobile app that uses anticipatory design to help users find the best deals on flights. It can anticipate price changes and recommend the best time to book a flight, as well as suggest alternative travel dates or airports to help users save money. This app employs anticipatory design to analyze flight prices and provide personalized recommendations for users seeking the best deals. Its data-driven approach, combined with its user-friendly interface, has gained recognition in the travel industry as an innovative solution for proactive trip planning.
Type of Data	Hopper gathers a range of data to power its anticipatory flight booking experiences. Here are some key data points: 1 - Historical Flight Price Data: Hopper analyzes historical flight prices to identify patterns and trends in pricing. This data allows the app to make predictions about future price fluctuations. 2 - Current Flight Prices: Hopper continuously monitors and updates real-time flight prices from various airlines and travel agencies. This data enables the app to provide users with up-to-date information on flight costs. 3 - Pricing Trends: By analyzing historical and current flight price data, Hopper can identify pricing trends, such as seasonal fluctuations, price drops, or price increases.

	This information helps users make informed decisions about when to book their flights. 4 - Flight Availability: Hopper tracks the availability of flights across different airlines and routes. This data is crucial for suggesting alternative travel dates or airports to users if it can potentially result in cost savings or better flight options. 5 - User Search and Booking History: Hopper keeps a record of users' search and booking history, including their travel preferences, such as preferred travel dates, airports, and destinations. This data allows the app to personalize recommendations based on the user's past behavior and preferences. 6 - Location Data: Hopper may leverage location data to provide location-specific recommendations or alerts. For example, if a user is in a particular city, the app may suggest nearby airports or deals available for that location.
Forecast <> Backcast	The Hopper service is primarily based on forecast properties. It uses historical and real-time data to predict and forecast future flight prices and availability. By analyzing trends and patterns in flight prices, Hopper can anticipate price changes and recommend the best time for users to book their flights. This forward-looking approach enables users to make informed decisions based on projected future conditions rather than relying solely on past data.
Outcomes	Overall, the main outcomes of Hopper's revolve around cost savings, convenience, improved travel planning, decision-making confidence, and an enhanced user experience. Hopper's anticipatory experiences strive to provide users with a seamless and rewarding flight booking process by: 1 - Cost Savings: By leveraging its predictive algorithms, Hopper helps users find the best deals on flights. It can anticipate price drops and recommend the optimal time to book, enabling users to save money on their airfare. 2 - Convenience: Hopper simplifies the flight booking process by providing personalized recommendations and notifications. Users receive alerts when prices are expected to change, allowing them to make timely decisions and secure the best fares without constantly monitoring the market. 3 - Enhanced Travel Planning: The anticipatory nature of Hopper's design empowers users to plan their trips more effectively. It suggests alternative travel dates or airports based on price fluctuations, enabling users to consider flexible options and potentially find more convenient or affordable itineraries. 4 - Confidence in Decisions: Hopper's data-driven approach instills confidence in users' decision-making. By providing insights and forecasts, users can make informed choices about when to book their flights, knowing that they are backed by the app's predictive capabilities. 5 - Improved User Experience: Hopper's user-centric design and proactive recommendations contribute to an enhanced overall travel experience. Users can navigate the complexities of flight pricing more easily, feel empowered in their booking decisions, and have a smoother journey from planning to departure.
Pitfalls	There are a few potential pitfalls that Hopper may encounter in providing its anticipatory flight booking service: 1 - Accuracy and Reliability: The success of Hopper's anticipatory design relies heavily on accurate data analysis and predictions. If the algorithms or data sources used by Hopper are not reliable, it could lead to inaccurate flight recommendations, pricing predictions, or alternative travel suggestions. Inaccurate information may erode trust among users and result in negative experiences. 2 - Unforeseen Events and Disruptions: Anticipatory design is based on historical patterns and data trends. However, unforeseen events such as natural disasters, political unrest, or global health crises can significantly impact travel plans and pricing. Hopper must be prepared to adapt its recommendations and provide timely updates to users to account for such disruptions.

	3 - Privacy and Data Security: Anticipatory design relies on collecting and analyzing large amounts of personal data, including travel preferences, booking history, and location information. Hopper must prioritize user privacy and data security to ensure that sensitive information is protected and not misused or compromised. 4 - User Acceptance and Adoption: Anticipatory design may not be familiar to all users, and some may be hesitant to rely on automated recommendations for flight booking decisions. Hopper needs to effectively communicate the benefits and value of its service to gain user acceptance and encourage adoption. Educating users about how the system works and addressing any concerns about data privacy and accuracy is crucial. 5 - Competition and Market Dynamics: The travel industry is highly competitive, with multiple players offering flight search and booking services. Hopper needs to continually innovate and differentiate itself to stay ahead of the competition. Additionally, market dynamics, such as changes in airline pricing strategies or the emergence of new players, can impact Hopper's business model and value proposition. 6 - Technical Challenges: Anticipatory design requires robust technical infrastructure and advanced algorithms to analyze large datasets and deliver personalized recommendations in real-time. Hopper needs to invest in technology and ensure the scalability and reliability of its systems to handle the increasing user base and data volume. 7 - Regulatory Compliance: As Hopper deals with sensitive user data and operates in multiple jurisdictions, it must comply with relevant data protection and privacy regulations. Adhering to laws such as the General Data Protection Regulation (GDPR) and ensuring compliance with regional privacy requirements can be challenging and may require ongoing efforts and resources.

Company: Ada Health **Industry:** Health **Channel:** Mobile

Criteria	Analysis
Solution	Ada Health is a symptom-checking app that uses anticipatory design to provide personalized health assessments and recommendations based on the user's symptoms and medical history. It can also predict potential health risks and suggest preventive measures.
Type of Data	Ada Health uses various types of data to provide anticipatory experiences to its users. These data types include: 1 - Symptom data: Ada Health collects information about the user's symptoms, such as their nature, severity, duration, and accompanying factors. This data helps in generating personalized health assessments and recommendations. 2 - Medical history: Users can input their medical history, including past diagnoses, treatments, and medications. This information helps Ada Health in understanding the user's health context and providing more accurate recommendations. 3 - User demographics: Basic demographic information, such as age, gender, and location, may be collected by Ada Health. This data helps in tailoring the recommendations to specific user groups or considering region-specific health risks. 4 - Health risk factors: Ada Health may ask users about their lifestyle habits, family history of diseases, and known risk factors. This data helps in assessing the user's susceptibility to certain health conditions and providing preventive measures accordingly. 5 - Contextual data: Ada Health may take into account contextual information, such as the current season, prevalent diseases in the user's region, or recent outbreaks. This data helps in providing timely recommendations and alerts for potential health risks. 6 - User feedback: Ada Health may gather user feedback, including user ratings of the accuracy of provided recommendations or outcomes of suggested preventive

	measures. This data helps in refining the system's algorithms and improving the anticipatory experiences.
Forecast <> Backcast	The combination of these forecast and backcast properties allows Ada Health to provide personalized health assessments, predictions, and preventive measures to its users. By considering both the user's current symptoms and medical history, as well as historical medical knowledge and patterns, the app aims to deliver anticipatory experiences that are tailored to the individual's health needs. Forecast: Ada Health's anticipatory design involves making predictions about potential health risks based on the user's symptoms, medical history, and risk factors. By analyzing the data provided by the user, the app can forecast potential health conditions or issues that the user may be at risk for in the future. This allows Ada Health to offer personalized recommendations and preventive measures to mitigate those risks. Backcast: Ada Health also utilizes a backcast approach by leveraging historical data and knowledge of medical conditions. By analyzing a user's symptoms and medical history, the app can compare and match patterns to previously diagnosed conditions or similar cases. This helps in providing accurate assessments and recommendations based on past experiences and outcomes.
Outcomes	The main outcomes of Ada Health's anticipatory experiences for users can include: 1 - Personalized health assessments: Users receive personalized health assessments based on their symptoms, medical history, and risk factors. The system provides insights into potential conditions or health issues that may be causing the symptoms, helping users understand their health status more accurately. 2 - Relevant recommendations: Ada Health offers personalized recommendations for further actions, such as self-care measures, lifestyle modifications, or seeking medical attention. These recommendations are tailored to the user's specific health situation and can help guide them towards appropriate next steps. 3 - Early detection and prevention: By analyzing the user's data and risk factors, Ada Health can identify potential health risks and suggest preventive measures. This proactive approach may help users take preventive actions to avoid or mitigate certain health conditions before they become more severe or problematic. 4 - Health education and awareness: Ada Health provides educational content and information about various health conditions, symptoms, and preventive measures. This helps users enhance their health literacy, empowering them to make informed decisions about their well-being and become more proactive in managing their health. 5 - Improved health outcomes: The anticipatory experiences provided by Ada Health aim to enhance health outcomes by empowering users with personalized insights, recommendations, and preventive measures. By catching potential health issues early and providing relevant guidance, users may experience improved health outcomes and better overall well-being. 6 - User empowerment and engagement: Ada Health's anticipatory experiences promote user empowerment by giving them access to personalized health information and recommendations. This engagement can encourage users to take a more proactive role in managing their health, leading to a stronger sense of control and involvement in their well-being.
Pitfalls	It's important to note that while Ada Health aims to provide accurate and helpful information, their service does not replace professional medical advice. Users are encouraged to consult healthcare professionals for a proper diagnosis and treatment of their health conditions. While ADA Health's anticipatory service holds significant potential, there are also potential pitfalls that should be addressed: 1 - Diagnostic limitations: Although ADA Health strives for accurate assessments, there can be limitations in relying solely on symptom-based analysis. The app may not always capture the full context of a user's health condition, potentially leading to inaccurate or incomplete diagnoses. Users should be encouraged to seek professional

	medical advice for proper diagnosis and treatment. 2 - Data privacy and security: ADA Health collects sensitive personal health information from users. It is crucial for the service to maintain robust data privacy and security measures to protect user data from unauthorized access, breaches, or misuse. Strong encryption, strict data access controls, and compliance with relevant data protection regulations are essential to address privacy concerns. 3 - User reliance and overreliance: There is a risk of users relying too heavily on the app for health-related decisions. While ADA Health provides valuable insights, it is important to encourage users to seek medical professionals for comprehensive evaluations and guidance. Clear disclaimers and reminders to consult healthcare providers should be communicated to users to avoid overreliance on the app's recommendations. 4 - Accessibility and inclusivity: ADA Health's services should be designed to be accessible and inclusive for users with different backgrounds, abilities, and languages. Considerations should be made to ensure the app is usable by individuals with disabilities, provides language support, and is culturally sensitive to diverse populations. 5 - Ethical use of data: As ADA Health collects and analyzes user data, it is crucial to maintain ethical practices in data usage. Clear consent mechanisms should be in place to ensure users understand how their data is being utilized, and data should be anonymized and aggregated whenever possible to protect individual privacy. 6 - Avoiding medical misinformation: ADA Health should be diligent in ensuring the accuracy and reliability of the information and recommendations provided. Regular updates and reviews of medical content, as well as collaboration with medical experts, can help minimize the risk of disseminating misleading or incorrect information to users. 7 - Managing user expectations: Anticipatory experiences can create high user expectations, and it is important for ADA Health to manage these expectations appropriately. Users should be made aware of the limitations of the service and the importance of consulting healthcare professionals for a comprehensive evaluation and treatment. 8 - Handling medical emergencies: ADA Health should provide clear instructions and disclaimers regarding medical emergencies. Users should be advised to seek immediate medical attention in urgent situations and be provided with appropriate emergency contact information.

Company: Lifesum **Industry:** Healthcare **Channel:** Mobile

Criteria	Analysis
Solution	Lifesum is another health and fitness app that uses anticipatory design to suggest personalized meal plans and nutritional advice based on the user's goals, preferences, and progress. It can also predict potential health risks and suggest preventive measures.
Type of Data	Lifesum is a health and wellness app that provides personalized recommendations and guidance to its users. To offer such a tailored experience, Lifesum utilizes various types of data. Some of the key data sources and types used by Lifesum include: 1 - User Input: Lifesum collects data directly from users through their input in the app. This includes information such as age, gender, weight, height, dietary preferences, fitness goals, and activity levels. User input serves as the foundation for personalization and customization of the experience. 2 - Food and Nutrition Databases: Lifesum integrates with extensive food and nutrition databases to provide accurate and detailed information about different food items, including their nutritional values, calorie counts, macronutrient composition, and other relevant information. This data allows Lifesum to track users' food intake and provide personalized nutrition recommendations.

	3 - Exercise and Activity Data: Lifesum incorporates exercise and activity data to help users track their physical activities, including steps, workouts, and other forms of exercise. This data can be sourced from user input, fitness trackers, or integrated apps and devices. Lifesum uses this data to calculate calorie burn, track progress, and provide personalized activity recommendations. 4 - Health and Biometric Data: Lifesum may integrate with health-tracking devices or apps to access additional health and biometric data, such as heart rate, sleep patterns, and other health metrics. This data helps provide a more holistic understanding of users' overall health and well-being, enabling Lifesum to offer personalized recommendations and insights. 5 - Machine Learning and AI: Lifesum employs machine learning and AI algorithms to analyze and process the collected data. These technologies help identify patterns, understand user preferences, and provide personalized recommendations for nutrition, exercise, and wellness goals.
Forecast <> Backcast	Lifesum's service is primarily based on forecast properties rather than backcast properties. While it may utilize historical data from users' input and tracking, the focus is on predicting and planning for future behavior and outcomes. Lifesum uses the data collected from users, such as their input on health goals, dietary preferences, and activity levels, to forecast and provide personalized recommendations for nutrition, exercise, and overall wellness. The app leverages algorithms and machine learning techniques to analyze the data and generate forecasts on users' calorie intake, nutrient balance, and activity requirements. Based on these forecasts, Lifesum can offer proactive suggestions and guidance to help users achieve their health and wellness goals. It provides meal plans, recipe recommendations, and exercise routines that are tailored to each user's specific needs and objectives. The aim is to assist users in making informed choices and planning for their future health and well-being. While Lifesum may also consider past data and patterns to provide insights and track progress, the primary focus is on using forecast properties to anticipate and guide users towards their desired health outcomes.
Outcomes	The main outcomes of Lifesum's are: 1 - Personalized Nutrition and Health Recommendations: Lifesum's anticipatory experiences leverage user data and insights to provide personalized nutrition and health recommendations. Users receive tailored meal plans, recipe suggestions, and dietary advice based on their specific goals, dietary preferences, and health conditions. This personalization helps users make informed choices and maintain a balanced and nutritious diet. 2 - Goal Achievement and Progress Tracking: Lifesum's anticipatory design focuses on helping users achieve their health and wellness goals. The app provides features to track progress, such as monitoring calorie intake, nutrient balance, and exercise activities. Users receive feedback and insights on their progress, which motivates and encourages them to stay on track and make positive lifestyle changes. 3 - Behavior Modification and Habit Formation: Lifesum's anticipatory experiences aim to support behavior modification and habit formation. By analyzing user data and patterns, the app can identify areas for improvement and provide personalized suggestions for developing healthier habits. It may offer reminders, tips, and nudges to encourage users to adopt positive behaviors and make sustainable changes in their lifestyle. 4 - Enhanced User Engagement and Motivation: Lifesum's anticipatory design creates an engaging and motivating user experience. The app provides real-time feedback, notifications, and rewards to keep users engaged and motivated in their health journey. It may celebrate milestones, provide positive reinforcement, and offer challenges or gamification elements to make the experience more enjoyable and rewarding. 5 - Improved Overall Well-being: The ultimate outcome of Lifesum's anticipatory experiences is to contribute to users' improved overall well-being. By providing personalized recommendations, tracking progress, and promoting positive

