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Belief Updating and Optimistic Bias for Negative Events Are Preserved in Schizophrenia

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BELIEF UPDATING AND OPTIMISTIC BIAS FOR NEGATIVE EVENTS ARE PRESERVED IN SCHIZOPHRENIA

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Resumo

Os sintomas relacionados com esquizofrenia podem ser analisados de acordo com o Predictive Processing Framework, que defende um menor impacto das novas informações na atualização das expetativas nesta psicopatologia, traduzindo-se em crenças disfuncionais. Há, portanto, uma disparidade entre a exatidão das previsões e o input sensorial, que se reflete nas competências de tomada de decisão perante novas informações. Esta investigação propõe que indivíduos neurotípicos (grupo de controlo) apresentam níveis mais elevados de enviesamento otimista comparativamente a pessoas com diagnóstico de esquizofrenia (grupo clínico). Explora-se, adicionalmente, a existência de diferenças entre os grupos, no que diz respeito à atualização de expetativas quando se recebe novas informações sobre eventos de vida adversos. Desde modo, a tarefa utilizada requer a estimativa de uma lista de eventos de vida negativos, sucedendo-se a apresentação da probabilidade real dos mesmos. Num segundo momento, é pedida, novamente, a estimativa desses eventos, mas sem exibir a probabilidade de ocorrerem. Os resultados obtidos indicam que não existem diferenças estatisticamente significativas entre o grupo clínico e o grupo de controlo no que concerne à atualização das expetativas e ao enviesamento otimista. Além disso, não foram encontradas diferenças entre homens e mulheres com diagnóstico de esquizofrenia relativamente à atualização das expetativas. A interpretação destes resultados pode indicar que o tratamento farmacológico detém um grande impacto. Os resultados podem, adicionalmente, apontar para uma robustez na noção de continuum da psicose.

Palavras-chave: Esquizofrenia, Processamento Preditivo, Erro de Previsão, Atualização de Expectativas, Enviesamento Otimista.

Abstract

Symptoms related to schizophrenia can be analysed according to the Predictive Processing Framework, which argues that new information has a lower impact on belief updating in this psychopathology, resulting in dysfunctional beliefs. There is, therefore, a disparity between the accuracy of predictions and the input, which is reflected in decision-making skills, regarding new information. This research proposes that neurotypical individuals (control group) exhibit higher levels of Optimistic Bias compared to people diagnosed with schizophrenia (clinical group). Additionally, the existence of differences between the groups is explored, regarding belief updating when receiving new information about negative life events. The task used requires estimating a list of negative life events, followed by the presentation of their real probability. In a second trial, participants are asked to estimate these events again, but without displaying the probability of their occurrence. The results obtained indicate that there are no statistically significant differences between the clinical group and the control group regarding the Belief Updating and the Optimistic Bias. Furthermore, no differences were found between men and women diagnosed with schizophrenia concerning this Belief Update. The interpretation of these results may suggest that pharmacological treatment has a significant impact. The results may additionally point to a robust support for the construct of psychosis continuum.

Keywords: Schizophrenia, Predictive Processing, Predictive Error, Belief Update, Optimistic Bias.

Resumé

Les symptômes liés à la schizophrénie peuvent être analysés selon le Predictive Processing Framework, qui préconise un impact moindre des nouvelles informations sur la mise à jour des attentes dans cette psychopathologie, se traduisant par des croyances dysfonctionnelles. Il existe donc une disparité entre l'exactitude des prédictions et l'entrée sensorielle, qui se reflète dans les compétences de prise de décision face aux nouvelles informations. Cette recherche suggère que les personnes neurotypiques (groupe témoin) ont des niveaux plus élevés de biais optimiste que les personnes diagnostiquées avec la schizophrénie (groupe clinique). En outre, l'existence de différences entre les groupes est explorée, en ce qui concerne la mise à jour des attentes lors de la réception de nouvelles informations sur des événements négatifs de la vie. Ainsi, la tâche utilisée nécessite l'estimation d'une liste d'événements négatifs de la vie, suivie de la présentation de leur probabilité réelle. Deuxièmement, l'estimation de ces événements est demandée à nouveau, mais sans montrer la probabilité de leur survenance. Les résultats indiquent qu'il n'y a pas de différences statistiquement significatives entre le groupe clinique et le groupe témoin en ce qui concerne la mise à jour des attentes et le biais optimiste. De plus, aucune différence n'a été observée entre les hommes et les femmes ayant reçu un diagnostic de schizophrénie en ce qui concerne la mise à jour des attentes. L'interprétation de ces résultats peut indiquer que le traitement pharmacologique a un grand impact. Les résultats peuvent également indiquer une robustesse dans la notion de continuum de la psychose.

Mots-clés : Schizophrénie, Biais optimiste, Traitement prédictif, Erreur prédictive, Mise à jour des attentes.

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1. Introduction

Schizophrenia is one of the psychopathologies characterized by perceptual and reasoning problems, with problems of autonomy, agency, and sense of self (Hohway, 2013), with an impact on several daily life domains. The core symptoms of this disorder are related to delusions, hallucinations, and disorganized speech, which fall into the category of "positive symptoms" (Tandon et al., 2013). In addition, negative symptoms correspond to anhedonia, inappropriate affect, and social withdrawal (Jablensky, 2010). Thus, the current definition of schizophrenia emphasizes cognitive deficits as a central feature (Jablensky, 2010), as well as deficits inherent to social functioning (Seidman et al., 2017). These deficits are present in more than half of patients with schizophrenia, and the impairment of these areas is related to the course of the disorder, which configures itself as a moderately stable trait (Jablensky, 2010).

It is known that heredity does not prove a genetic etiology, although it is recognized that a higher genetic risk is more likely to trigger – but not predict – schizophrenia in adverse environments, compared to a low genetic risk (Seidman et al., 2017). Therefore, an interaction between genes, environment, stress, protective and risk factors play a role in the onset, course, and recovery in schizophrenia (Seidman et al, 2017). As previously mentioned, schizophrenia is a heterogeneous disorder, revealing also differences between men and women, with a higher incidence in men (Ochoa et al., 2012). These gender differences are a well establish aspect of this disorder (Abel et al., 2010). Furthermore, the age of onset is also earlier in men, between the ages of 18-25, compared to women, who typically have an age of onset at 25-35 years old. If, on the one hand, some studies show that women have a more preserved social functioning, requiring a greater exposure to family and environmental risk factors to trigger a psychotic disorder; on the other hand, it appears that comorbidity with substance abuse is more frequent in men. The discrepancies also reflect in the course of schizophrenia, with women having a better chance of remission (Ochoa et al., 2012). The worse prognosis in men is sometimes ascribed to the earlier onset of the disease (Abel et al., 2010).