	behaviors, the app aims to help users lead healthier and more balanced lives. This can include benefits such as increased energy, weight management, improved mood, and a sense of empowerment and control over one's health.
Pitfalls	While Lifesum offers valuable anticipatory experiences, there are some potential pitfalls to consider: 1 - Data Privacy and Security: As Lifesum collects and analyzes personal health and nutrition data, there is a risk of data breaches or unauthorized access. Safeguarding user data and maintaining robust security measures is crucial to protect user privacy and maintain trust in the service. 2 -Overreliance on Algorithms: While advanced algorithms can enhance anticipatory experiences, relying solely on algorithmic recommendations without considering individual preferences or circumstances may lead to suboptimal outcomes. It's important for Lifesum to strike a balance between automated recommendations and user input. 3 - Limited User Control: Anticipatory experiences may make decisions on behalf of users, potentially limiting their control over their own health and nutrition choices. It's important for Lifesum to ensure that users have the ability to customize and adjust recommendations based on their preferences, dietary restrictions, and individual needs. 4 - Lack of Human Expertise: Anticipatory experiences may not fully replace the value of human expertise in areas such as nutrition and health. Relying solely on automated recommendations without access to professional advice or guidance may overlook unique user circumstances or specific dietary requirements. 5 - Algorithmic Bias: Algorithms used in anticipatory experiences can be susceptible to biases if the underlying data or training processes are not properly managed. Lifesum needs to be vigilant in identifying and addressing potential biases to ensure equitable and inclusive recommendations for all users. 6 - User Adoption and Engagement: Anticipatory experiences may require users to consistently engage with the service and provide accurate information for the system to make effective recommendations. Encouraging and maintaining user adoption and engagement can be a challenge, especially if users perceive the service as intrusive or burdensome. 7 - Unforeseen Circumstances: Anticipatory experiences rely on predictive capabilities, which are based on historical data and patterns. However, unforeseen circumstances, such as sudden changes in user preferences, health conditions, or external factors, may impact the accuracy and relevance of the recommendations.

Company: MyFitnessPal **Industry:** Healthcare **Channel:** Mobile

Criteria	Analysis
Solution	MyFitnessPal is a health and fitness app that uses anticipatory design to track the user's diet and suggest personalized meal plans and calorie goals based on their preferences and nutritional needs. MyFitnessPal stands out as a leading health and fitness app that effectively utilizes anticipatory design to provide personalized recommendations and support for users' wellness goals. Its data-driven approach and user-centric design make it a popular choice among individuals looking for proactive health management.
Type of Data	MyFitnessPal leverage from a diverse set of data to deliver personalized and proactive recommendations, empowering users to make informed decisions about their diet and health. Such as: 1 - User Profile Data: MyFitnessPal collects information from users' profiles, such as

	age, gender, weight, height, and activity level. This data helps in establishing baseline metrics and understanding the user's specific health and fitness goals. 2 - Food and Nutrition Data: The app tracks users' food intake through manual input or barcode scanning. It utilizes a comprehensive database of food items, including their nutritional content such as calories, macronutrients (protein, carbohydrates, and fats), vitamins, and minerals. This data enables personalized meal planning and goal setting. 3 - Physical Activity Data: MyFitnessPal integrates with fitness tracking devices or apps to gather data on users' physical activities, such as steps taken, distance covered, and calories burned. This information helps in providing more accurate calorie and nutrient recommendations based on the user's energy expenditure. 4 - User Feedback and Behavior Data: The app allows users to provide feedback on their food choices, track their progress, and log their emotions related to eating habits. This data provides insights into user preferences, patterns, and behaviors, which can be used to refine recommendations and improve the overall user experience. 5 - Data Aggregation and Analysis: MyFitnessPal uses aggregated and anonymized user data to analyze broader trends and patterns related to nutrition, fitness, and wellness. This analysis helps in improving the app's algorithms, developing new features, and providing valuable insights to users and health professionals.
Forecast <> Backcast	The MyFitnessPal service is primarily based on forecast properties. It utilizes the data provided by users, such as their profile information, food intake, physical activity, and feedback, to generate personalized recommendations and goals for the future. The app forecasts the user's nutritional needs, calorie targets, and meal plans based on their current data and desired outcomes. By leveraging this anticipatory design approach, MyFitnessPal helps users plan and make proactive choices to support their health and fitness goals.
Outcomes	Overall, the anticipatory experiences provided by MyFitnessPal aim to empower users in their pursuit of a healthier lifestyle, offering personalized guidance, goal tracking, and real-time feedback for improved health and well-being and this can happen os several dimensions like: 1 - Personalized Nutrition Guidance: MyFitnessPal provides users with personalized meal plans, calorie goals, and nutrient recommendations based on their specific needs and goals. This helps users make informed decisions about their diet and maintain a balanced and healthy eating routine. 2 - Enhanced Goal Tracking: The app allows users to set goals related to weight loss, weight gain, or overall wellness. By utilizing anticipatory design, MyFitnessPal offers progress tracking, reminders, and adjustments to help users stay on track and achieve their goals. 3 - Efficient Meal Planning: MyFitnessPal's anticipatory design simplifies meal planning by suggesting suitable food options and portion sizes based on users' preferences, dietary restrictions, and nutritional requirements. This saves time and effort for users and supports them in making healthier choices. 4 - Real-time Feedback and Insights: The app provides instant feedback and insights on users' food choices, nutritional intake, and progress towards goals. This helps users understand the impact of their decisions and make adjustments as needed, leading to better awareness and self-management of their health and fitness. 5 - Behavior Change and Accountability: MyFitnessPal's anticipatory experiences encourage behavior change by offering reminders, motivation, and accountability. Users receive reminders to log their meals and activities, encouraging consistent tracking and fostering a sense of responsibility for their health journey. 6 - Community Support: MyFitnessPal fosters a sense of community by connecting users with similar goals and interests. This social aspect allows for sharing achievements, seeking advice, and receiving support from peers, promoting motivation and engagement.

Pitfalls	While MyFitnessPal offers valuable anticipatory experiences, there are some potential pitfalls to consider: 1 - Data Privacy and Security: Collecting and analyzing personal health data poses privacy and security concerns. MyFitnessPal must ensure robust security measures to protect user information and comply with data protection regulations. Any data breaches or mishandling of sensitive data can lead to loss of user trust. 2 - Accuracy of Recommendations: Anticipatory design relies on accurate data analysis and predictive algorithms. If the recommendations provided by MyFitnessPal are not precise or fail to align with the user's preferences and goals, it can lead to frustration and dissatisfaction. 3 - User Reliance on the App: While MyFitnessPal can be a helpful tool, there is a risk that users may become overly reliant on the app for their health and fitness decisions. This could potentially lead to a decrease in personal responsibility and a dependence on technology rather than making informed choices based on individual needs and circumstances. 4 - Limited Human Interaction: Anticipatory experiences in MyFitnessPal may reduce the level of human interaction and support. Some users may prefer a more personalized and hands-on approach from healthcare professionals or fitness experts, which the app may not provide. 5 - Inflexibility and User Individuality: Anticipatory experiences in MyFitnessPal are based on aggregated data and general patterns. However, individual users may have unique dietary requirements, preferences, or health conditions that require personalized approaches. The app should allow for customization and adaptation to cater to diverse user needs. 6 - Potential for Overreliance on Technology: While MyFitnessPal can be a helpful tool for tracking and managing health, there is a risk that users may overly rely on technology without developing a holistic approach to their well-being. It's important to promote a balanced perspective that integrates technology with other healthy lifestyle practices. 7 - Emotional and Psychological Considerations: Health and fitness journeys can be emotionally challenging, and relying solely on an app for support may overlook the importance of emotional and psychological well-being. MyFitnessPal should consider integrating features that address mental health aspects and provide resources for emotional support. 8 - User Accountability and Responsibility: Anticipatory experiences in MyFitnessPal can assist users in setting goals and providing recommendations. However, it is essential for users to maintain accountability and take responsibility for their own health choices. The app should encourage users to actively engage in their health journey and avoid creating a sense of reliance solely on the app's suggestions.

Company: Medisafe **Industry:** Healthcare **Channel:** Web

Criteria	Analysis
Solution	Medisafe is a medication management app that uses anticipatory design to remind users to take their medications at the right time and in the right dosage. It can also predict potential drug interactions and suggest alternative medications if necessary.
Type of Data	Medisafe is a medication management platform that helps users track and adhere to their medication schedules. To provide such an experience, Medisafe relies on various types of data. Here are the main types of data that Medisafe utilizes: 1 - Medication information: Medisafe collects data about the medications users are taking, including the name, dosage, frequency, and instructions. This data helps in

	creating personalized medication schedules and reminders. 2 - User input: Users can manually input their medication details, such as the specific time they need to take each medication and any additional instructions from their healthcare providers. User input helps customize the medication management experience. 3 - Health conditions: Users may provide information about their health conditions, such as chronic illnesses or specific medical requirements. This data enables Medisafe to tailor medication management features to individual health needs. 4 - Reminder activity: Medisafe tracks users' interactions with medication reminders, such as whether they acknowledge or dismiss reminders. This data helps assess adherence and identify potential issues or patterns. 5 - Health measurements: Medisafe may integrate with other health tracking devices or apps to gather additional data, such as blood pressure readings, glucose levels, or weight measurements. This information provides a more comprehensive picture of the user's health status. 6 - Health records: In some cases, Medisafe may access users' electronic health records (EHRs) or medication history, with the user's explicit consent. This data offers insights into past medications and treatments, helping to avoid potential drug interactions or duplications.
Forecast <> Backcast	The Medisafe service is primarily based on forecast properties rather than backcast properties. Medisafe's primary goal is to help users manage and adhere to their medication schedules in the future, rather than analyzing past data or behavior. The service utilizes data inputs such as medication information, user input, health conditions, and reminder activity to forecast and anticipate the user's medication needs and schedule. By providing personalized reminders, tracking adherence, and offering support, Medisafe aims to improve medication management in the present and future, focusing on proactive measures rather than analyzing historical data.
Outcomes	The main outcomes of Medisafe's anticipatory experiences for users can include: 1 - Improved Medication Adherence: Medisafe helps users stay on track with their medication schedules by providing timely reminders and notifications. Anticipatory experiences can help users remember to take their medications, reducing the risk of missed doses and improving overall adherence. 2 - Personalized Medication Management: Medisafe leverages user data, such as medication information, dosage instructions, and health conditions, to provide personalized medication management. Anticipatory experiences can offer tailored recommendations and reminders specific to each user's medication needs and schedules. 3 - Enhanced Health Monitoring: Medisafe may integrate with other health monitoring devices or apps to provide a holistic view of users' health. Anticipatory experiences can leverage this data to provide insights and alerts related to medication management, potential drug interactions, or health-related issues. 4 - Simplified Medication Tracking: Medisafe's anticipatory experiences aim to simplify medication tracking and management for users. The service can provide a consolidated view of medication schedules, refill reminders, and prescription information, making it easier for users to stay organized and informed. 5 - Support and Education: Medisafe may offer educational resources, such as medication information, side effects, and interactions. Anticipatory experiences can provide proactive suggestions and information to users, helping them make informed decisions about their medications and promoting better health outcomes.
Pitfalls	There are potential pitfalls that Medisafe may need to address in order to ensure the effectiveness and success of their service: 1 - Data Privacy and Security: As Medisafe collects and stores sensitive health data, ensuring robust data privacy and security measures is crucial. There is a risk of unauthorized access, data breaches, or misuse of personal health information. Medisafe must invest in robust security protocols, encryption techniques, and

	compliance with relevant data protection regulations to maintain user trust and protect their data. 2 - Accuracy of Predictive Analytics: The effectiveness of Medisafe's anticipatory experiences relies on accurate predictive analytics. Inaccurate predictions or recommendations may result in users receiving irrelevant or incorrect information, leading to confusion or potential health risks. Medisafe should continuously refine and improve their predictive models to ensure reliable and accurate insights. 3 - User Engagement and Adoption: While Medisafe's anticipatory experiences offer convenience and support, user engagement and adoption can be a challenge. Some users may be resistant to relying on technology for medication management or may struggle to adapt to new routines. Medisafe should provide clear instructions, educational resources, and user-friendly interfaces to encourage user adoption and engagement. 4 - Reliance on Technology: Medisafe's service heavily relies on technology, including smartphones, internet connectivity, and software applications. Technical issues, such as app crashes, device compatibility problems, or network outages, can disrupt the anticipatory experiences and impact user satisfaction. Medisafe should have contingency plans in place to address such issues promptly and minimize user frustration. 5 - Limited Accessibility: Anticipatory experiences may not be accessible to all users, particularly those with limited access to smartphones, internet connectivity, or digital literacy. Medisafe should consider alternative channels or support options to ensure that their service is inclusive and available to a wider range of users, including those with diverse backgrounds or physical limitations. 6 - Ethical Considerations: Medisafe should carefully consider the ethical implications of their anticipatory experiences. This includes ensuring transparent and informed consent for data collection, avoiding bias in recommendations, and maintaining a balance between personalization and user autonomy. Ethical guidelines and regular evaluations can help Medisafe navigate these considerations effectively.

Company: Oportun (formerly Digit) **Industry:** Finance **Channel:** Mobile

Criteria	Analysis
Solution	Oportun, formerly Digit, is a financial management app that uses anticipatory design to automate savings for users. It analyzes their spending habits and income to determine how much they can afford to save, and automatically transfers the money to a savings account.
Type of Data	Data on users' income, spending habits, bills and expenses, and historical cash flow. The app also uses ML algorithms to analyze this data and predict how much money a user can safely save without impacting their daily financial needs. They also track user's employment status, income level, and credit score, which can be used to improve the accuracy of its savings recommendations and help users achieve their financial goals. Additionally, Oportun may use data from external sources such as financial market trends, economic indicators, and interest rates to provide users with personalized financial advice and investment opportunities.
Forecast <> Backcast	is primarily based on forecast properties, as it uses data analysis to predict how much a user can afford to save and automatically transfers the money to a savings account accordingly. However, it may also use backcast properties by analyzing a user's past spending and saving behavior to inform future predictions and recommendations.

Outcomes	The primary outcome is to support users in building a stronger financial foundation and achieving their savings objectives. But the results can be broken down into: 1- Improved savings behavior: By automating savings based on a user's financial situation and spending habits, Oportun helps users develop better savings habits and increase their savings over time. 2 -Financial stability: Oportun's anticipatory experiences contribute to the financial stability of users by encouraging regular savings and helping them build a safety net for unexpected expenses or future goals. 3- Convenience and ease of use: Oportun's automated savings process eliminates the need for users to manually set aside money, making it convenient and effortless to save regularly. 4 - Financial empowerment: By providing personalized savings recommendations and insights, Oportun empowers users to take control of their finances and make informed decisions about their savings goals. 5 - Increased confidence: Oportun's anticipatory experiences can boost users' confidence in their ability to save and achieve their financial aspirations, fostering a sense of financial well-being.
Pitfalls	While Oportun's anticipatory service offers numerous benefits, there are some potential pitfalls to consider: 1 - Privacy and data security: Oportun collects and analyzes sensitive user financial data to provide its service. Ensuring robust privacy measures and data security protocols is crucial to protect user information from unauthorized access or data breaches. 2 - Overreliance on automation: While automation can simplify savings and decision-making, there is a risk of users becoming overly reliant on the system. This may lead to a reduced sense of personal financial responsibility and less engagement in actively managing their finances. 3 - Accuracy of predictions: Oportun's service relies on accurate predictions of users' financial situations and savings capacity. If the predictions are not precise or fail to adapt to changing circumstances, users may experience dissatisfaction or unexpected financial challenges. 4 - Lack of customization: The automated nature of Oportun's service may limit the level of customization available to individual users. Some users may have unique financial circumstances or specific savings goals that may not be fully accommodated by the system. 5 - Limited control and decision-making: Users who prefer a high degree of control over their savings may feel constrained by the automated nature of Oportun's service. The system makes decisions on their behalf, potentially leading to a loss of autonomy or personalization. 6 - Technical issues and dependency: The functionality of the Oportun app relies on technology infrastructure and connectivity. Technical glitches, system downtime, or dependency on third-party services may impact the user experience and accessibility of the service.

Company: Mint **Industry:** Finance **Channel:** Mobile

Criteria	Analysis
Solution	Mint is a financial management tool that uses anticipatory design to help users track their personal finances, budgets, and manage their financial accounts. Mint, a product of Intuit, operates by aggregating financial data from various sources to provide users with a comprehensive view of their financial situation. It categorizes and tracks expenses,

	income, and transactions across multiple bank accounts, credit cards, loans, and investment accounts. It can anticipate upcoming bills and expenses and provide personalized financial advice based on the user's spending habits and patterns.
Type of Data	The types of data Mint typically uses to provide its financial management services include: 1 - Transaction Data: Mint collects and analyzes transaction data from linked bank accounts, credit cards, and other financial institutions. This includes details of purchases, withdrawals, transfers, and deposits. 2 - Account Balances: It tracks the balances of your various financial accounts to provide you with an up-to-date view of your net worth. 3 - Investment Data: For users who link investment accounts, Mint retrieves data on investment holdings, portfolio values, and investment transactions. 4 - Bill Payment Information: Mint allows users to track upcoming bills and due dates, which often requires accessing bill payment information. 5 - Credit Score: It may provide users with access to their credit scores, which is based on credit report data from credit bureaus. 6 - Budgeting Categories: Users can set budgeting categories, and Mint categorizes transactions based on spending categories like groceries, entertainment, rent, and more. 7 - Trends and Analytics: Mint uses the collected data to provide insights into spending patterns, trends, and financial goals tracking.
Forecast <> Backcast	Primarily relies on backcast properties. it looks at past financial transactions, account balances, and historical data to provide users with insights and information about their financial history and current financial situation. Here's how Mint typically uses backcasting properties: 1 - Transaction History: Mint aggregates and analyzes your past financial transactions to categorize spending, track income, and provide a historical record of your financial activity. Users can review past transactions to see where their money has been spent. 2 - Account Balances: The platform displays current and historical account balances, allowing users to track how their balances have changed over time. 3 - Budgeting: Mint helps users create budgets based on past spending habits and income. It uses historical data to make budgeting recommendations and to show users how they have performed against their budget in the past. 4 - Trends and Insights: By analyzing historical data, Mint generates trends and insights about your financial behavior. For example, it might show you how your spending in certain categories has changed over the past months or years. 5 - Financial Goals: Users can set financial goals within Mint, and the platform uses historical data to help users plan for and track progress toward those goals. While backcasting is a significant aspect of Mint's functionality, it also incorporates some forecasting elements. For example, it can project future trends in spending and account balances based on historical data. However, these forecasts are generally limited to providing users with estimates based on past behavior rather than predicting future market conditions or investment returns. In summary, Mint primarily relies on backcasting properties by analyzing historical financial data to provide users with insights, budgeting recommendations, and a comprehensive view of their financial history and current situation.
Outcomes	Mint offers several anticipatory experiences for its users that can lead to various outcomes, primarily aimed at helping users manage their finances more effectively. The main outcomes of Mints anticipatory experiences for users include: 1 - Better Financial Awareness: Mint provides users with a comprehensive view of their financial accounts and transactions in one place. This awareness allows users to have a better understanding of their financial situation, including income, expenses, and account balances.

	2 - Expense Tracking: Users can effortlessly track their spending habits and see where their money is going. This knowledge can lead to more responsible spending and budgeting decisions. 3 - Budgeting and Saving: Mint assists users in creating and sticking to budgets. Anticipatory features help users set budget limits for various expense categories and provide alerts when they approach or exceed those limits. This can lead to better financial discipline and increased savings. 4 - Bill Reminders: The service sends reminders for upcoming bills and due dates, helping users avoid late fees and missed payments. This contributes to better financial organization and credit score management. 5 - Investment Insights: For users with investment accounts, Mint provides insights into portfolio performance and diversification. This can assist users in making informed investment decisions. 6 - Credit Score Monitoring: Mint offers credit score tracking, allowing users to monitor their credit health. Improving credit scores can lead to better borrowing terms and financial opportunities. 7 - Financial Goal Setting: Users can set financial goals within the platform, such as saving for a vacation or paying off debt. Mint's anticipatory features help users track progress toward these goals, fostering a sense of achievement. 8 - Alerts and Notifications: Users receive alerts for unusual account activity, low balances, or potential fees. These notifications can help users avoid financial pitfalls and make timely corrections. 9- Savings Recommendations: Based on a user's financial history and goals, Mint can offer personalized savings recommendations, such as setting up an emergency fund or contributing more to retirement accounts. 10 - Expense Trends and Insights: Users can access historical spending trends and insights, helping them identify areas where they can cut costs or reallocate funds to align with their financial objectives. 11 - Financial Planning: Mint provides users with a platform for financial planning, enabling them to create a roadmap for achieving long-term financial stability and success. 12- Reduced Financial Stress: By providing a clear overview of one's financial situation, offering timely reminders, and suggesting budgeting strategies, Mint can help reduce financial stress and anxiety.
Pitfalls	There are several potential pitfalls and challenges that Mint, or any financial service provider implementing anticipatory experiences, should be aware of: 1 - Data Security and Privacy Concerns: As Mint collects and analyzes sensitive financial data, ensuring robust data security and privacy measures is paramount. Data breaches or unauthorized access could have severe consequences. The platform must employ encryption, multi-factor authentication, and adhere to strict data protection regulations to safeguard user information. Mint typically requires users to provide their login credentials for their various financial accounts. The platform then uses these credentials to access the relevant financial data. Security measures are in place to protect this sensitive information. 2 - Accuracy of Predictions: Anticipatory experiences rely on accurate data analysis and predictive algorithms. If predictions regarding expenses, income, or investment performance are incorrect, it can lead to financial errors and user dissatisfaction. Regularly refining and improving predictive models is essential. 3 - Overreliance on Technology: Users might become overly reliant on Mint for their financial decisions, potentially diminishing their financial literacy or responsibility. It's vital to encourage users to actively engage in their financial planning and decisions, using the platform as a tool rather than a substitute for financial knowledge. 4 - Technical Glitches and System Reliability: Technical issues or system failures, such as server outages or syncing problems with financial institutions, can disrupt the user experience. Ensuring system reliability, quick issue resolution, and effective customer support are essential to maintain user trust. 5 - Algorithmic Bias: Algorithms used for anticipatory experiences can inadvertently

	introduce biases if not managed carefully. Biased recommendations could lead to unfair financial outcomes for users. Regularly audit and adjust algorithms to minimize biases and ensure fairness. 6 - User Engagement and Adoption: While anticipatory features can be valuable, some users may resist relying on technology for financial management. Encouraging user adoption and engagement, particularly among those less tech-savvy, requires clear communication and user-friendly interfaces. 7 - Unforeseen Economic Events: Anticipatory design relies on historical data, and unexpected economic events, like recessions or market crashes, can disrupt predictions. Users may face financial difficulties if they rely too heavily on automated recommendations during such events. 8 - Regulatory Compliance: Mint must comply with financial regulations, especially when offering investment-related services. Ensuring compliance with securities laws and financial regulations can be complex and requires ongoing efforts. 9 - Loss of Personal Touch: The platform's automated nature may result in a loss of personal touch, which some users may value. Mint should offer user support options and educational resources for users who seek personalized advice. 10 - Ethical Considerations: Maintaining ethical practices in data usage and recommendations is essential. Users should be fully informed about how their data is used, and ethical guidelines should be followed when designing anticipatory experiences. 11 - Communication and Transparency: Mint should clearly communicate to users how the anticipatory features work, what data is used, and how recommendations are generated. Maintaining transparency builds trust and user confidence. 12 - Market Competition: The personal finance management market is highly competitive, with many players offering similar services. Mint must continue to innovate and provide unique value to stay competitive and retain its user base. 13 - Loss of Control: Users might feel they're losing control of their financial decisions when relying on anticipatory features. Balancing automation with user control and customization is crucial. These pitfalls emphasize the importance of maintaining a strong focus on data security, user education, system reliability, and ethical data practices while continuously working to improve the accuracy and relevance of anticipatory experiences in personal finance management.

Company: Betterment **Industry:** Finance **Channel:** Mobile

Criteria	Analysis
Solution	Betterment is a robo-advisor platform that uses automation design to manage investments on behalf of users. Betterment uses algorithms to make investment decisions based on the user's risk tolerance, investment goals, and market trends. It uses a combination of user-provided data and financial market data to provide a personalized investing experience. Users do not need to make investment decisions themselves, as Betterment automates the process for them.
Type of Data	The type of data Betterment typically uses includes: 1 - User Financial Information: Betterment collects information from users about their financial goals, risk tolerance, income, and investment preferences. This data helps Betterment customize an investment strategy for each user. 2 - Account Information: Users link their financial accounts, such as bank accounts and investment accounts, to Betterment. This allows the platform to track account balances, transactions, and overall financial health. 3 - Market Data: Betterment relies on real-time financial market data, including stock

	prices, bond yields, and economic indicators, to make investment decisions and provide recommendations to users. 4 - Historical Data: Historical market data is used to analyze past performance trends, assess risk factors, and develop predictive models for future investment performance. 5 - Tax-Related Data: Betterment takes into account tax-related data, such as tax-efficient investing strategies and tax-loss harvesting opportunities, to optimize after-tax returns for users. 6 - User Goals and Preferences: Betterment considers user-defined financial goals, like retirement savings or a down payment for a home, and preferences for socially responsible investing or specific asset classes. 7 - Behavioral Data: Betterment may analyze user behavior on the platform, such as how often users log in or adjust their investment strategy. This data can help personalize the user experience and provide timely recommendations. 8 - Economic Indicators: Information about the broader economic environment, including interest rates, inflation rates, and geopolitical events, is considered when making investment decisions. 9 - Machine Learning and Algorithms: Betterment employs machine learning algorithms to continuously analyze and optimize investment portfolios based on the data mentioned above. 10 - User Feedback: Feedback from users can also be used to refine the platform and its anticipatory features, ensuring they align with user expectations and preferences.
Forecast <> Backcast	Betterment's robo-advisory service primarily relies on forecast properties. Here's how: 1 - Forecasting Future Returns: Betterment uses historical market data and advanced algorithms to forecast the future returns of different asset classes (e.g., stocks, bonds). Based on these forecasts, it recommends an optimal asset allocation for a user's investment portfolio. This is forward-looking, as it's based on the expectation of how different investments will perform in the future. 2 - Risk Assessment: Betterment assesses a user's risk tolerance and financial goals to determine an appropriate investment strategy. This involves forecasting how different levels of risk may affect the likelihood of achieving those goals. 3 - Tax Optimization: Betterment uses tax-efficient investing strategies and tax-loss harvesting, which are based on forecasts of how tax laws and investment conditions will impact a user's tax liability in the future. 4 - Goal Tracking: Users set financial goals with specific targets and deadlines. Betterment forecasts how a user's investments should perform over time to reach those goals, and it provides progress tracking based on these forecasts. While Betterment uses historical data as a foundation for its forecasts, its core functionality involves projecting future financial outcomes and optimizing investment strategies accordingly. This aligns with the typical characteristics of a forecasting approach rather than a backcasting approach, which would focus on explaining past performance.
Outcomes	Betterment's anticipatory experiences main outcome is collectively enhance the user's financial well-being by providing personalized, data-driven investment strategies and ongoing support in achieving their financial objectives. But we can break down the outcomes in: 1 - Personalized Investment Portfolios: Users receive a tailored investment portfolio based on their financial goals, risk tolerance, and other factors. This anticipatory experience ensures that the portfolio aligns with their unique objectives and circumstances. 2 - Optimized Asset Allocation: Betterment continuously optimizes the asset allocation within a user's portfolio. This anticipatory approach aims to maximize returns while managing risk, adapting to changing market conditions and the user's goals over time. 3 - Tax Efficiency: Betterment's tax-efficient investing and tax-loss harvesting strategies help users minimize their tax liabilities. Users can potentially reduce capital gains taxes, resulting in higher after-tax returns.

	4 - Goal Tracking: Users can set specific financial goals, such as retirement savings or buying a house. Betterment's anticipatory features track progress toward these goals, providing users with a clear picture of their financial journey. 5 - Automated Rebalancing: Betterment automatically rebalances users' portfolios to maintain the desired asset allocation. This ensures that investments stay on track with the user's financial objectives without requiring constant manual adjustments. 6 - Risk Management: Betterment's anticipatory experiences help users manage investment risk by aligning their portfolios with their risk tolerance. Users receive guidance on selecting a risk level that matches their comfort and long-term goals. 7 - Financial Education: Betterment provides educational content and insights to help users make informed financial decisions. These resources are anticipatory in the sense that they proactively address users' questions and concerns. 8 - Long-Term Wealth Building: Ultimately, Betterment's anticipatory experiences aim to assist users in building long-term wealth. By optimizing investments, minimizing taxes, and tracking progress toward goals, users are better positioned to achieve financial success and security over time.
Pitfalls	There are some potential pitfalls and challenges that Betterment may encounter in providing its anticipatory financial services: 1 - Data Privacy and Security: Handling sensitive financial data comes with significant privacy and security concerns. Betterment must ensure robust data protection measures to safeguard user information and comply with financial data regulations. Data breaches or mishandling of personal financial data can erode user trust. 2 - Market Volatility: The financial markets are subject to fluctuations and uncertainties. Anticipatory investment recommendations may not always accurately predict market changes, leading to financial losses for users. Betterment needs to manage user expectations regarding the risks associated with investing. 3 - Regulatory Compliance: Financial services are highly regulated, and compliance with these regulations is essential. Anticipatory experiences must adhere to relevant financial laws, which can vary by jurisdiction. Navigating these regulatory complexities while providing innovative services can be challenging. 4 - Algorithmic Bias: Anticipatory experiences rely on algorithms, which can inherit biases present in historical data. These biases may lead to unfair or unequal recommendations, affecting different user groups. Betterment needs to be vigilant in identifying and addressing algorithmic biases. 5 - User Understanding and Education: Users may not fully understand how anticipatory financial services work or the associated risks. It's essential for Betterment to provide clear explanations and educational resources to ensure users make informed decisions and don't blindly follow recommendations. 6 - Overreliance on Technology: There's a risk that users may become overly reliant on the platform for financial decisions, neglecting the importance of personal financial literacy and judgment. Betterment should encourage users to remain engaged in their financial planning and not rely solely on automated suggestions. 7 - Market Competition: The robo-advisory industry is highly competitive, with many players offering similar services. Betterment needs to continually innovate to maintain a competitive edge and differentiate itself from competitors. 8 - Economic Downturns: Anticipatory financial services may face challenges during economic downturns or crises, as predicting market behavior in such conditions can be particularly challenging. Betterment should have strategies in place to adapt to changing market dynamics. 9 - User Trust: Building and maintaining user trust is crucial in the financial services sector. Negative user experiences or inaccurate recommendations can damage trust quickly. Betterment must prioritize transparency, accuracy, and reliability in its anticipatory services. 10 - Scalability: As Betterment's user base grows, scaling its anticipatory services to handle increased data volume and user demands can be challenging. Ensuring the platform remains responsive and reliable at scale is essential.