Hallucination symptoms can be studied using Predictive Processing Framework (PPF), as features of the brain that continually awaits perceptual inputs based on prior beliefs and sensory input and emerge a sense of reality (Hohwy, 2013). According to Predictive Processing, the brain learns regularities from the external world to elaborate

inferences (Castelnovo et al., 2015). In order to understand the functioning of schizophrenia under the light of the Predictive Processing, it is important, first of all, to comprehend an eventual mismatch between beliefs and sensory stimuli.

These Bayesian inference constructs explain prior beliefs as inferences about the states of the world, with higher brain levels sending predictive signals to lower levels. Accordingly, a sensory error occurs whenever internal or external sensory input diverges from the predictions (Adams et al., 2013; Randeniya et al., 2018), which updates the encoding of beliefs at higher levels (Sterzer et al., 2019). This decision-making process is reflected in schizophrenia because these neural mechanisms are likely compromised, affecting several hierarchical levels, from more basic sensory processes to more complex cognitive functions. Thus, according to Sterzer et al. (2019), multiple impairment gradients contribute to several psychotic experiences, for example, delusions are related to decision-making based on insufficient information. In other words, in schizophrenia there is a disparity between the accuracy of the predictions and the sensory data, i.e., individuals with schizophrenia ascribe to salience to irrelevant stimuli (Sterzer et al., 2019). In general, the psychotic symptoms related with perceptual anomalies, such as hallucinations and delusions, function at low hierarchical levels of inference mechanisms (Sterzer et al., 2019).

Moreover, the ability to make predictions based on sensory inputs may also be associated with an Optimistic Bias. Otherwise stated, when faced with information about the future, neurotypical participants optimistically demonstrate a biased updating pattern. Therefore, when facing these stimuli, they assign more importance to desirable information in contrast to undesirable information. Healthy individuals "process information about their personal future in a positively biased way" (Korn et al., 2014). Specifically, people are more likely to update their beliefs regarding information that is better than their expectations compared to information that is worse than what they expected (Sharot et al., 2011). When faced with the probability of adverse events, there is a reinforcement of optimism, rather than a more pessimistic change of beliefs (Korn et al., 2014). Beliefs can be associated with the Bayes' Rule, which, succinctly, claims that people tend to more easily incorporate information that favours their beliefs, which does not happen for unfavourable information (Sharot et al., 2012).

In fact, it is currently known that the learning of this information involves brain regions associated with error processing, such as anterior cingulate cortex, adjacent medio-frontal regions, and lateral prefrontal regions. This involvement of cortical functions can

be explained by the implication of higher cognitive functions, since the estimation of errors alludes to the predictions of a certain event and the real probability of occurrence (Sharot et al., 2011). Consequently, when it comes to making predictions about the future, the brain underestimates negative probabilities. This bias is associated with a big asymmetry, in which a selective update is mediated by several brain regions of the frontal cortex, performing error estimations in the presence of a positive update; however, it has a lower coding of errors related to negative updates (Sharot et al., 2012).

As previously described, it is known that schizophrenia is associated with neurocognitive deficits, which can often compromise the ability to assess risk and make decisions (Prentice et al., 2005; Sharot et al., 2012). Studying this Optimistic Bias will help to understand how people make decisions in different contexts. According to an investigation conducted by Prentice et al. (2005), both the control group with healthy individuals and the group with schizophrenia registered, in general, an Optimistic Bias. However, they found that individuals in the control group showed a higher level of optimism, particularly regarding events perceived as controllable.

In conclusion, if, on the one hand, the predictive theory states that the brain performs hierarchical inferences, using predictions to infer probable causes of sensory stimuli; on the other hand, Optimistic Bias indicates that we tend to prioritize positive information that confirms our beliefs. In this way, the present investigation intends to verify if, among individuals with schizophrenia, this Optimistic Bias is decreased, as a possible consequence of a lower updating based on new information. Nevertheless, there is some controversy regarding gender differences in cognitive functions. Some studies point to worse scores in executive functions, attention and language in men compared to women (Ochoa et al., 2011) and, for this reason, it is important to understand how women's decision-making when confronted with new information may differ from men. In addition, given the vulnerability, in schizophrenia, to risk perceptions, neurotypical individuals may find it easier to update their beliefs (Korn et al., 2014).

1.1 Predictive Processing

Predictive Processing describes the way the brain processes information. The central idea is that the brain creates internal models about the world and uses these models to make predictions about what happens in the environment. These predictions are

compared with the sensory information the brain receives, and when there are discrepancies between the predictions and the sensory information, an update occurs in the internal models. This paradigm considers the nervous system not only as responding to perceptions, but also as actively predicting sensory information, rather than giving a passive response (Wilkinson et al., 2017). A well-functioning one conceives accurate predictions about future events in order to be able to mobilize preparatory responses. For this, it is necessary to make associations and understand the probabilistic world (Griffin & Fletcher, 2017). Therefore, the nervous system establishes hypotheses about what is occurring, based on sensory inputs, which can exhibit varying degrees of ambiguity (Corlett et al., 2009; Kafadar et al., 2020; Wilkinson et al., 2017).

According to this paradigm, the person is constantly faced with the challenge of integrating several stimuli, sometimes competing, to produce a better explanation for a given input. Thus, for the updating of these inferences, the sensory information must be reliable. For example, the source of the information can affect the updating of expectations, to the extent that the source has to be integrated as reliable (Griffin & Fletcher, 2017). Nevertheless, there are circumstances in which models should not be updated, even in the presence of errors, since evaluation of context is also an important factor (Griffin & Fletcher, 2017).

1.1.1 Prediction Error

PPF explores how cognition changes perception. In this sense, the processes of association and prediction can generate a mismatch between what was expected and what was experienced. This mismatch translates into a Prediction Error (PE), which can be ignored or used to update subsequent expectations of new learnings (Corlett et al., 2020).