Company: Wealthfront **Industry:** Finance **Channel:** Mobile

Criteria	Analysis
Solution	Wealthfront is a robo-advisor platform that uses anticipatory design to automate investment management and financial planning. It uses algorithms and machine learning to analyze user data and make personalized investment recommendations based on factors such as risk tolerance, time horizon, and financial goals. This robo-advisor uses a combination of quantitative and user-provided data to provide anticipatory financial services to its users.Wealthfront also offers additional features such as a high-yield cash account and a stock-level tax-loss harvesting service to optimize returns and minimize taxes. The goal is to provide users with a tailored and proactive approach to managing their finances and investments.
Type of Data	The type of data Wealthfront typically uses includes: 1 - Financial Data: This includes information about a user's financial accounts, such as bank accounts, investment accounts, retirement accounts, and credit cards. Wealthfront may access this data with user consent through APIs or other secure methods. 2 - Risk Tolerance Data: Users often provide information about their risk tolerance through questionnaires or surveys. This data helps Wealthfront determine the appropriate asset allocation for the user's investment portfolio. 3 - Income and Expense Data: Users may input details about their income, expenses, and financial goals. This information is used to create a personalized financial plan. 4 - Tax Information: Wealthfront may gather data related to a user's tax situation, including tax filing status, income tax rate, and any specific tax preferences or goals. 5 - Investment Preferences: Users may specify their investment preferences, such as ethical investing, socially responsible investing, or specific asset classes they want to avoid or focus on. 6 - Goals and Time Horizons: Users provide information about their financial goals, such as saving for retirement, buying a home, or funding education. Wealthfront uses this data to create customized investment strategies. 7 - Market Data: Real-time market data, including stock prices, bond yields, and economic indicators, is used to make real-time decisions about portfolio rebalancing and investment choices. 8 - Behavioral Data: Wealthfront may collect data on how users interact with their platform, including the timing and frequency of logins, reactions to market events, and responses to financial advice. 9 - Historical Data: Data on a user's past financial transactions and investment performance can be used to improve anticipatory experiences by learning from historical patterns.
Forecast <> Backcast	Wealthfront primarily relies on forecast properties when providing anticipatory experiences to its users. Here's why: 1 - Forecasting Future Returns: Wealthfront uses historical market data, modern portfolio theory, and other quantitative models to forecast future returns on different asset classes. These forecasts are used to optimize the asset allocation in a user's investment portfolio. 2 - Goal-Based Planning: Wealthfront helps users plan for future financial goals, such as retirement or buying a home. These plans are based on forecasts of how much money a user needs to save and invest over time to reach those goals. 3 - Tax-Loss Harvesting: Wealthfront employs tax optimization strategies that involve forecasting tax implications of different investment decisions. For example, it may forecast opportunities to harvest tax losses to offset gains. 4 - Rebalancing: The service continuously monitors a user's portfolio and, when

	necessary, rebalances it to maintain the target asset allocation. This process relies on forecasts of how different asset classes will perform relative to each other. In essence, Wealthfront uses historical data and quantitative models to forecast future financial market conditions, investment returns, and tax implications. These forecasts are then used to make decisions about asset allocation, portfolio management, and financial planning. While these forecasts are based on historical data and mathematical models, they are inherently forward-looking in nature as they aim to predict future financial outcomes. Therefore, the service is primarily based on forecast properties.
Outcomes	Wealthfront's anticipatory experiences for users can lead to several key outcomes: 1 - Optimized Investment Portfolios: Wealthfront uses anticipatory algorithms to optimize investment portfolios based on a user's financial goals, risk tolerance, and market conditions. This can result in portfolios that are well-diversified and aligned with the user's objectives. 2 - Tax Efficiency: Wealthfront's anticipatory tax-loss harvesting and tax-efficient investing strategies aim to minimize tax liabilities. Users may experience reduced tax obligations, leading to potential cost savings over time. 3 - Goal Achievement: The service helps users plan for and achieve their financial goals, such as retirement or buying a home. Anticipatory projections and automated adjustments can increase the likelihood of meeting these objectives. 4 - Automated Rebalancing: Wealthfront anticipates when portfolio rebalancing is necessary to maintain the desired asset allocation. This ensures that users' investments remain aligned with their risk preferences and long-term goals. 5 - Time Savings: Users can benefit from time savings by delegating investment and financial planning tasks to Wealthfront's automated system. They can avoid the need for constant monitoring and decision-making regarding their investments. 6 - Peace of Mind: Anticipatory features can reduce financial stress by providing users with a clear roadmap for achieving their goals and optimizing their investments. This can lead to greater peace of mind regarding their financial future. 7 - Cost Efficiency: Wealthfront typically offers low management fees compared to traditional financial advisors. Users can benefit from cost-efficient investment management services. 8 - Continuous Monitoring: Anticipatory experiences involve ongoing monitoring of users' portfolios and goals. This helps ensure that investment strategies remain aligned with changing circumstances and market conditions. 9 - Transparency: Wealthfront provides users with transparency into their investments and financial plans. Users can track progress and see how their portfolios are performing relative to their goals. 10 - Financial Education: The service often includes educational resources and insights to help users better understand their investments and financial planning decisions.
Pitfalls	There are potential pitfalls and challenges that Wealthfront, like any financial advisory service, should be mindful of when offering anticipatory experiences: 1 - Data Privacy and Security: Collecting and analyzing sensitive financial data poses significant privacy and security concerns. Wealthfront must implement robust data encryption, access controls, and comply with data protection regulations to protect user information from breaches and unauthorized access. 2 - Algorithmic Bias: Anticipatory algorithms may inadvertently introduce biases in financial advice, especially if they are trained on historical data that reflects existing inequalities or biases. Ensuring fairness and addressing any bias in the system's recommendations is crucial. 3 - Risk of Over-Reliance: Users might become overly reliant on Wealthfront's anticipatory advice, potentially leading to a lack of personal responsibility and financial knowledge. There's a risk that users may not fully understand the rationale behind recommendations or the associated risks. 4 - Market Volatility: Anticipatory experiences rely on historical data and patterns,

	but unexpected market events or economic shifts can impact the accuracy of predictions. Wealthfront should provide guidance on how the system adapts to such changes and how users should respond. 5 - User Engagement: Encouraging consistent user engagement can be a challenge. Some users may set and forget their financial plans, which can be counterproductive if their financial situation or goals change. Wealthfront should find ways to keep users engaged and informed. 6 - Educational Gaps: Users with varying levels of financial literacy may struggle to understand and trust anticipatory recommendations. Wealthfront should provide educational resources to help users make informed decisions and understand the rationale behind the advice. 7 - Regulatory Compliance: Navigating financial regulations and compliance can be complex, especially if Wealthfront expands internationally. Ensuring full compliance with financial laws and regulations is essential to avoid legal pitfalls. 8 - Technical Challenges: Anticipatory experiences require robust technical infrastructure and accurate data. Technical issues, such as system outages or inaccurate data feeds, can disrupt the service and negatively impact user experience. 9 - Market Competition: The financial advisory industry is highly competitive, with both traditional and fintech firms vying for users' trust. Wealthfront should continually innovate to stay ahead and differentiate itself. 10 - Ethical Considerations: Wealthfront should carefully consider the ethical implications of its anticipatory recommendations, especially regarding investments. Ensuring that investments align with users' values and ethical considerations can be challenging. 11 - Loss of Human Touch: While automation offers efficiency, some users may still value the human touch in financial advisory services. Striking the right balance between automation and human interaction is crucial. 12 - Managing User Expectations: Anticipatory experiences can create high user expectations. Wealthfront should effectively manage these expectations by communicating the limitations of the service and the importance of ongoing financial assessment.

Company: Smart Sparrow **Industry:** Education **Channel:** Web

Criteria	Analysis
Solution	Smart Sparrow is an adaptive courseware platform that uses anticipatory design to provide personalized learning experiences for students. The platform uses data analytics and machine learning to predict each student's needs and adapt the course content to meet those needs. Smart Sparrow is an innovative educational platform that transforms learning experiences through anticipatory design. Its adaptive learning capabilities and personalized feedback make it a standout in the field of education, providing tailored learning paths and fostering student engagement.
Type of Data	Smart Sparrow collects various types of data to provide personalized learning experiences to its users. This includes: 1 - Student Performance Data: Smart Sparrow tracks students' performance data, such as quiz scores, assignment completion rates, and time spent on different activities. 2 - Learning Progress Data: The platform monitors students' progress throughout the course, including their completion of learning modules, mastery of concepts, and engagement with course materials. 3 - Interaction Data: Smart Sparrow analyzes students' interactions with the platform, including their clicks, inputs, and responses to interactive elements within the course. 4 - Learning Preferences Data: The platform collects data on students' learning

	preferences, such as their preferred learning styles, preferred media formats, and prior knowledge in specific subject areas. 5 - Feedback and Assessment Data: Smart Sparrow gathers data from student feedback, surveys, and assessments to understand their learning experience, identify areas of improvement, and provide targeted feedback.
Forecast <> Backcast	The Smart Sparrow platform is primarily based on forecast properties. It uses data analytics and machine learning algorithms to analyze students' past performance, behavior, and learning patterns to predict their future needs and adapt the course content accordingly. The platform anticipates the areas where students may struggle, identifies knowledge gaps, and proactively provides personalized learning resources and guidance to help them progress in their learning journey. By leveraging predictive analytics, Smart Sparrow aims to optimize the learning experience and enhance student outcomes.
Outcomes	The main outcomes of Smart Sparrow's anticipatory experiences for users are: 1 - Personalized Learning Paths: Smart Sparrow tailors the learning experience for each student, providing personalized learning paths that adapt to their individual needs, knowledge level, and learning pace. This personalized approach helps students stay engaged, motivated, and focused on their specific learning goals. 2 - Adaptive Content Delivery: The platform dynamically adjusts the course content and activities based on students' performance and progress. It anticipates areas where students may struggle and provides targeted interventions, remedial resources, or additional challenges to ensure a customized learning experience. 3 - Immediate Feedback and Support: Smart Sparrow offers real-time feedback to students, providing immediate guidance and support when they encounter difficulties or make mistakes. This timely feedback helps students understand concepts better, correct misconceptions, and progress more effectively through the course. 4 - Mastery-Based Learning: Smart Sparrow enables mastery-based learning, allowing students to advance through the course at their own pace. The platform identifies areas where students have already demonstrated proficiency and allows them to move ahead, focusing their efforts on challenging topics or areas requiring further practice. 5 - Enhanced Engagement: By providing interactive and immersive learning experiences, Smart Sparrow enhances student engagement and motivation. The platform incorporates gamification elements, simulations, and interactive assessments that make learning enjoyable and help students stay actively involved in the learning process. 6 - Data-Driven Insights: Smart Sparrow generates detailed analytics and insights about students' learning patterns, progress, and performance. Educators can leverage these insights to gain a deeper understanding of students' strengths and weaknesses, identify areas for improvement, and make data-informed instructional decisions.
Pitfalls	There are potential pitfalls that Smart Sparrow may face in its anticipatory service. Some of these pitfalls include: 1 - Data Privacy and Security: Collecting and analyzing student data to provide anticipatory experiences raises concerns about data privacy and security. Smart Sparrow must ensure that robust measures are in place to protect the confidentiality and integrity of student data, complying with relevant regulations and guidelines. 2 - Accuracy of Predictions: Anticipatory experiences rely on accurate predictions of student needs and learning pathways. There is a risk of inaccurate predictions, which may result in inappropriate content recommendations or ineffective adaptations. Smart Sparrow should continually refine and validate its prediction algorithms to minimize errors and enhance the accuracy of its anticipatory features. 3 - Overreliance on Technology: While technology can greatly enhance learning experiences, there is a risk of overreliance on technology and devaluing the role of

	human educators. It is important for Smart Sparrow to strike a balance between leveraging technology and maintaining the essential human element in education to ensure optimal learning outcomes. 4 - Lack of Customization: Anticipatory experiences aim to provide personalized learning paths; however, there is a challenge in striking the right balance between customization and standardization. Smart Sparrow needs to ensure that the platform allows for sufficient customization while still maintaining consistency and adherence to educational standards. 5 - User Engagement and Acceptance: Anticipatory experiences may face challenges in user engagement and acceptance. Some students may prefer more control over their learning experiences or may be skeptical about the effectiveness of personalized recommendations. Smart Sparrow should focus on creating user-friendly interfaces, providing clear explanations of the anticipatory features, and addressing user concerns to foster engagement and acceptance. 6 - Bias in Predictive Algorithms: Anticipatory experiences rely on predictive algorithms that analyze student data and make recommendations. There is a risk of bias in these algorithms, leading to unequal treatment or perpetuating existing biases. Smart Sparrow should ensure that its algorithms are developed and validated with diverse datasets to mitigate biases and promote fairness and equity in the learning experience. 7 - Ethical Considerations: Anticipatory experiences raise ethical considerations regarding the use of student data and the extent of influence over their learning journey. Smart Sparrow should establish clear ethical guidelines and practices, including obtaining informed consent, transparent data handling, and providing options for users to control and adjust the level of anticipatory interventions. 8 - Technical Challenges: Implementing and maintaining an anticipatory platform like Smart Sparrow may involve technical challenges. Ensuring seamless integration with existing learning management systems, scalability to handle large user bases, and timely updates and improvements can pose technical hurdles that need to be addressed effectively. 9 - Learning Adaptation Limitations: While anticipatory design aims to adapt the learning experience to individual needs, there may be limitations in accommodating diverse learning styles, preferences, and abilities. Smart Sparrow should continuously enhance its adaptive capabilities and explore innovative approaches to cater to a wide range of learners and their unique requirements. 10 - Educator Training and Support: The successful implementation of Smart Sparrow's anticipatory service relies on the effective training and support of educators. Educators need to understand how to leverage the platform's features and interpret the data-driven insights to optimize the learning experience. Smart Sparrow should provide comprehensive training programs and ongoing support to educators to ensure their readiness and confidence in utilizing the anticipatory features.

Company: Knewton **Industry:** Education **Channel:** Web

Criteria	Analysis
Solution	Knewton is an adaptive learning platform that uses anticipatory design to personalize the learning experience for each student. The platform analyzes the student's learning style, behavior, and progress to predict what content they will need to master next and deliver it to them. Knewton's adaptive learning system uses sophisticated algorithms and machine learning to analyze and interpret this data. It then uses this analysis to dynamically adjust the learning experience for each user, providing personalized content, recommendations, and challenges to optimize the

	learning journey based on individual needs and progress. This adaptability is a key feature of Knewton's educational technology.
Type of Data	To provide its adaptive learning experiences to users, Knewton leverages a wide range of data types, which can include: 1 - User Data: Knewton collects data about individual learners. This includes information such as the learner's past academic performance, current skill levels, learning preferences, and personal goals. User data is used to create a learner profile that informs the adaptive learning process. 2 - Assessment Data: Knewton often relies on assessment data to gauge a learner's knowledge and proficiency in various subjects or skills. This data can be collected through quizzes, tests, or other forms of assessment within the platform. 3 - Content Data: Knewton uses data related to the educational content available on its platform. This can include the difficulty level of different learning materials, the format of content (text, video, interactive exercises), and metadata about educational resources. 4 - Interaction Data: Interaction data tracks how users engage with the platform. This may include which content they access, how much time they spend on specific topics or exercises, and their responses to questions or activities. 5 - Progress Data: Knewton monitors a learner's progress over time. This involves tracking improvements in knowledge and skills, completion of lessons or modules, and achievements of learning goals. 6 - Learning Path Data: Knewton uses data related to the learner's path through the educational material. This includes recommendations for which content to study next based on the learner's performance and goals. 7 - Feedback Data: Learner feedback, such as comments, ratings, or reactions to content, can provide valuable insights for improving the learning experience. 8 - Demographic Data: While privacy is a concern, some educational platforms may use limited demographic data to tailor content or recommendations to specific user groups. This data is often anonymized and aggregated to protect user privacy. 9 - Behavioral Data: Data on how learners navigate the platform, including where they click, how they scroll, and how long they spend on various elements, can help optimize the user interface and content delivery. 10 - Device and Technical Data: Information about the devices and technical specifications learners use to access the platform, such as operating systems, browsers, and internet connection speeds, can help ensure a seamless user experience.
Forecast <> Backcast	Knewton's adaptive learning service is primarily based on forecast properties. It uses predictive analytics and machine learning algorithms to forecast a learner's future educational needs and adapt the learning experience accordingly. Here's how it works: 1 - Learner Profiling: Knewton creates a learner profile for each user based on their past academic performance, current skill levels, learning preferences, and goals. This learner profile serves as the basis for making predictions about what the user should study next. 2 - Predictive Analytics: Knewton's algorithms analyze a learner's interactions with the platform, such as their responses to quizzes, time spent on different topics, and progress through lessons. These interactions are used to predict the learner's future knowledge gaps, strengths, and areas where they might need additional support. 3 - Adaptive Recommendations: Based on these predictions, Knewton's system makes adaptive recommendations about which educational content the learner should engage with next. For example, if the system predicts that a learner is likely to struggle with a particular concept, it might recommend additional resources or exercises related to that concept. 4 - Continuous Adjustment: As the learner progresses and interacts with the platform, Knewton continues to adjust its recommendations in real-time. It constantly forecasts the learner's evolving needs and adapts the learning path accordingly. In essence, Knewton's adaptive learning system is forward-looking, continuously

	forecasting what the learner needs to achieve their educational goals and tailoring the learning experience accordingly. It's designed to anticipate and address knowledge gaps before they become barriers to learning. While Knewton's approach is primarily based on forecasting, it does incorporate some elements of backcasting. For example, if a learner struggles with a particular concept, the system may provide additional resources to help the learner catch up. This can be seen as a form of backcasting, where the system identifies a deficiency in the learner's knowledge and seeks to remediate it. However, the overall adaptive nature of the system is forward-focused on predicting and addressing future learning needs.
Outcomes	Knewton's anticipatory experiences in adaptive learning can lead to several key outcomes for users: 1 - Personalized Learning: Users benefit from a highly personalized learning experience tailored to their individual needs, strengths, and weaknesses. This personalization can result in a more efficient and effective learning journey. 2 - Improved Learning Efficiency: Anticipatory recommendations ensure that users focus on the topics or concepts they are most likely to benefit from. This can lead to improved learning efficiency, with users making faster progress in their studies. 3 - Knowledge Mastery: Knewton's anticipatory system helps users master the subject matter by addressing knowledge gaps as they arise. Users are more likely to achieve a deeper understanding of the material, leading to better retention and application of knowledge. 4 - Increased Engagement: Personalized recommendations and content make the learning experience more engaging and relevant to users. This can lead to higher levels of motivation and a greater commitment to their studies. 5 - Confidence Building: As users experience success in mastering challenging topics, their confidence in their own abilities can increase. This boost in self-confidence can have a positive impact on their overall learning experience. 6 - Time Savings: By focusing on what users need to learn most, Knewton's anticipatory experiences can help users save time compared to traditional, non-adaptive learning methods. Users spend less time on topics they've already mastered and more time on areas that need improvement. 7 - Higher Achievement Levels: Ultimately, the anticipatory experiences are designed to help users achieve their educational goals. Whether it's acing a test, passing a course, or gaining a deeper understanding of a subject, users are more likely to succeed with the personalized support provided by Knewton. 8 - Lifelong Learning: Knewton's adaptive learning can foster a culture of lifelong learning. Users may become more accustomed to seeking out educational resources and adapting their learning strategies even beyond their interactions with the platform. 9 - Data-Driven Insights: Users may gain a better understanding of their own learning patterns and preferences through the data-driven insights provided by Knewton. This self-awareness can be valuable in future educational endeavors. 10 - Accessibility: Anticipatory experiences can make education more accessible to a broader range of learners. It can benefit students with varying abilities and backgrounds, leveling the playing field and reducing achievement gaps. 11 - Educational Progress: Users can track their progress and see how they've improved over time. This sense of achievement and visible progress can motivate users to continue their educational journey. 12 - Reduced Frustration: Anticipatory experiences can reduce frustration associated with hitting learning roadblocks. Users are less likely to get stuck on difficult topics because the system identifies and addresses challenges as they arise.
Pitfalls	While Knewton's anticipatory learning service offers substantial benefits, there are potential pitfalls and challenges to consider: 1 - Data Privacy and Security Concerns: Collecting and analyzing user data to provide personalized learning experiences raises significant privacy and security concerns. Ensuring robust data encryption, user consent mechanisms, and

	compliance with data protection regulations is essential to protect user information. 2 - Algorithmic Bias: Anticipatory learning algorithms must be carefully designed to avoid introducing biases into educational recommendations. If not managed properly, these algorithms may inadvertently favor certain groups or learning styles, potentially resulting in unfair educational outcomes. 3 - Overemphasis on Standardized Testing: Depending on the data sources and algorithms used, there is a risk that Knewton's system may prioritize performance on standardized tests over holistic learning outcomes. This can lead to a narrow focus on test preparation rather than fostering a deep understanding of subject matter. 4 - User Engagement and Autonomy: While anticipatory experiences can be highly personalized, there's a risk that students may become overly reliant on the platform, diminishing their self-directed learning skills and autonomy. Encouraging a healthy balance between technology-assisted learning and self-motivated learning is crucial. 5 - Technical Challenges: Anticipatory learning relies on complex algorithms and technical infrastructure. Technical glitches, system outages, or inaccuracies in data processing can disrupt the learning experience and negatively impact user trust. 6 - Ethical Considerations: Knewton should carefully consider the ethical implications of its anticipatory learning service. Transparency in data usage, informed consent, and ethical guidelines for educational content and recommendations are essential. 7 - User Trust and Data Transparency: Building and maintaining user trust is paramount. Users must understand how their data is used, and Knewton should be transparent about its data practices to ensure users are comfortable with the platform's operation. 8 - Learning Styles and Diversity: Anticipatory learning may not suit all learning styles or accommodate diverse cultural or educational backgrounds. Ensuring that the platform is inclusive and adaptable to various learner needs is a challenge. 9 - Teacher Integration: If Knewton's platform is intended for use in educational settings, integrating it into existing teaching practices and curricula may require substantial teacher training and support. Resistance from educators can be a barrier to adoption. 10 - Resource and Content Development: Creating high-quality, diverse, and engaging educational content for anticipatory learning can be resource-intensive. Ensuring that content remains current and aligns with various educational standards is a challenge. 11 - Depersonalization of Learning: Overpersonalization can result in a depersonalization of the learning experience. Students may feel that their learning journey is solely determined by algorithms, potentially leading to disengagement or frustration. 12 - Accessibility and Inclusivity: Ensuring that the anticipatory learning platform is accessible to users with disabilities and addresses the needs of diverse learners requires careful design and ongoing commitment. 13 - Regulatory Compliance: Adhering to educational regulations and standards in different regions and educational levels can be complex. Ensuring that the platform complies with varying educational laws is essential for its acceptance in formal education settings. 14 - User Feedback and Adaptation: Effectively incorporating user feedback into the platform's development and adaptation processes is crucial. Balancing user requests with pedagogical principles and data-driven recommendations can be challenging. 15 - Continuous Research and Improvement: Anticipatory learning requires ongoing research and development to improve algorithms, educational effectiveness, and user experience. Remaining at the forefront of educational technology requires a commitment to innovation.

Company: Dreambox **Industry:** Education **Channel:** Web

Criteria	Analysis
Solution	Dreambox Learning is a math learning platform for students that uses anticipatory design to adapt to each student's learning style and pace. The platform uses AI to predict which concepts the student is struggling with and provides targeted instruction and feedback to help them master the material. DreamBox Learning uses a variety of data to provide its personalized learning experiences to users, primarily focusing on educational data.
Type of Data	Some of the types of data they may use include: 1 - Student Performance Data: This includes data on how students are performing in various subjects, topics, or skills. It can include information on correct and incorrect answers, time spent on tasks, and progress over time. 2 - Assessment Data: Data from assessments and quizzes are essential for evaluating a student's knowledge and areas of strength or weakness. It helps in tailoring the learning experience to meet specific learning objectives. 3 - Learning Style and Preferences: DreamBox may gather data on how students prefer to learn. For example, some students may learn best through visual aids, while others prefer interactive exercises. Understanding these preferences can help personalize the learning experience. 4 - Progress Tracking: The platform tracks a student's progress over time, showing how they have improved in various areas. This data helps in setting new learning goals and adjusting the difficulty level of exercises. 5 - Response Time Data: The time a student takes to respond to questions or exercises can provide insights into their confidence and understanding of the material. It can help identify when a student might be struggling with a concept. 6 - Curriculum Data: Information about the curriculum and learning objectives is crucial. DreamBox aligns its content with specific standards, so tracking progress toward these objectives is essential. 7 - Engagement Data: Data on how engaged a student is with the platform can indicate their interest and motivation levels. It can help in designing more engaging content. 8 - User Feedback: Direct feedback from students, teachers, and parents can be valuable. This might include comments on the difficulty of exercises or areas where additional help is needed. 9 - Teacher Data: For educators, the platform might collect data on how they use the system, what tools they find most helpful, and how they track their students' progress. 10 - Data on Learning Paths: The platform often recommends a specific learning path for each student. Data on which paths are most effective for different types of students is used to improve recommendations. 11 - Demographic Data: In some cases, demographic data might be collected to understand how factors like age, grade level, or location influence learning patterns.
Forecast <> Backcast	DreamBox Learning primarily operates based on forecast properties rather than backcast properties. In education technology like DreamBox, the primary aim is to anticipate a student's learning needs and adapt the learning experience in real-time. This is a forward-looking approach, often referred to as "forecasting." Here's how it works: 1 - Anticipating Student Needs: DreamBox uses data analytics and algorithms to forecast what a student needs to learn next. It doesn't rely solely on past performance (backcast) but instead uses a variety of data points to predict what concepts a student is ready to tackle. 2 - Personalized Learning: Based on these forecasts, DreamBox provides personalized learning pathways for each student. This means that even if a student has struggled with a particular topic in the past, the system can present that topic

	again if it predicts that the student is now ready to grasp it. 3 - Continuous Adaptation: DreamBox continually adapts its content and recommendations as students progress. It's not limited to repeating past content (backcasting) but actively adjusts to the student's current and future learning needs. 4 - Feedback-Driven Improvement: The system uses real-time feedback from student interactions to refine its forecasts and recommendations. This feedback loop helps enhance the accuracy of the system's predictions over time. In summary, DreamBox's approach is forward-looking and anticipatory, focusing on predicting what a student needs to learn next rather than simply repeating past content. This is a hallmark of many modern adaptive learning platforms in the education technology sector.
Outcomes	DreamBox Learning's anticipatory experiences for users in the field of education primarily aim to achieve several key outcomes: 1 - Personalized Learning: DreamBox's anticipatory experiences enable personalized learning pathways for each student. This personalization tailors the learning experience to the individual's current abilities, ensuring that they receive content and challenges that are appropriate for their skill level. The main outcome here is a more effective and engaging learning experience. 2 - Improved Learning Outcomes: By predicting and delivering content that matches each student's readiness level, DreamBox aims to improve learning outcomes. Students are more likely to grasp and master new concepts when they are introduced at the right time in their learning journey, leading to better academic performance. 3 - Increased Engagement: Anticipatory experiences can boost student engagement. When students find the content relevant and appropriately challenging, they are more motivated to participate in lessons, complete assignments, and take ownership of their learning. 4 - Reduced Frustration: DreamBox's anticipatory approach can help reduce student frustration. When content is neither too easy nor too difficult, students are less likely to become discouraged or disinterested in their studies. 5 - Data-Driven Insights: The platform generates valuable data on each student's learning journey. This data can provide insights into areas where students excel or struggle. Educators can then use this information to tailor their teaching and support strategies, ultimately leading to more effective instruction. 6 - Efficient Resource Allocation: Anticipatory experiences help optimize resource allocation. Schools and teachers can focus their efforts and resources on students who need the most assistance, ensuring that interventions are timely and effective. 7 - Self-Paced Learning: DreamBox's anticipatory experiences enable self-paced learning. Students can progress through content at their own speed, ensuring that they fully grasp a concept before moving on to the next one. This fosters a deeper understanding of the material. 8 - Confidence Building: Success in learning builds confidence. When students experience success by mastering concepts at their readiness level, they gain confidence in their abilities, which can have positive effects on their overall attitude toward learning. 9 - Differentiation: Anticipatory experiences allow for differentiation in the classroom. Educators can more easily accommodate students with varying skill levels within the same class, ensuring that each student receives the appropriate level of challenge and support. 10 - Teacher Empowerment: Educators benefit from the data and insights provided by the anticipatory system. This empowers teachers to make informed decisions about lesson planning, intervention strategies, and resource allocation, ultimately improving their effectiveness in the classroom. 11 - Time Savings: Anticipatory experiences can save teachers time by automating certain aspects of lesson planning and assessment. This allows educators to focus more on instructional strategies and individualized support for students.