When it comes to sensory inputs, PEs serve as valuable tools for updating how the brain interprets the reliability of this information. First, there is an update of the prior belief about the reliability degree of the input itself in predicting a specific outcome, for example, if an input often predicts a certain outcome, then the PE will be low, indicating high reliability. This means that when there is low ambiguity, greater accuracy is expected and, conversely, when there is high ambiguity, a low prediction is estimated (Wilkinson et al., 2017). That is, PEs also contribute to the assessment about the reliability of the source of sensory information, i.e., if the source is often inaccurate, then an update occurs that reduces it (Griffin & Fletcher, 2017). Indeed, inputs are inherently ambiguous, but this ambiguity also manifests itself differently in diverse contexts. In order to optimize

predictions, the nervous system needs to accurately estimate the level of ambiguity (Wilkinson et al., 2017).

When presented with two or more pieces of information, the nervous system must choose one particular hypothesis over another, by evaluating not only the input, but also the statistical probability of that particular hypothesis, regardless of the specific input. This "prior probability" is also influenced by past experience; in other words, a hypothesis may align with the input, but the prior probability may register low values, causing the hypothesis to be disregarded. On the contrary, the hypothesis may reveal a high "prior probability" and, even if it does not align with the input, it can be established regardless. Therefore, one hypothesis is selected over another if it better minimizes PE. Efficient functioning refers to the ability to draw inferences quickly and accurately, with the lowest possible energy expenditure (Wilkinson et al., 2017).

1.1.2 Top-down, Hierarchical Structures e Precision Weighting

Top-down refers to the influence that internal models and expectations have on the interpretation of sensory information. This means that our beliefs, past experiences, and previous knowledge can shape the way we perceive and interpret the world, often prioritizing information that is in line with our expectations (Kveraga et al., 2007). It should also be noted that top-down processing is often considered more efficient than bottom-up processing, which relies solely on sensory information (Rauss & Pourtois, 2013).

In the context of top-down processing, higher-level information serves as resources used in perception and decision-making, such as expectations and prior knowledge. These expectations can be understood as beliefs that guide the perception and interpretation of inputs. The brain operates based on predictions and prediction errors hierarchically, in the sense that each hierarchical level attempts to forecast the activity in the layer that projects itself in the first level (Corlett et al., 2020). In this way, prior knowledge and more complex brain functions contribute to the processing of information in an effective and adaptive way, playing a role in adapting to new information. Therefore, mental representations are hierarchically modelled in the brain (Corlett et al., 2020).

In this sense, the hypotheses of a given level provide the input to the next level, and the nature of these hypotheses varies depending on their position within the hierarchy. This implies that higher parts of the hierarchy are further away from sensory stimuli, characterized by a greater degree of abstraction and complexity. On the other hand, lower

parts are closer to sensory stimuli, thereby representing lower levels of abstraction (Wilkinson et al., 2017).

Therefore, it is essential to mention precision-weighting, in which different sources of information also have diverse degrees of reliability (or precision), with higher reliability of sensory information corresponding to greater weighting. When we have expectations or prior knowledge about a stimulus or a situation, they can affect how we weigh the accuracy of relevant sensory information, corresponding to turning up or down the inputs (Wilkinson et al., 2017).

In short, mental representations of stimuli are constructed from sensory organs through hierarchical processing. Top-down expectations are communicated from areas with more abstract representations, descending through the hierarchical structure (Mesulam, 2008), with our prior knowledge influencing the assignment of value to new information.

1.1.3 Predictive Processing in Schizophrenia

Within this framework, positive symptoms can be analysed in terms of dysfunctional inferences or beliefs. PPF makes a significant contribution to explaining the manifestation of neurobiological disorders in the form of bizarre beliefs and hallucinations, given its application to perception, beliefs, attention, and action (Griffin & Fletcher, 2017). In current research, PPF is applied more narrowly to evaluate the processes of updating and inference, which allow the optimization of brain functions that model the statistical regularities of the surrounding environment. In this sense, it is argued that the symptoms of schizophrenia can be framed within this paradigm.

Maintaining, updating, and generalizing expectations are complex problems that require: (a) a system capable of forming associations flexible enough to change them whenever necessary; but (b) resilient enough not to extinguish in the face of occasional PEs. This perspective may therefore explain the delusions and hallucinations in flexibility in the face of change and robustness when challenged by noise (Griffin & Fletcher, 2017). Thus, the multiplicity of unstable sensory signals that integrate the experience demands a coordinated organization with the surrounding world. The nervous system is tasked with filling in gaps, generalizing observations, and prioritizing stimuli that require more detailed processing, all while making immediate judgments about the meaning of sensory input (Kraus et al., 2009).

Thereby, in schizophrenia, the inadequate inference about the world arises from an imbalance related to precision of beliefs (Adams et al., 2013), which corresponds to an incompatibility between the prediction of an inference's salience and the selection of a specific action to respond to that input (Castelnovo et al., 2015). In particular, this concerns the balance of the precision about prior beliefs and sensory stimuli, and not as much the prediction of sensory input itself (Friston et al., 2011, as cited in Adams et al., 2013). In this sense, for example, hallucinations can be understood as a failure to mitigate the sensory consequences, so the atypical precision processing can lead to manifestation of false inferences and, therefore, psychotic symptoms (Adams et al., 2013; Schmack et al., 2017). This brain response is crucial for adaptive behavior, indicating patients with schizophrenia show deficits regarding this sensory prediction of external stimuli and self-generated stimuli (Randeniya et al., 2018).

Predictive Processing highlights the influence of beliefs, but also how they shape people's interpretations. In other words, when a particular belief is present, it can guide how specific information is understood and, more precisely, dopaminergic dysfunction may be present in the emergence of delusions (Griffin & Fletcher, 2017). In fact, dopamine is quite implicated in several psychopathologies, playing a significant role in schizophrenia (Sharot et al., 2012), with two hypotheses being identified: (1) hyperdopaminergic, in which positive symptoms may be related to increased dopamine; and (2) hypodopaminergic, decreased dopamine seems to be associated with negative symptoms (Davis et al., 1991). Therefore, the results of the study conducted by Sharot et al (2012) indicate that manipulating dopamine through medication has an impact on how people adjust their beliefs, reducing negative expectations and promoting unrealistic optimism. In this regard, antipsychotic medication acts in the normalization of dopamine levels and, consequently, in the regulation of symptoms.