Pitfalls	There are potential pitfalls and challenges that DreamBox Learning, like any educational technology service, should be mindful of when offering anticipatory experiences: 1 - Data Privacy and Security: DreamBox collects sensitive student data to provide its anticipatory experiences. Ensuring robust data privacy and security measures is paramount to protect student information from unauthorized access or data breaches. 2 - Algorithmic Bias: Anticipatory algorithms may inadvertently introduce biases into learning recommendations. This can result in unequal educational outcomes for students. Regularly auditing and adjusting algorithms to minimize biases is essential. 3 - Loss of Human Element: While automation can enhance learning, there's a risk of students losing the personal touch of traditional education. Striking the right balance between automation and human interaction, particularly in areas where human guidance is crucial, is essential. 4 - Overreliance on Technology: Students might become overly reliant on DreamBox for their learning, potentially diminishing their independent problem-solving skills and creativity. Encouraging students to use the platform as a learning aid rather than a replacement for traditional learning is important 5 - Teacher Preparedness: Teachers need adequate training and support to effectively use anticipatory experiences in their classrooms. A lack of teacher preparedness can hinder the successful integration of technology into the curriculum. 6 - User Engagement: Ensuring students remain engaged with the platform is challenging. Some students may disengage or lose interest in the learning process if not properly motivated or if they feel overwhelmed by technology. 7 - Assessment Accuracy: The accuracy of assessments and predictions is critical. If the system misjudges a student's readiness or struggles, it can lead to inappropriate learning recommendations or frustration. 8 - Access Disparities: Ensuring equitable access to DreamBox for all students, regardless of socioeconomic status or access to technology at home, is a significant challenge. Addressing these disparities is crucial for inclusive education. 9 - Content Quality: The quality of educational content on the platform is essential. Outdated or inaccurate content can negatively impact the learning experience. 10 - Regulatory Compliance: Navigating educational regulations and compliance, especially when serving students in multiple regions, can be complex. Ensuring that the platform complies with local educational standards and privacy regulations is essential. 11 - Technical Issues: Technical problems, such as platform outages or compatibility issues with various devices and browsers, can disrupt the learning experience. Ensuring system reliability and quick issue resolution is crucial. 12 - Ethical Considerations: DreamBox should carefully consider ethical considerations in the use of student data and technology in education. Ensuring transparent data practices and ethical guidelines is important. 13 - Parental Involvement: Involving parents in their child's learning journey through DreamBox can be challenging, as some parents may not be tech-savvy or actively engaged in their child's education. 14 - Adaptive Learning Limitations: While adaptive learning is a powerful tool, it may not be suitable for every learning scenario or subject. Identifying where traditional teaching methods are more effective is important. 15 - Student Health and Wellbeing: Prolonged screen time and technology use can have implications for students' health and wellbeing. Balancing technology-based learning with physical activity and offline activities is important. 16 - Feedback Mechanisms: Establishing effective feedback mechanisms for students, teachers, and parents to communicate concerns, report issues, or suggest improvements is crucial for ongoing improvement. In summary, DreamBox Learning has numerous opportunities to advance its anticipatory experiences in education, from refining algorithms and expanding content to enhancing teacher support and addressing the diverse needs of students and educators. These opportunities position the platform for growth and broader positive impact in the education sector.

Company: BMW ConnectedDrive **Industry:** Transportation **Channel:** IoT

Criteria	Analysis
Solution	BMW ConnectedDrive vehicle connectivity system anticipates users' needs by providing real-time traffic information, route recommendations, and other personalized services based on the user's location and driving habits. BMW ConnectedDrive showcases anticipatory design in the automotive industry better than anyone. They offer proactive assistance and personalized recommendations to drivers. Its integration of sensors, connectivity, and data analysis enables a more seamless and anticipatory driving experience.
Type of Data	BMW ConnectedDrive utilizes various types of data to provide an anticipatory driving experience to its users. Some of the key data types include: 1 - Location Data: BMW ConnectedDrive uses GPS and location-based services to track the user's current location, enabling it to provide real-time traffic information and route recommendations. 2 - Driving Habits Data: The system collects data on the user's driving behavior, such as acceleration, braking, and speed patterns. This information helps it understand the user's driving preferences and tailor recommendations accordingly. 3 - Vehicle Data: BMW ConnectedDrive gathers data from the vehicle's sensors and systems, including engine performance, fuel consumption, and maintenance status. This data allows the system to provide personalized maintenance reminders and optimize vehicle performance. 4 - User Preferences Data: The system stores user preferences, such as preferred routes, music playlists, and climate settings. It leverages this data to customize the driving experience and make proactive suggestions based on individual preferences. 5 - Traffic Data: BMW ConnectedDrive integrates with traffic information sources to access real-time traffic data, road conditions, and congestion levels. This data is used to anticipate traffic situations and offer alternative routes or timely alerts to the user. 6 - External Data Sources: The system may also integrate data from external sources, such as weather forecasts, event schedules, and points of interest databases, to provide relevant and timely recommendations.
Forecast <> Backcast	BMW ConnectedDrive is primarily based on forecast properties. It uses real-time data, such as location, traffic information, and driving habits, to anticipate the user's needs and provide proactive recommendations. By analyzing the current data and applying algorithms and predictive models, the system can forecast potential driving scenarios, traffic conditions, and personalized services. It aims to anticipate the user's requirements before they arise, enabling a seamless and anticipatory driving experience.
Outcomes	The main outcomes of BMW ConnectedDrive's anticipatory experiences for users include: 1 - Enhanced driving convenience: Users can benefit from real-time traffic information, route recommendations, and personalized services tailored to their driving preferences. This improves their overall driving experience and helps them navigate more efficiently. 2 - Increased safety: The system can provide warnings and alerts based on the user's driving behavior and the surrounding conditions. This proactive approach enhances safety by notifying users of potential hazards and suggesting precautionary measures. 3 - Time and energy savings: By anticipating traffic patterns and offering optimized route suggestions, BMW ConnectedDrive helps users save time and avoid congested areas. This can lead to more efficient and stress-free journeys, saving both time and fuel. 4 - Personalized services: The system can offer personalized services based on the

	user's preferences, such as recommendations for nearby points of interest, restaurants, and attractions. This adds a layer of personalization to the driving experience and helps users discover new places. 5 - Seamless integration with other devices: BMW ConnectedDrive integrates with other devices and platforms, allowing users to connect their smartphones, smartwatches, and other devices for a seamless and connected driving experience. This integration enhances convenience and accessibility for users.
Pitfalls	While BMW ConnectedDrive offers exciting anticipatory experiences, there are potential pitfalls that should be addressed: 1 - Data privacy and security: Collecting and analyzing user data to deliver personalized anticipatory experiences requires careful attention to data privacy and security. BMW ConnectedDrive must ensure robust data protection measures and transparent data usage policies to maintain user trust and comply with privacy regulations. 2 - Reliance on accurate data and connectivity: Anticipatory experiences heavily rely on accurate data and seamless connectivity. Any disruptions in data sources, such as inaccurate traffic information or unreliable internet connectivity, can impact the accuracy and reliability of the anticipatory features, leading to potential frustrations for users. 3 - User acceptance and trust: Anticipatory experiences may raise concerns about data usage and potential intrusiveness. BMW ConnectedDrive should communicate the value proposition of its anticipatory features clearly and transparently to address any user concerns and build trust in the system. 4 - Adaptation to diverse user preferences: Anticipatory systems need to accommodate individual preferences and adapt to diverse user behaviors. Balancing personalized recommendations with user control and customization options is crucial to avoid overwhelming or alienating users who may have different preferences and needs. 5 - Maintenance and updates: Anticipatory systems require regular maintenance and updates to ensure optimal performance. Keeping up with evolving technologies, data sources, and user expectations is essential to provide a seamless and reliable anticipatory experience. BMW ConnectedDrive should have robust processes in place to monitor and improve the system over time.

Company: Citymapper **Industry:** Transportation **Channel:** Mobile

Criteria	Analysis
Solution	Citymapper is a comprehensive urban transportation app that integrates various modes of transportation, including buses, trains, bikes, and ride-sharing services. The app provides real-time updates on transit schedules, route options, and disruptions. Citymapper also uses machine learning algorithms to anticipate user needs, such as suggesting optimal transit routes and notifying users of any service changes or delays Citymapper's anticipatory experiences in the transportation sector aim to provide users with comprehensive, real-time transit information, personalized route suggestions, and a more efficient, eco-friendly, and less stressful commuting experience.
Type of Data	Citymapper utilizes a wide array of data sources to offer its comprehensive urban transportation service. This includes real-time transit data from public agencies, covering bus and train schedules, arrival times, and service disruptions. The app integrates various transportation modes, such as buses, subways, bikes, and ride-sharing services like Uber, offering users multiple route options. To optimize routes, Citymapper incorporates real-time traffic data to anticipate congestion and suggest

	alternative paths. Machine learning algorithms analyze user behavior and preferences, enabling personalized route recommendations. Crowd-sourced data from users reporting issues and sharing journey information further enhances the platform's accuracy and completeness. In sum, Citymapper harnesses this diverse data ecosystem to deliver a dynamic and anticipatory urban transportation experience, simplifying navigation in complex city environments.
Forecast <> Backcast	Citymapper primarily relies on forecast properties to provide its anticipatory urban transportation service. It uses real-time data, including transit schedules, traffic conditions, and user preferences, to predict optimal routes and transportation options for users. The app forecasts the best routes and suggests them to users based on current and anticipated conditions. While it can incorporate historical data and past user behavior to improve its recommendations, the core of its service is forward-looking, aiming to provide users with the most efficient and up-to-date transportation options in real-time.
Outcomes	The main outcomes of Citymapper's anticipatory experiences for users in the transportation sector include: 1 - Comprehensive Urban Mobility: Citymapper integrates various modes of transportation, such as buses, trains, bikes, and ride-sharing services, into a single platform. This provides users with a comprehensive view of available transit options in their city, promoting multi-modal transportation. 2 - Real-Time Transit Updates: Users receive real-time updates on transit schedules, delays, and disruptions. This ensures that they have the most up-to-date information for planning their journeys and helps avoid inconveniences caused by transit delays. 3 - Optimal Route Suggestions: Citymapper uses machine learning algorithms to anticipate user needs and suggests optimal transit routes. This feature streamlines the planning process, helping users select the fastest and most efficient way to reach their destinations. 4 - Customized Commute: The app allows users to set their preferred modes of transportation and provides tailored recommendations based on their preferences. This personalization enhances the user experience and encourages sustainable transportation choices. 5 - Service Change Notifications: Citymapper notifies users of any service changes, route diversions, or disruptions, enabling them to adjust their plans accordingly. This reduces uncertainty and minimizes the impact of unexpected changes in transit services. 6- Increased Mobility: By providing a comprehensive view of transportation options, Citymapper promotes mobility and accessibility within urban areas. Users can confidently navigate the city using a wide range of transit choices. 7 - Reduced Commute Stress: Access to real-time information and optimized routes helps users reduce the stress associated with daily commuting. They can plan their journeys with confidence, knowing they are making the most efficient choices. 8 - Eco-Friendly Transportation: Citymapper encourages users to choose eco-friendly transportation options, such as walking, biking, or public transit. This supports sustainability and reduces traffic congestion and pollution in urban areas. 9 - Cost Savings: Users can make informed choices that lead to cost savings by using the most cost-effective transportation options available. This can include choosing public transit over more expensive alternatives like ride-sharing services. 10 - Community Engagement: Citymapper thrives on user input and engagement. Users can contribute data and feedback, creating a sense of community among commuters and improving the accuracy of information available on the platform.
Pitfalls	There are potential pitfalls and challenges that Waze may encounter as it continues to develop its anticipatory navigation service: 1 - Data Privacy Concerns: Collecting and sharing real-time data from users raises privacy concerns. Users may worry about the extent to which their location and

	travel data are being tracked and shared. Maintaining robust data privacy measures and transparent data handling practices is crucial to address these concerns. 2 - Data Accuracy: The accuracy of real-time data, including traffic updates and road conditions, is vital. Inaccurate information can lead to misinformed decisions and frustration among users. Waze must continuously improve its data accuracy and validation processes. 3 - Algorithm Bias: Waze's routing algorithms should be carefully designed to avoid introducing bias. Biased algorithms might unintentionally favor certain routes or areas, potentially causing traffic congestion in some neighborhoods while benefiting others. 4 - Overreliance on Technology: There's a risk that users may become overly reliant on Waze for navigation, leading to decreased situational awareness and decision-making skills. Encouraging users to use the service as a tool rather than a substitute for their judgment is essential. 5 - Traffic Manipulation: As a crowd-sourced platform, Waze may be susceptible to manipulation by users who report fake incidents or traffic conditions. Developing robust mechanisms to detect and prevent such abuse is crucial. 6 - Safety Concerns: While Waze provides valuable real-time information, it can also be distracting for drivers. Ensuring that the app's interface remains user-friendly and non-distracting is important to prevent accidents 7 - User-Generated Content: Relying on user-generated content means that the quality and accuracy of information can vary. Waze needs effective ways to filter and verify user-generated data to maintain its reliability. 8 - Competitive Pressure: The navigation app market is highly competitive, with both established players and newcomers. Waze must continually innovate to stay ahead of the competition and meet changing user expectations. 9 - Regulatory Challenges: Navigating various local and international regulations, especially in terms of data collection and privacy, can be complex. Compliance with these regulations is essential to avoid legal issues. 10 - User Fatigue: Waze's frequent notifications and alerts could lead to user fatigue or annoyance if not managed properly. Offering customization options for notifications and reminders is important. 11 - Dependency on Internet Connectivity: Waze relies heavily on a stable internet connection for real-time updates. Poor connectivity in certain areas can disrupt the user experience. 12 - Negative Impact on Local Roads: Waze's rerouting to avoid traffic congestion might lead to increased traffic on smaller, local roads not designed for heavy traffic. This could be a concern for local communities. 13 - Environmental Impact: Constant rerouting can result in increased fuel consumption and emissions, potentially contributing to environmental concerns. 14 - Community Management: Managing a community of users who contribute data and reports requires effective moderation and mechanisms to handle disputes and ensure the quality of shared information. 15 - Technology Integration: Ensuring compatibility and smooth integration with various in-car systems and mobile devices can be challenging as technology evolves.

Company: Waze **Industry:** Transportation **Channel:** Mobile

Criteria	Analysis
Solution	Waze is a navigation app that uses anticipatory design to suggest the best routes based on real-time traffic data and the user's preferred settings. It can also predict the user's destination based on their frequent locations and time of day. Waze's anticipatory experiences in the transportation sector focus on real-time

	updates, personalized recommendations, and community collaboration, ultimately leading to improved efficiency, reduced stress, and enhanced safety for users.
Type of Data	Waze primarily relies on real-time and crowd-sourced data to provide its anticipatory navigation and traffic updates. This data includes information on current traffic conditions, road closures, accidents, road hazards, speed traps, and even user-generated reports about these incidents. Additionally, Waze collects data on user location and movement patterns to anticipate traffic congestion and recommend alternative routes. This combination of real-time and crowd-sourced data enables Waze to offer its users highly accurate and up-to-date navigation information, allowing them to make informed decisions while driving.
Forecast <> Backcast	Waze predominantly relies on forecast properties to provide its anticipatory navigation and traffic service. It gathers real-time data from its community of users, including their GPS locations, driving speeds, and reports of road conditions. By analyzing this data, Waze can anticipate traffic congestion, accidents, road closures, and other potential disruptions. It then uses this information to forecast and suggest alternative routes to drivers in real-time. While historical traffic data can play a role in its algorithms, the core of Waze's service is focused on providing users with proactive and forward-looking recommendations to optimize their driving routes.
Outcomes	The main outcomes of Waze's anticipatory experiences for users in the transportation sector include: 1 - Real-Time Traffic Updates: Waze provides users with real-time traffic information, allowing them to make informed decisions about their routes. This leads to reduced commute times, less frustration, and a smoother driving experience 2 - Anticipatory Routing: Waze anticipates traffic conditions and suggests alternative routes to avoid congestion, accidents, or road closures. Users benefit from quicker and more efficient routes, saving time and fuel. 3 - Alerts for Hazards: The app provides alerts for road hazards, accidents, and speed traps. This enhances safety by helping drivers navigate potentially dangerous situations and maintain compliance with speed limits. 4 - Crowd-Sourced Data: Waze's community-based model relies on data from its users. This fosters a sense of community and collaboration among drivers, as they contribute to the accuracy and effectiveness of the app by reporting real-time information. 5 - Personalized Experience: Waze customizes its recommendations based on a user's location, driving habits, and real-time data. This personalized approach ensures that users receive relevant information tailored to their specific needs. 6 - Reduced Stress: By providing proactive information about traffic conditions and suggesting optimal routes, Waze helps reduce stress for drivers. Knowing what to expect on the road ahead can lead to a more relaxed and pleasant driving experience 7 - Improved Efficiency: Users can plan their journeys more efficiently, whether for daily commutes or long-distance travel. This contributes to better time management and increased productivity. 8 - Cost Savings: Waze's anticipatory features can lead to cost savings through reduced fuel consumption and minimized wear and tear on vehicles. Drivers can also avoid toll roads and other expenses with route optimization. 9 - Community Engagement: Waze fosters a sense of community among its users who actively contribute to the app's data. This collective effort enhances the overall user experience and strengthens the Waze community.
Pitfalls	There are potential pitfalls and challenges that Waze may encounter as it continues to develop its anticipatory navigation service: 1 - Data Privacy Concerns: Collecting and sharing real-time data from users raises privacy concerns. Users may worry about the extent to which their location and

	travel data are being tracked and shared. Maintaining robust data privacy measures and transparent data handling practices is crucial to address these concerns. 2 - Data Accuracy: The accuracy of real-time data, including traffic updates and road conditions, is vital. Inaccurate information can lead to misinformed decisions and frustration among users. Waze must continuously improve its data accuracy and validation processes. 3 - Algorithm Bias: Waze's routing algorithms should be carefully designed to avoid introducing bias. Biased algorithms might unintentionally favor certain routes or areas, potentially causing traffic congestion in some neighborhoods while benefiting others. 4 - Overreliance on Technology: There's a risk that users may become overly reliant on Waze for navigation, leading to decreased situational awareness and decision-making skills. Encouraging users to use the service as a tool rather than a substitute for their judgment is essential. 5 - Traffic Manipulation: As a crowd-sourced platform, Waze may be susceptible to manipulation by users who report fake incidents or traffic conditions. Developing robust mechanisms to detect and prevent such abuse is crucial. 6 - Safety Concerns: While Waze provides valuable real-time information, it can also be distracting for drivers. Ensuring that the app's interface remains user-friendly and non-distracting is important to prevent accidents 7 - User-Generated Content: Relying on user-generated content means that the quality and accuracy of information can vary. Waze needs effective ways to filter and verify user-generated data to maintain its reliability. 8 - Competitive Pressure: The navigation app market is highly competitive, with both established players and newcomers. Waze must continually innovate to stay ahead of the competition and meet changing user expectations. 9 - Regulatory Challenges: Navigating various local and international regulations, especially in terms of data collection and privacy, can be complex. Compliance with these regulations is essential to avoid legal issues. 10 - User Fatigue: Waze's frequent notifications and alerts could lead to user fatigue or annoyance if not managed properly. Offering customization options for notifications and reminders is important. 11 - Dependency on Internet Connectivity: Waze relies heavily on a stable internet connection for real-time updates. Poor connectivity in certain areas can disrupt the user experience. 12 - Negative Impact on Local Roads: Waze's rerouting to avoid traffic congestion might lead to increased traffic on smaller, local roads not designed for heavy traffic. This could be a concern for local communities. 13 - Environmental Impact: Constant rerouting can result in increased fuel consumption and emissions, potentially contributing to environmental concerns. 14 - Community Management: Managing a community of users who contribute data and reports requires effective moderation and mechanisms to handle disputes and ensure the quality of shared information. 15 - Technology Integration: Ensuring compatibility and smooth integration with various in-car systems and mobile devices can be challenging as technology evolves.

Company: Amazon **Industry:** Retail **Channel:** Mobile & Web

Criteria	Analysis
Solution	Amazon is a pioneering force in the realm of anticipatory experiences, harnessing data analytics and machine learning algorithms to offer a highly personalized and efficient service. By analyzing user behavior and purchase histories, Amazon provides tailored product recommendations, making online shopping more convenient and engaging. Additionally, the company streamlines the checkout

	process, storing user information securely for swift, one-click purchases. Amazon Prime, one of its flagship services, epitomizes anticipatory design by delivering fast shipping options that meet users' desires for rapid deliveries. Amazon has been utilizing anticipatory experiences for some time, consistently enhancing its algorithms and services to better comprehend and satisfy customer needs, thus fostering loyalty and driving substantial growth in sales.
Type of Data	Amazon employs a wide array of data types to deliver its anticipatory experiences to users, including: 1 - User Behavior Data: Amazon collects and analyzes user behavior on its platform, including product searches, clicks, and purchases. This data helps identify user preferences, interests, and shopping habits. 2 - Purchase History Data: Information on previous purchases enables Amazon to make tailored product recommendations, suggesting items related to a user's past buying patterns. 3 - Product Data: Amazon gathers data on its vast inventory of products, including details like product descriptions, customer reviews, and ratings. This information is used to enrich product recommendations and provide users with valuable insights. 4 - Location Data: When users provide location information or grant access to their device's location, Amazon can offer localized services, such as delivery options and availability of products in nearby warehouses. 5 - Device Data: Information about the devices users use to access Amazon's platform, such as smartphones, tablets, or desktop computers, helps optimize the user experience for different devices. 6 - Clickstream Data: Analyzing the sequence of actions users take on the platform, such as which products they view before making a purchase, aids in refining the recommendation algorithms. 7 - Session Data: Data about the duration and frequency of user sessions on the platform contributes to understanding user engagement and refining the user experience. 8 - External Data Sources: Amazon may integrate external data sources, such as weather forecasts during the holiday season or trending products in various categories, to enhance its recommendations and services.
Forecast <> Backcast	Amazon's anticipatory experiences primarily rely on forecast properties. Through the analysis of user behavior, purchase history, and other data, Amazon uses machine learning algorithms to predict what products or services a user might be interested in. These predictions are used to provide personalized product recommendations, streamlined checkout processes, and fast shipping options through services like Amazon Prime. This forward-looking approach aims to anticipate and fulfill user needs and preferences before they explicitly express them, enhancing the overall shopping experience.
Outcomes	The main outcomes of Amazon's anticipatory experiences for users include: 1 - Personalized Product Recommendations: Amazon's algorithms analyze user data to suggest products and services tailored to individual preferences, leading to more relevant and satisfying shopping experiences. 2 - Streamlined Checkout Processes: By anticipating user intent, Amazon simplifies the checkout process, making it faster and more convenient for users to complete their purchases. 3 - Fast and Efficient Shipping: Through services like Amazon Prime, the platform can predict which items users are likely to order and proactively ship them to distribution centers near users' locations. This results in quicker delivery times and increased customer satisfaction. 4 - Enhanced Customer Engagement: Anticipatory experiences keep users engaged with the platform, as they receive relevant recommendations and updates, encouraging repeat visits and increased time spent on the site.

	5 - Improved User Experience: Amazon's anticipatory features reduce the effort users need to invest in finding products or navigating the site, resulting in a smoother and more enjoyable shopping experience. 6 - Increased Sales and Customer Loyalty: By effectively meeting user needs and desires, Amazon boosts sales and fosters customer loyalty, as users are more likely to return to the platform for future purchases. 7 - Data-Driven Decision-Making: Amazon's use of anticipatory data analysis informs business decisions, such as inventory management, marketing strategies, and product offerings, leading to more efficient operations and increased profitability. 8 - Competitive Advantage: Amazon's anticipatory capabilities give it a significant edge in the e-commerce industry, setting it apart from competitors and attracting a broad customer base.
Pitfalls	There are potential pitfalls and challenges that Amazon must navigate in its anticipatory experiences and services: 1 - Privacy Concerns: As Amazon collects and analyzes vast amounts of user data to make anticipatory recommendations, it must address growing privacy concerns. Users may become uncomfortable with the extent of data collection and how their information is used. 2 - Data Security: Ensuring the security of user data is paramount. Data breaches or unauthorized access can result in significant trust and reputation damage. Amazon must continually invest in robust security measures. 3 - Algorithmic Bias: Like other anticipatory systems, Amazon's algorithms may inadvertently introduce biases into recommendations. This could lead to unequal treatment or reinforce existing biases, which is a significant ethical concern. 4 - Overreliance on Automation: Overpersonalization and excessive reliance on algorithms might diminish the human touch in shopping experiences. Users may feel frustrated if they perceive that their choices are overly determined by algorithms. 5 - Invasive Marketing: While personalized recommendations can be beneficial, Amazon must be careful not to inundate users with constant marketing messages, which can lead to user fatigue and reduced engagement. 6 - Prediction Accuracy: There's a challenge in ensuring the accuracy of predictions. Incorrect recommendations can lead to user frustration or missed opportunities for Amazon. Continuous refinement of prediction models is essential. 7 - Consumer Backlash: If users perceive that Amazon is too intrusive or manipulative in its anticipatory experiences, there could be a backlash, leading to decreased trust and engagement. 8 - Regulatory Compliance: Adhering to evolving data protection and privacy regulations is complex. Amazon must remain vigilant in complying with regional and international laws and standards. 9- User Resistance: Some users may resist anticipatory features, preferring a more traditional and manual shopping experience. Amazon must strike a balance between providing anticipatory services and respecting user autonomy. 10 - Competitive Landscape: As other companies invest in anticipatory experiences, Amazon faces competition in delivering the most accurate and valuable recommendations. Staying ahead in this competitive landscape requires continuous innovation. 11 - Data Monopoly Concerns: Amazon's vast amount of user data can raise concerns about data monopolies and antitrust issues. Regulators may scrutinize its data practices and market influence.

Company: Walmart **Industry:** Retail **Channel:** Stores

Criteria	Analysis
Solution	Walmart's anticipatory service is a customer-focused approach that utilizes data, technology, and predictive analytics to enhance the shopping experience. By analyzing factors like purchase history, online behavior, and location data, Walmart provides personalized product recommendations, anticipates replenishment needs, offers location-specific promotions, and utilizes weather forecasts for tailored suggestions. It also ensures efficient order tracking, integrates with smart home devices, optimizes inventory management, and provides proactive customer support. These efforts aim to create a seamless, convenient, and highly personalized shopping experience for customers, promoting loyalty and satisfaction. The goal is to provide a more personalized and convenient shopping experience.
Type of Data	Walmart utilizes various types of data to provide anticipatory experiences to its users, particularly in the context of its retail and e-commerce operations. Some of the key types of data they use include: 1 - Purchase History: Walmart collects and analyzes data on customers' past purchases, including product categories, brands, and frequency of shopping. This data helps in making product recommendations tailored to individual preferences. 2 - User Profiles: User accounts and profiles store information such as demographics, location, and shopping preferences. These profiles enable the customization of shopping experiences and targeted promotions. 3 - Product Search and Browsing Data: Data on the products users search for and browse online or in-store can be used to suggest related items or provide discounts on products of interest. 4 - Location Data: With the help of location-based services, Walmart can provide information on nearby stores, product availability at specific locations, and local promotions. 5 - Behavioral Data: Walmart analyzes user behavior on its website and mobile app. For example, how long a user spends on a product page or what items are added to the shopping cart can inform personalized recommendations. 6 - Transaction Data: Data from completed transactions includes details on payment methods, shipping addresses, and the products purchased. This data helps in streamlining the checkout process and providing shipping options. 7 - Social Media and Reviews: Analyzing a customer's social media activity, reviews, and comments related to products can provide insights into their preferences and needs. 8 - Seasonal and Trend Data: Walmart tracks seasonal trends and market preferences, allowing them to offer relevant products and promotions during specific times of the year. 9 - External Data Sources: In some cases, Walmart may integrate external data sources, such as weather forecasts or traffic data, to provide anticipatory services like weather-appropriate product recommendations or delivery time estimates. 10 - IoT and Smart Home Data: If customers have IoT devices or smart home products linked to Walmart's ecosystem, data from these devices can inform personalized recommendations and convenience features. 11 - Predictive Analytics: Walmart employs predictive analytics to forecast customer needs and behaviors based on historical data and market trends.
Forecast <> Backcast	Walmart's anticipatory service is primarily based on forecasting properties. It relies on predictive analytics and data-driven insights to anticipate customer needs and behaviors. By analyzing historical data, customer behavior, and various other factors, Walmart aims to forecast what products or services customers are likely to require in the future. This allows them to make proactive recommendations and provide a more

	personalized and convenient shopping experience. While forecasting plays a central role, it's important to note that some elements of the anticipatory service may involve elements of backcasting. Backcasting involves working backward from a desired future outcome to determine the steps needed to achieve that outcome. In the context of Walmart's service, they might work backward from the goal of providing a certain level of customer satisfaction or convenience and use historical data and insights to determine how to achieve that goal. So, while forecasting is the primary approach, elements of backcasting may be involved in the strategic planning and goal-setting processes to enhance the anticipatory service's effectiveness.
Outcomes	Walmart's anticipatory experiences for users aim to achieve several key outcomes that benefit both the customers and the retailer. The main outcomes of Walmart's anticipatory service for users include: 1 - Enhanced Customer Convenience: Anticipatory services make shopping more convenient by offering personalized product recommendations and automating tasks like product replenishment, reducing the need for customers to actively search for or reorder items. 2 - Personalization: Customers receive tailored product recommendations and promotions, creating a more personalized shopping experience that aligns with their preferences and needs. 3 - Time Savings: By anticipating customer needs and automating processes, Walmart's service can save customers time, as they don't need to spend as much time searching for products or managing reorders. 4 - Improved Inventory Management: Walmart's anticipatory service helps ensure that products are in stock when customers need them, reducing instances of out-of-stock items and the associated customer frustration. 5 - Reduced Shopping Friction: The service aims to reduce friction points in the shopping process, providing a smoother and more enjoyable experience for customers. 6 - Cost Savings: By offering relevant promotions and discounts, customers can save money on products they need, while Walmart can benefit from increased sales and customer loyalty. 7 - Proactive Customer Support: Predictive analytics can help Walmart offer proactive customer support, addressing potential issues or inquiries before they become problematic. 8 - Increased Customer Loyalty: By consistently providing a high level of service and convenience, Walmart aims to foster customer loyalty and encourage repeat business. 9 -Data-Driven Insights: The data generated and analyzed through anticipatory services provide Walmart with valuable insights into customer behavior and preferences, enabling them to make informed business decisions. 10 - Competitive Advantage: By offering anticipatory experiences, Walmart can gain a competitive edge in the retail industry by providing a more advanced and customer-centric shopping experience. 11 -Positive Customer Reviews and Feedback: Satisfied customers are more likely to leave positive reviews and recommendations, which can further enhance Walmart's reputation and attract new customers.
Pitfalls	While anticipatory services can offer numerous benefits, there are also potential pitfalls and challenges that Walmart or any company offering such services should be aware of: 1 - Data Privacy Concerns: Collecting and using customer data for anticipatory services can raise privacy concerns. Mishandling or data breaches can erode customer trust and lead to legal issues. 2 - Data Accuracy: Predictive analytics and machine learning models are only as good as the data they are trained on. Inaccurate or biased data can lead to incorrect