Research has shown that hallucinations exhibit a specific association with behaviours, resulting from excessively restrictive prior beliefs (Kafadar et al., 2020). Positive symptoms, once established, can therefore be self-reinforcing, as evidence is interpreted according to expectations (Griffin & Fletcher, 2017), i.e., they result from over-weighting of prior beliefs relative to sensory evidence (Kafadar et al., 2020).

1.2. Optimistic Bias

An Optimistic Bias occurs when there is an underestimation of the probability of negative events. This bias is associated with an asymmetry, in which people tend to update their expectations more in response to information that is better than expected, compared to information worse than their expectations (Sharot et al., 2012; Yoshimura & Hashimoto, 2020; Marks & Baines, 2017). Accordingly, Korn et al. (2013) report that neurotypical participants, when challenged with information about the future, tend to demonstrate an optimistically biased updating pattern, i.e., it is defined by both the overestimation of positive events and the underestimation of negative events (Sharot et al., 2011).

According to Korn et al. (2013), neurotypical individuals maintain optimistic expectations because they process information about their future in a positively biased way, describing this process *Selective Update*. In this sense, people update their expectations more when adverse events have lower probabilities of occurrence than expected, indicating an asymmetry in belief updating (Korn et al., 2013). Sharot et al. (2011) demonstrated this asymmetry through the tendency to update beliefs when the probability of occurrence of a negative event was lower than the expectation given by the participant. The research carried out by Sharot et al. (2011) reveals the existence of estimation errors, which depend on how the new information has inherent an optimistic or pessimistic direction. In this regard, the Selective Update is mediated by specific areas of the frontal cortex that perform the monitoring of errors when they request a positive update. However, these regions demonstrate a limited ability to encode errors that can provide a negative update (Sharot et al., 2012). Therefore, the Optimistic Bias postulates that this propensity is due to mismatches regarding estimation errors' coding, when these point to a negative update, occurring a selective and change-resistant update. For that reason, this reinforces optimism, and depreciates undesirable errors (Sharot et al., 2011).

Sharot et al. (2012) argue that dopamine plays an important role in the way healthy individuals asymmetrically integrate information about future life events, resulting in an Optimistic Bias. They have demonstrated that improved dopamine functioning increases the bias of expectations in an optimistic direction (Sharot et al., 2012). Therefore, increased dopamine levels attenuate the tendency to integrate undesirable information, leading to an underestimation of the probability of negative events (Sharot et al., 2012).

Risk perception biases can influence decision-making in various contexts (Karnick et al., 2023), and individuals with schizophrenia often have compromised risk assessment

abilities (Prentice et al., 2005). There has been considerable research on unrealistic optimism; however, the biological and computational principles that help maintain biased optimistic predictions are still unknown (Sharot et al., 2011). The possibility of anticipating and addressing possible distortions in risk perception provides an opportunity to promote more broadly informed choices, both in patients with schizophrenia and in neurotypical adults (Prentice et al., 2005; Shah et al., 2016).

1.3 Research Questions

The present study seeks to comprehend the differences in belief updating between neurotypical individuals and individuals with schizophrenia and, consequently, to assess the impact of Optimistic Bias on decision-making in a task involving negative life events. The aim of this investigation is, therefore, based on three hypotheses: H1: the clinical group shows a lower Belief Updating compared to the control group; H2: the clinical group has an Optimistic Bias towards new information that is lower than control group; H3: women from the clinical group are more likely to update beliefs, based on new information, compared to men from the clinical group.

2. Method

2.1 Participants

The research was conducted with two groups of participants: the control group, consisting of 26 subjects, and a clinical group comprising 23 respondents. The participants of the control group and the clinical group were, as much as possible, matched regarding relevant variables, such as age, sex, and education level. In addition, it was important to verify if the recruited participants, from both groups, registered a normal or corrected visual acuity. Participants in the clinical population were diagnosed with schizophrenia or psychosis. In turn, individuals in the control group who reported diagnosed psychopathology were also excluded from the study. Therefore, four participants from the control group were excluded from the statistical analysis, due to having indicated the existence of psychopathology, and one participant from the clinical group due to anomalous responses, which did not comply with the instructions in the protocol. These criteria resulted in a final sample of 22 individuals in each group. In the clinical group, there were 13 participants diagnosed with schizophrenia and nine diagnosed with psychosis (without a final confirmation of a schizophrenia diagnosis).

Participants were recruited through various methods between May 3, 2023, and July 31, 2023: the clinical group participants represent an intentional sample, as they consist of patients from Centro Hospitalar Universitário de São João, by their clinical condition; the control group is characterized as a convenience sample, recruited by direct contact.

2.2 Materials

The task was adapted from previous studies (Sharot et al., 2011), and the events were translated from English to Portuguese, according to the probability of occurrence in the participant's sociocultural environment. These events correspond to negative life occurrences, such as assault, Alzheimer's, cancer, etc., excluding the ones that may be related to Schizophrenia or Psychosis.

After translating the original list of events (from [Sharot et al., 2011]), a decision was made to reduce it by selecting events based on their similarities, so that in the face of similar stimuli, one of them was eliminated. The initial list was reduced from 80 to 40 negative life events. This reduction also had the objective of making the task shorter, and thus more amenable to data collection with patients.

Since the task involves the presentation of the probabilities according to the sociocultural environment of the participants, statistical data on sociodemographics were sought from databases such as the National Institute of Statistics (INE) and PORDATA; in the case of data from other sources, we preferentially used article databases (PubMed, APA PsycArticles, Psychology & Behavioral Sciences Collection, etc.), and in cases of limited information, to media reports. In a subsequent stage, due to the difficulty in finding data statistics for the Portuguese population, the number of events was reduced from 40 to 20, with an additional 3 events added for the training phase. The criterion for selecting these events was based on the available data obtained through the aforementioned sources.

After gathering the list of events found, it was necessary to process these probabilities according to the original study, where:

$$1 - (1 - Annual\ probability) \times 10\ years$$
$$= P\ of\ occurring, at\ least, once\ in\ the\ next\ 10\ years$$

Therefore, this calculation determines the probability of a given event occurring, at least once, over the next 10 years, for an individual from the same sociocultural environment.