	recommendations and dissatisfied customers. 3 - Overpersonalization: Being too aggressive with personalization can make customers feel uncomfortable or even stalked. Striking the right balance is essential. 4 - Customer Resistance: Some customers may be resistant to the idea of companies making assumptions about their needs. Walmart must educate and communicate the value of anticipatory services to customers effectively. 5 - Technology Challenges: Technical issues, such as app crashes or service outages, can disrupt the anticipatory experience and frustrate customers. 6 - Unwanted Assumptions: Predictive models may make assumptions about customers that are incorrect or unwanted, leading to recommendations that feel off or intrusive. 7 - Inventory Management Challenges: Overestimating or underestimating product demand can result in overstock or out-of-stock situations, which can frustrate customers and lead to financial losses. 8 - Competitive Pressure: As more companies offer anticipatory services, the competition intensifies, making it harder to stand out and deliver a superior experience. 9 - Cultural and Regional Differences: Anticipatory services may not work equally well in all markets due to cultural and regional variations in shopping habits and preferences. 10 - User Control: Some customers may prefer full control over their shopping experience, and they may find anticipatory services limiting or intrusive. 11 - Costs and ROI: Implementing and maintaining anticipatory services can be costly. Walmart needs to ensure that the investment is justified by increased customer loyalty and sales. 12 - Feedback Loop Issues: Relying too heavily on past behavior might miss opportunities for customers to try new products or explore different interests. 13 - Environmental Impact: Repeated deliveries due to anticipatory services can have environmental consequences, contributing to packaging waste and carbon emissions. To mitigate these pitfalls, Walmart and other companies should prioritize data security and privacy, invest in robust data quality and model validation, provide clear opt-in/opt-out options for customers, and continually seek feedback and iterate on their anticipatory service offerings. Balancing the benefits of anticipation with customer preferences and concerns is essential for long-term success.

Company: ASOS **Industry:** Retail **Channel:** Web

Criteria	Analysis
Solution	ASOS, is a popular online fashion and clothing retailer, uses various types of data to provide a personalized and anticipatory experience to its users. These data types help ASOS make tailored product recommendations, improve the shopping experience, and anticipate customer needs.
Type of Data	There are some common types of data ASOS typically uses: 1 - Purchase History: ASOS analyzes a customer's past purchase history, including the products they have bought, how often, and when they made those purchases. 2 -Online Behavior: Data from a customer's online interactions on the ASOS website or app, such as the products they view, the time spent on specific pages, and items added to the cart, helps understand their preferences. 3 - Customer Profile Information: Information provided by the customer during registration or in their profile, such as age, gender, location, and style preferences, is used for personalization. 4 - Wishlists and Saved Items: ASOS takes into account the products a customer has saved to their wishlist or marked as favorites to offer recommendations based on their interests.

	5 - Search Queries: Analyzing the specific products or categories customers search for can provide insights into their immediate needs and preferences. 6 - Loyalty Program Data: Data from ASOS's loyalty program members, such as purchase history and preferences, helps in offering tailored promotions and rewards. 7 - Location Data: Utilizing location data can enable ASOS to provide location-specific offers and recommendations, such as suggesting products available at nearby stores. 8 - Product Reviews and Ratings: Customer feedback, product reviews, and ratings provide insights into product quality and customer satisfaction, which can influence recommendations. 9 - Fashion Trends and Seasonality: ASOS may consider global and seasonal fashion trends to make relevant product recommendations and showcase trending items. 10 - Demographic Data: Information related to a customer's age, gender, and other demographics can be used to offer products that align with their demographic group's preferences. 11 - Social Media Data: Analyzing a customer's social media activity related to fashion, trends, and brands can provide additional insights into their style and interests. 12 - Device and Browser Data: Information about the devices and browsers customers use to access the ASOS platform can help optimize the user experience.
Forecast <> Backcast	ASOS's anticipatory service is primarily based on forecast properties. It relies on predictive analytics and data-driven insights to anticipate customer needs and preferences, often before customers explicitly express those needs. By analyzing historical data, customer behavior, and various other factors, ASOS aims to forecast what products or styles customers are likely to be interested in. This allows them to make personalized product recommendations and enhance the shopping experience. While forecasting is the primary approach, some elements of backcasting may also be involved. Backcasting involves working backward from a desired future outcome to determine the steps needed to achieve that outcome. In the context of ASOS, they might work backward from the goal of providing a high level of customer satisfaction or driving sales and use historical data and insights to determine how to achieve that goal.
Outcomes	ASOS's anticipatory experiences for users aim to achieve several key outcomes that enhance the online shopping experience for customers. The main outcomes of ASOS's anticipatory service for users include: 1 - Personalized Product Recommendations: ASOS provides customers with tailored product suggestions based on their past behavior, preferences, and browsing history, making it easier to discover new items and styles. 2 - Enhanced User Engagement: By offering personalized recommendations and a curated shopping experience, ASOS increases user engagement and time spent on their platform. 3 - Improved Customer Satisfaction: Anticipatory experiences lead to a more personalized and relevant shopping journey, ultimately boosting customer satisfaction and loyalty. 4 - Time and Effort Savings: Customers save time and effort by finding products they like quickly, reducing the need for extensive searches and decision-making. 5 - Optimized Inventory Management: ASOS can better manage inventory and reduce the likelihood of out-of-stock items, ensuring that customers can purchase the products they desire. 6 - Increase in Sales: Anticipatory recommendations can lead to increased sales as customers are more likely to make purchases when presented with items that align with their preferences. 7 - Higher Customer Retention: Satisfied customers are more likely to return to ASOS for future purchases, leading to higher customer retention rates. 8 - Reduced Returns: By suggesting items that match customer preferences, ASOS can reduce the likelihood of customers returning products due to dissatisfaction. 9 - Simplified Shopping Process: Anticipatory experiences streamline the shopping

	process, making it more convenient and efficient for users. 10 - Improved User Loyalty: By consistently delivering a personalized and convenient shopping experience, ASOS can build long-term user loyalty and advocacy. 11 - Data-Driven Insights: The data generated and analyzed through anticipatory services provide ASOS with valuable insights into customer behavior and preferences, enabling them to make informed business decisions. 12 - Competitive Advantage: By providing anticipatory experiences, ASOS can gain a competitive edge in the crowded online fashion retail market by offering a superior and more personalized shopping experience. 13 - These outcomes collectively contribute to a more satisfying and customer-centric online shopping experience, benefiting both the customers and ASOS. The service enhances customer engagement and loyalty while driving business success.
Pitfalls	There are potential pitfalls and challenges that ASOS or any company offering such services should be aware of: 1 - Data Privacy and Security: Collecting and using customer data for anticipatory services can raise privacy concerns. Mishandling or data breaches can erode customer trust and lead to legal issues. 2 - Data Accuracy and Bias: Predictive analytics and machine learning models are only as good as the data they are trained on. Inaccurate or biased data can lead to incorrect recommendations and dissatisfied customers. 3 - Overpersonalization: Being too aggressive with personalization can make customers feel uncomfortable or even stalked. Striking the right balance is essential. 4 - Customer Resistance: Some customers may be resistant to the idea of companies making assumptions about their preferences. ASOS must educate and communicate the value of anticipatory services to customers effectively. 5 - Technical Issues: Technical problems, such as website crashes or service outages, can disrupt the anticipatory experience and frustrate customers. 6 - Sustainability Concerns: Repeated deliveries due to anticipatory services can have environmental consequences, contributing to packaging waste and carbon emissions. 7 - Cultural and Regional Differences: Anticipatory services may not work equally well in all markets due to cultural and regional variations in fashion preferences and shopping habits. 8 - Competition and Expectations: As more companies offer anticipatory services, the competition intensifies, making it harder to stand out and meet customer expectations. 9 - Feedback Loop Issues: Relying too heavily on past behavior might miss opportunities for customers to explore new styles and interests. 10 - User Control: Some customers may prefer full control over their shopping experience and may find anticipatory services limiting or intrusive. 11 -Sensitivity to Trends: The fast-changing nature of fashion trends can make it challenging to predict and recommend styles accurately. 12 - Costs and ROI: Implementing and maintaining anticipatory services can be costly. ASOS needs to ensure that the investment is justified by increased customer loyalty and sales. 13 - To mitigate these pitfalls, ASOS and other companies should prioritize data privacy and security, invest in robust data quality and model validation, provide clear opt-in/opt-out options for customers, and continually seek feedback and iterate on their anticipatory service offerings. Balancing the benefits of anticipation with customer preferences and concerns is essential for long-term success.

Company: Easysize **Industry:** Retail **Channel:** Web

Criteria	Analysis
Solution	Easysize is a service that specializes in providing personalized size recommendations for online shoppers in the fashion industry. By leveraging advanced data analytics and technology, Easysize takes into account a variety of factors, including a customer's past shopping behavior, garment measurements, brand-specific sizing, and individual body measurements to determine the most suitable size for a particular item. The aim is to reduce the common problem of ordering ill-fitting clothing online, which often leads to returns and customer dissatisfaction. Easysize's integration with online retailers offers a more tailored and user-friendly shopping experience, ultimately improving customer confidence and satisfaction while reducing return rates for both customers and retailers.
Type of Data	Easysize uses a combination of various types of data to provide personalized size recommendations and enhance the online shopping experience for its users. The specific data types and sources may include: 1 - Customer Data: Easysize may collect and analyze customer data, including past purchase history, returns, and any feedback or preferences provided by the user. 2 - Garment Measurements: The service uses data related to the measurements of the specific clothing items available for purchase on partner retailer websites. 3 - Brand Sizing Information: Easysize incorporates data on brand-specific sizing standards, as different brands may have variations in how they size their garments. 4 - Body Measurements: Users may be asked to provide their personal body measurements, which Easysize uses to create more accurate size recommendations. 5 - Fit Preferences: The service may consider a customer's individual preferences for how they like their clothing to fit, such as loose, regular, or slim fit. 6 - User Feedback: Easysize may collect feedback and reviews from users regarding the fit and comfort of clothing they've purchased, incorporating this data to improve recommendations. 7 - E-commerce Retailer Data: Easysize typically partners with online fashion retailers, integrating its service into their websites to access product data and provide recommendations directly to users. 8 - Machine Learning and Algorithms: Easysize employs machine learning algorithms that continuously analyze and learn from user behavior and data to enhance the accuracy of size recommendations over time.
Forecast <> Backcast	Easysize's service is primarily based on forecast properties. It uses predictive analytics and data-driven insights to anticipate the most suitable size for a specific garment when a customer is shopping online. The service analyzes various data points, including the customer's past shopping history, body measurements, brand sizing information, and garment measurements to forecast the size that is likely to provide the best fit. While forecasting is the primary approach, some elements of backcasting may also be involved. Backcasting involves working backward from a desired future outcome to determine the steps needed to achieve that outcome. In the context of Easysize, they might work backward from the goal of reducing returns and improving customer satisfaction to determine how to provide more accurate size recommendations. This process may involve analyzing historical data to understand why returns occurred and using that information to make better size predictions. In summary, Easysize's service primarily relies on forecasting to provide size recommendations, but it may also incorporate elements of backcasting to continuously improve the accuracy of its predictions and enhance the user experience.

Outcomes	The main outcomes of Easysize's anticipatory experiences for users revolve around providing a more convenient and satisfying online shopping experience, with a focus on accurate size recommendations. These outcomes include: 1 - Improved Fit: Users receive size recommendations that are more likely to result in well-fitting clothing, reducing the frustration and inconvenience of receiving ill-fitting items. 2 - Reduced Returns: By helping users select the right size from the start, Easysize aims to significantly reduce the number of returns due to sizing issues, benefiting both customers and retailers. 3 - Enhanced User Confidence: Users gain confidence in their online shopping decisions, as they are more likely to receive clothing that fits as expected. 4 - Time and Effort Savings: Easysize's service streamlines the shopping process, saving users the time and effort required to return and exchange items. 5 - Personalization: Users experience a more personalized shopping journey, with size recommendations tailored to their unique body measurements and brand preferences. 6 - Higher Satisfaction: Accurate size recommendations and reduced returns contribute to higher customer satisfaction, promoting loyalty and repeat business. 7 - Convenience: Shopping for clothing becomes more convenient and hassle-free, leading to a positive online shopping experience. 8 - Feedback and Learning: Easysize continually learns from user behavior and feedback, allowing for ongoing improvement in the accuracy of size recommendations. 9 - Retailer Benefits: Online retailers that partner with Easysize benefit from lower return rates, reduced shipping costs, and improved customer satisfaction. 10 - Data-Driven Insights: The data collected by Easysize can provide valuable insights into user behavior and preferences, benefiting both users and retailers. 11 - Trust in Online Shopping: Easysize's service helps build trust in online fashion shopping, as users become more confident in their ability to select the right size.
Pitfalls	There are potential pitfalls and challenges that the company should be aware of: 1 - Data Privacy and Security: Handling customer data, especially body measurements, requires robust data security and privacy measures to protect user information. 2 - Accuracy Limitations: No sizing recommendation system can be 100% accurate, and there may still be instances where the recommended size does not fit perfectly. 3 - Cultural and Regional Differences: Sizing standards and fit preferences can vary by region and culture, making it challenging to provide accurate recommendations for a global customer base. 4 - User Preferences: Customers may have personal preferences for how they like clothing to fit, which may not align with Easysize's recommendations. 5 - Technology Limitations: Accuracy relies on the quality of data and the sophistication of algorithms, so technological limitations may affect the service's effectiveness. 6 - Returns Policy: Even with accurate sizing recommendations, a retailer's return policy may impact the overall experience, potentially dissuading users from making a purchase. 7 - Sustainability Concerns: Encouraging customers to order multiple sizes to compare can lead to increased shipping and packaging waste, potentially contradicting sustainability efforts. 8 - Costs and ROI: Implementing and maintaining the service can be costly for both Easysize and its retail partners, necessitating a clear return on investment. 9 - Customer Adoption: Convincing customers to provide their body measurements and trust sizing recommendations may require effective communication and incentives. 10 - User Control: Some users may prefer not to share their body measurements or may desire more control over the sizing selection process. 11 - Fashion Trends and Styles: Sizing recommendations may not account for the latest fashion trends and variations in garment style and cut. 12 - Size Labeling Discrepancies: Differences in how clothing brands label sizes can pose challenges in providing consistent recommendations.