Although the original study (Sharot et al., 2011) defined some criteria for the selection of events, some changes to these criteria were necessary in the present investigation. In fact, in the original study, the probabilities of event occurrence ranged from 10% to 70%, however, the participants were informed that it could vary between 3% and 77%, to ensure that the amplitude of overestimations and underestimates were equivalent. In our investigation, participants were asked to estimate the probability of a given negative life event occurring at least once in the next 10 years, being told that this estimate ranges between 1% and 99%. Hence, to better meet the objectives of the investigation, while still following the logic of the original study (Sharot et al., 2011), and given the scarcity of events that met the initial criteria, it was decided to consider events with a probability between 5% and 95%.

Additionally, we decided to exclude reaction times, in which the participants would have a time limit to respond, as well as to view the answers. In fact, one of the analysis parameters of the original task involved participants' reaction times, which were removed since data from fMRI were not assessed due to the unavailability of technical information necessary for this research.

Furthermore, changes were made to the training stimulus, replacing "Dying before 90 years" to "Dying between 70-79 years", and the stimulus "Dying before 60 years" was modified to "Dying between "50-69 years", based on sociodemographic information found. In addition, there was also a need to add a new event “Abdominal pain/Urinary problems” to the list of stimuli to be presented to the participants, in order to complete a list of 20 negative stimuli. Finally, the third training event was altered by excluding "Post-Traumatic Stress Disorder", since, as a psychopathology, it could cause bias into the data and constitute a comorbidity for some subjects (see Appendix A, for a complete list of the original English and the translated Portuguese stimuli).

Moreover, according to the original study (Sharot et al., 2011), two sessions with two blocks of 20 events each were planned. In the first block, participants made estimates as described earlier: they had to estimate the probability of negative life events occurring (presenting the probability of this event happening for a similar population); whereas, in the second block, they were asked to estimate the probability of events not occurring, with the probability of the event not happening for a similar population was presented. However, in the current study, changes were made to some of these aspects, including the existence of two sessions. Instead, there is now only one session, comprising two blocks of stimuli, in which the participant only provides the probability of occurrence for a similar population, ceasing to exist the second session in which they would have to present an estimate for the non-occurrence. In a second block, participants were asked to provide an estimate of the probability of experiencing the events, in order to assess how they used given the information. That is, this second block had the same events as the first, with the exception that the actual probability of occurrence of the event was not presented again. In fact, the change to only one block with two sessions on the probability of occurrence is justified due to the number of events presented, considering the population sample and the potential monotony and fatigue inherent to the task.

Thus, for each event, an update term was calculated, which consists in the difference between the participant's first and second estimations. It is important to note that when participants overestimate the probability of the event, they received desirable

information, which means the negative event is less likely to happen than estimated. On the contrary, when there is an underestimation concerning the actual likelihood, it entails in an undesirable information, indicating that the event is more likely to happen than the estimated one. Therefore, the participant may provide an overestimation or an underestimate of the current likelihood, i.e., a desirable (optimistic) or undesirable (pessimistic) direction. This means that estimation errors are positive for overestimations, and negative for underestimations. If the participants provide the same estimate as the probability presented, which expresses the estimation error equals zero. This exclusion must be carried out, because, in these cases, it is not possible to perform the desirable-undesirable classification.

We used OpenSesame (Mathôt et al., 2011) as a tool to present the task. Thus, after the insertion of the events and their probabilities in the program, it was decided to randomize the presentation of these stimuli, to avoid possible sequence effects. It is worth noting that, despite being an artificial situation that does not replicate everyday life, randomization allows prediction errors to be maximized, thereby facilitating a better understanding of Predictive Processing in the sample.

After completing the programming of our task, three pilot tests were performed. These tests aimed to ascertain whether the task was enlightening and well-constructed, in terms of the explanation provided in the protocol, and technical aspects, such as font size stimuli presentations, any difficulties, events that require definitions, etc. Therefore, adjustments to the task were made based on the feedback received.

2.3 Procedure

The data collection of the clinical group took place at Centro Hospitalar Universitário de São João, and the collection for the control group took place in the most convenient space for the participant, mostly at Faculdade de Psicologia e Ciências da Educação da Universidade do Porto, after the explanation of the study and the respective signature of the informed consent. The study received a favourable report from the Ethics Committee of the Hospital and was conducted in accordance with ethical guidelines and National and European regulations on research with human participants and management of personal data. It should be noted here that participants could refuse to participate in the study or discontinue their participation at any time or after participation.

Next, the participants filled out a brief questionnaire with demographic data and, subsequently, the study protocol was provided for reading and explained (see Appendices B through D). It should be noted that, in the case of the clinical group, the necessary information was collected regarding the clinical picture and psychotropic treatment of each participant.

In this regard, it was explained to the participant that they would need to provide an estimate of a certain negative life event occurring, at least once, in the next 10 years for a person living in the same sociocultural environment. After clarifying all the details about the task, it was initiated with three training exercises, during which the subject could ask any remaining questions.

The data collected from the OpenSesame program were extracted into Microsoft Excel, and then transferred to IBM SPSS software, Version 27.

2.4 Statistical Analysis

In statistical terms, it was considered important to verify whether the groups are statistically equivalent with regard to sociodemographic variables, namely, age, sex, and level of education. Therefore, descriptive statistics were obtained for these variables. In addition, descriptive statistics were verified, namely the minimum and maximum values of each item, in order to ascertain the possible existence of any item with an anomalous response to the protocol. For example, in trials with response 0, this value was changed to 1 in order to avoid the exclusion of another participant (as responses were expected to be from 1 to 99%).

Subsequently, calculations were programmed for dependent variables: the *Estimation Error* and the *Update*.

$$Estimation\ error = first\ estimation\ - probability\ presented$$

$$Update = first\ estimation\ - second\ estimation$$

It was also considered essential to ensure that all items measure the same construct, to be possible to use the mean of the *Estimation Error* and *Update* as representative and suitable for group comparisons. Reliability was assessed using Cronbach's alpha.

Subsequently correlations between individual items and the overall mean were examined for the variables *Estimation Error* and *Update*.

Descriptive statistics, including the mean and distribution, of the dependent variables were computed by group, and Shapiro–Wilk normality test was conducted. For variables with a non-normal distribution, the nonparametric Mann–Whitney U test was used, followed-up by t tests for independent samples. We used non-parametric tests to provide valid results when the assumptions of parametric tests were not ensured. The reason for following up these analyses with parametric tests is to provide results that are more directly comparable to the previous literature (and potentially necessary in the case of a meta-analysis on this topic).

Given that, as mentioned in the previous section, access to the participants of the clinical group was not uniform, it was necessary to ascertain whether there are differences between these two subgroups. We grouped the diagnoses of schizophrenia and psychosis into two categories. Thus, six subjects diagnosed with schizophrenia, one with schizophrenia (with acute episode), four diagnosed with chronic schizophrenia, one with chronic schizophrenia (with acute exacerbation), and one with typical schizophreniform prodrome (with drug use) were included in the general category "Schizophrenia"; and eight subjects diagnosed with psychosis and one with chronic psychotic condition were included in the category "Psychosis". With these subdivisions into two groups, normality tests were performed in both of them regarding dependent variables. Given the non-normal distribution in one of the groups, non-parametric tests were used, followed by subsequent t tests.

To assess the differences between men and women within the clinical group, the Mann Whitney U test was performed, with confirmation using an independent samples t-test.

3. Results

3.1 Descriptive Statistics

In the present study, descriptive statistics for age, sex and level of education were first calculated. Thus, as shown in Table 1, the final population sample includes the control group consisting of 10 women and 12 men, and the clinical group consisting of nine women and 13 men (see Table 1 for the means and standard deviations concerning the sociodemographic variables). The groups were not significantly different in any sociodemographic variables, since the *p-value* exceeds .05 for all comparisons.

The descriptive statistics for each item, in the first and second trials, are available in Tables 2 and 3, respectively.

Table 1

Sociodemographic statistics

	Clinical Group N=22	Control Group N=22	Comparison
Age	32.2(1.8)	29.7(2.2)	$t(42) = 0.86$, p=.397
Sex	9F, 13M	12F, 10M	$t(42) = 0.89$, p=.377
Educational Level			$t(42) = -0.72$, p=.475
5th - 6th grade	1	1	
7th - 9th grade	3	0	
High school (10th - 12th grade)	6	12	
College degree	12	9	

Table 2

Descriptives statistics – first trial

Trial number	Clinical Group N=22	Control Group N=22
E1	57.3(18.2)	54.6(24.1)
E2	14.1(13.9)	25.5(26.4)
E3	40.5(20.5)	36.3(21.7)
E4	32.7(13.2)	31.6(19.5)
E5	33.7(20.8)	30.2(18.7)
E6	31.4(20.2)	31.7(12.0)
E7	34.3(23.0)	36.1(19.9)
E8	26.3(15.1)	28.8(21.2)
E9	35.8(20.6)	33.3(16.4)
E10	42.9(26.4)	61.2(21.1)
E11	42.8(20.2)	47.5(20.2)
E12	17.9(17.4)	25.7(20.8)
E13	36.3(22.0)	46.4(19.5)
E14	43.5(19.7)	44.8(23.7)
E15	41.1(18.6)	47.9(23.6)
E16	39.6(20.5)	48.9(19.8)
E17	39.5(16.4)	32.3(20.0)
E18	16.3(13.4)	13.8(13.0)
E19	33.1(21.1)	21.9(14.7)
E20	29.6(17.5)	47.9(19.3)

Table 3

Descriptives statistics – second trial

Trial number	Clinical Group N=22	Control Group N=22
E21	79.5(17.6)	82.5(23.6)
E22	28.7(16.4)	24.3(20.9)
E23	46.0(17.0)	49.4(16.8)
E24	37.8(23.0)	37.1(22.8)
E25	37.0(15.8)	43.8(14.1)
E26	45.8(19.0)	49.5(19.1)
E27	28.5(12.3)	27.0(18.3)
E28	36.5(14.5)	23.2(12.3)
E29	42.6(18.2)	30.2(15.0)
E30	47.8(23.3)	45.4(21.4)
E31	39.1(20.0)	67.1(22.5)
E32	37.8(25.6)	48.1(17.9)
E33	48.2(17.6)	51.0(15.6)
E34	43.8(16.0)	47.5(20.6)
E35	55.9(14.8)	65.1(14.0)
E36	58.9(18.9)	69.8(14.3)
E37	39.2(19.0)	52.8(21.8)
E38	24.0(16.6)	17.4(20.0)
E39	24.9(17.6)	16.1(9.7)
E40	37.5(29.9)	18.8(13.0)

3.2 Reliability

Before proceeding towards the evaluation of the hypotheses, there are some aspects to take into account, namely the assessment of the statistical assumptions required for the choice of the most appropriate tests to be used.

First, the reliability was assessed to determine if all the items are in agreement in measuring the same construct. If this internal consistency is verified, it becomes possible to consider the mean of both the *Estimation Error* and the *Update* for group comparisons. In other words, in this instance, reliability was evaluated, assuming that all 20 items represent the same measure.

Therefore, for the 20 items, a Cronbach's alpha of .65 was registered for the *Estimation Error*; and of .69 for the *Update*, both of which are reasonable values of reliability. Nevertheless, after analysing the correlation between each item and the mean of the *Estimation Error* and the *Update*, it was noticed that item 01 *("*Obesity*")* is the only one with a negative Pearson Correlation (r = -.03). In this sense, it was decided to remove it as it contributes to poorer consistency, meaning it represents a different measure of the construct. After this exclusion, Cronbach's alphas become more robust, increasing to .69 for the *Estimation Error*, and to .72 for the *Update*, with 19 items. With this adjustment of items, it is now possible to consider the mean of the variables *Estimation Error* and *Update* as representative of each constituent item and use them to compare both groups.

3.3 Results

Given the inability to create a clinical sample exclusively diagnosed with schizophrenia, it was considered important to understand if there are differences between participants diagnosed with schizophrenia and participants diagnosed with psychosis that compromise statistical integrity. Therefore, normality tests for the dependent variables were conducted, which indicated a normal distribution for the *Estimation Error* variable, either for the group diagnosed with schizophrenia and for the group with psychosis. For the *Update* variable, the group with schizophrenia also presented a normal distribution unlike the group diagnosed with psychosis, which reveals statistically significant differences. Thus, it is decided to proceed, for both variables, with the evaluation of the results with the Mann Whitney U test. Participants with psychosis and participants with schizophrenia do not reveal statistically significant differences in *Estimation Error (*U = 36.5, p = .144), nor in *Update (*U = 45, p = .393). Therefore, they can be compared as a representative group of the clinical sample in this investigation.

Next, it was verified whether the clinical group and the control group followed a normal distribution for the variables *Estimation Error* and *Update*. The distribution of

Estimation Error, both for the control group and for the clinical group deviated significantly from normality. In turn, in the *Update* variable, a normal distribution was found, in which the control group and the clinical group did not present statistically significant differences in the distribution.

The dependent variables – specifically, the *Estimation Error* and the *Update* – are continuous variables – and the independent variable is dichotomic, so the independence of the samples and observations is assured.

Therefore, the Mann-Whitney U test was performed to compare the control group vs. the clinical group, both for the *Estimation Error* variable and for the *Update* variable. The z-value, for all variables, is outside the range |1.96|, so the null hypotheses are retained. That said, H1 did not have statistically significant support *(*z = 1.03*,* p = .302), i.e., there were no differences between the groups regarding the *Update* of expectations. Therefore, there are no statistically significant differences between the groups regarding the *Estimation Error* (z = 1.46, p = .145), that is, H2 is not corroborated. In this sense, considering both variables, there is no evidence to support that the control group is, from the outset, more optimistic, nor registers, after receiving new information, an Optimistic Bias in their answers. These results were replicated with t tests for independent samples, since the control group (M = -6.65 , SD = 7.76), compared to the clinical group (M = -10.09 , SD = 7.36), did not demonstrate a significant difference (t(42) = -1.51 , p = .139) for *Estimation Error*. Additionally, the t test for independent variable followed accordingly to the non-parametric test, concerning the *Update* variable, with the control group (M = -4.57 , SD = 8.24) and the clinical group (M =-6.83 , SD = 11.97) presenting an absence of statistically significant differences (t(42) = -0.73, p = .471). Regarding H3, there were no significant differences that allow us to make a distinction between men and women in the clinical group, regarding the updating of beliefs (z = 0.815, p = .845). This data was reproduced with the parametric statistics, with women (M = -5.48, SD = 15.29) and men (M = -7.75, SD = 9.62) presenting a lack of statistically significant differences (t(20) = 0.34, p = .735).

4. Discussion

The present investigation aimed to explore the differences in belief updating between neurotypical individuals and individuals with schizophrenia and, consequently, to assess the impact of Optimistic Bias on decision-making regarding negative life events. Since the human nervous system continually engages with a wide range of ambiguous and ever-changing sensory signals (Kraus et al., 2009), dysfunctional beliefs constitute a factor to be taken into account in the development of psychopathologies, as they shape one's perception of the surrounding world (Kube & Rozenkrantz, 2021). Nevertheless, the results obtained provide a new perspective on understanding belief updating and Optimistic Bias. In general, according to Kraus et al. (2009), they postulate that individuals with schizophrenia require more complete stimuli than neurotypical individuals, so the lack of significant differences between the groups may indicate that the task was clear and comprehensive enough to mitigate differences in responses. Furthermore, an explanation for these unexpected results could be that our study examined clinically stable patients on antipsychotic medication (Kubota et al., 2022; Schmack et al., 2017).

Regarding H1 – the clinical group shows a lower belief updating compared to the control group – no statistically significant differences were found between the groups. Therefore, both the clinical group and the control group demonstrated equivalent results in updating their expectations after receiving new information, i.e., the actual probability of the occurrence of adverse events. In the absence of differences in updating with the received real probability, we can extrapolate that there was a biased data selection towards the confirmation of prior beliefs (Kube & Rozenkrantz, 2021). With the aim of understanding whether beliefs are adjusted when individuals with schizophrenia receive new information that questions the validity of such beliefs, we conclude that they update their beliefs in an equivalent manner to neurotypical individuals. In both groups, it was observed that more importance was given to prior beliefs in the response to the second trial, given the probabilities of adverse events.

Therefore, Kube and Rozenkrantz (2021) state that a determinant in this belief updating is the accuracy ascribed to prior beliefs, in relation to sensory evidence, and a balance between prior precision and sensory precision is associated with attention. Now, we can speculate here that given greater attention to the task and the focused effort, it can

be speculated that there is also a greater balance between prior precision and sensory input (Kube & Rozenkrantz, 2021), both in the clinical group and in the clinical group.

Despite expecting a result that would reflect the control group updating their beliefs more, we can consider a different scenario here. Weak priors can result in a greater impact of received sensory information and, consequently, a higher prediction error (Kube & Rozenkrantz, 2021). Therefore, we can question whether these weak priors may explain why the groups showed equivalent values in the *Update*, and the actual probabilities presented had a significant impact, albeit statistically equivalent, in both the clinical and control groups. In this sense, weak prior beliefs may be more susceptible to new inputs, which carry greater weight, suggesting greater fragility of beliefs. It is possible that the study population had less firm beliefs, making it more likely for them to use new information in their updating process. In fact, according to Kube and Rozenkrantz (2021) aberrant beliefs can also be applied to neurotypical individuals in certain circumstances, even though they are typically reported in relation to anomalies in belief updating in clinical populations.

It is known that there has been, in schizophrenia, an association between dopamine and positive symptoms (Koch et al., 2020). However, we can suggest that positive symptoms are controlled in our sample through medication, hence possibly explaining the absence of significant differences to controls. In adaptive decision-making under conditions of uncertainty, such as in our second trial, participants had to actively monitor the divergence that occurs between the expected and actual results – the Prediction Errors (Yaple et al., 2021). In addition, dopamine also has impacts memory consolidation (Bortolotti, 2018), so we can question whether these dopamine levels also affected the participants' responses, as surprise in response to actual probabilities may leave a marked memory that subsequently influences the second trial of the task. Although it is not the focus of this investigation, we cannot disregard the effect of medication on dopamine regulation (Koch et al., 2020), and we can only consider that dopamine levels are, more or less, regulated by medication, which may explain the statistical equivalence in the responses of the groups.

In a study conducted by Kraus et al. (2009), the superior performance of the clinical group diagnosed with schizophrenia results in longer reaction time in the task performed. Therefore, in the present investigation it could have been interesting to evaluate the reaction times (Kraus et al., 2009) to understand the impact and possible diversity of the results.

In other words, the clinical group did not update expectations to a lesser extent, as would be expected based on previous research, but this may lead us to draw further conclusions about the control group. Indeed, the general population tends to be less prone to updating their beliefs in the face of undesirable information, as demonstrated by Kuzmanovic et al. (2014), which aligns with the results we obtained based on the statistics of the *Update* variable.

The second hypothesis – the clinical group has an Optimistic Bias towards new information that is lower than control group – no differences were found that justify neurotypical individuals displaying a higher Optimistic Bias. Therefore, in this study we found that people remain optimistic even in the face of non-confirmatory evidence. Nevertheless, these results apply to subjects with a clinical diagnosis of schizophrenia and to healthy subjects. According to our findings, both groups selectively adopted information that benefits optimistic ideas, disregarding contradictory information, showing similar levels of Optimistic Biases.

These results, although pioneering, are not foreign to the literature. A significant portion of adults with chronic schizophrenia have levels of resilience and optimism similar to those of neurotypical individuals (Edmonds et al., 2016). In the study conducted by Edmonds et al. (2016), suggested that more than a third of participants with schizophrenia this population may exhibit a similar Optimistic Bias to the control group in the face of adverse information. Furthermore, according to Seo and Lim (2019) effective intervention in schizophrenia can impact individuals' levels of optimism. Therefore, given that the patients that participated in our study are medicated and under medical care, the absence of differences from controls may reflect an effect of this intervention in normalizing cognitive processing.

In summary, regarding this second hypothesis, probability assessments are inherently subjective and intuitive, which can lead to biases. This optimism bias has been proven to occur regardless of gender, education, age, and has an impact on decision-making (Kuzmanovic et al., 2014). In fact, the task we used may not represent a day-to-day activity, but it is inherently subjective. We have demonstrated that optimism is a cross-sectional aspect of both groups, with no statistically significant differences observed in any of these variables.

The last hypothesis of our investigation – women from the clinical group are more likely to update beliefs, based on new information, compared to men from the clinical group – for which we cannot argue the existence of gender differences in belief updating.

In other words, in the present research, results suggest that both men and women update their beliefs equally.

Despite knowing that the age of schizophrenia onset differs between men and women, the role of gender is somewhat under-researched (Li et al., 2022). We can argue that although there are clinically proven differences in symptoms when comparing men and women with schizophrenia (Seeman, 2021), there are not enough studies that assess predictive functioning when the psychopathology is controlled within these two groups. In the context of schizophrenia, differences between men and women regarding Predictive Processing, and consequently belief updating, are under-discussed aspect in the literature. Kubota et al. (2022) found differences between these two groups, but specifically for neurocognition related to social cognition. On a larger scale, studies focus on gender differences in the first episode or clinical symptoms (Li et al., 2022), so we point to a lack of recognition of potential post-intervention differences (Barajas et al., 2015). Our research suggests an equivalent belief updating between men and women with schizophrenia. We can assume that since all subjects are being followed up in a hospital setting, they are receiving an intervention appropriate to their characteristics, which may have mitigated differences and resulted in equivalent responses to the task.

These data draw our attention to another aspect that has been proposed: the notion of a psychosis continuum. DeRosse and Karlsgodt (2015) argue for continuity between subclinical and clinically significant psychotic symptoms, based on evidence showing similarities in the clinical profiles of patients with psychotic disorders and healthy individuals who report subclinical psychotic symptoms.

It is important to note that subclinical psychotic symptoms, such as altered perceptual experiences, disturbances in speech, attention, perception, motor action, etc., differ from clinically significant psychotic symptoms, such as delusions and hallucinations, based on the severity, frequency, and certainty of their presentation. Subclinical psychotic symptoms are indeed common in the general population, with a prevalence of around 7.2%, and they are associated with age (DeRosse & Karlsgodt, 2015). Therefore, they may represent an extreme end of the phenotypic spectrum of these symptoms (Barnett et al., 2012). Subclinical or low-grade psychotic symptoms are not held as fixed beliefs, but rather recognized by the person as a product of their own mind (Bortolotti, 2018). Through self-report instruments, approximately 25% of adults positively state about screening questions related to psychosis-like experiences, without meeting the criteria for psychotic disorder (Barnett et al., 2012). On the other hand,

individuals who, for example, are diagnosed with schizophrenia, would be at the extreme end of the spectrum of psychotic experiences.

It is important, however, to note here that this perspective of a psychosis spectrum has raised concerns that it may blur existing diagnostic categories (DeRosse & Karlsgodt, 2015). Nevertheless, both approaches are necessary and can adopt complementary purposes. In the context of the existence of this continuum, studying individuals with different characteristics allows us to understand the risk for psychotic disorders; while analysing individuals who do not meet diagnostic criteria but exhibit subclinical psychotic symptoms contributes to our understanding of resilience to these psychopathologies (DeRosse & Karlsgodt, 2015).

From this, we can draw two perspectives: (1) there is indeed a continuum, and the task we used does not exacerbate psychotic symptoms, or (2) the medication is highly effective and has a notable impact, translating into the absence of statistically significant differences. Furthermore, this study may lean more towards supporting the existence of a psychosis continuum rather than highlighting pronounced differences between individuals with schizophrenia and neurotypical individuals in terms of Predictive Processing functioning.

4.1 Implications

Although our study showed an absence of significant statistical differences between neurotypical controls and participants with schizophrenia, the Optimistic Bias could be an impairment factor in schizophrenia, given the symptoms and repercussions of this psychopathology. In the beginning of the intervention with these patients, it could be important to understand the Belief Update and Optimistic Bias functioning. This assessment can have significant practical implications for the treatment and management of schizophrenia, particularly in terms of personalizing interventions by understanding how individuals update their beliefs and the way vulnerability to Optimistic Bias works. In a clinical context, professionals can address dysfunctional beliefs and adjust treatment plans, which is crucial for developing effective therapeutic interventions.

The assessment of Optimistic Bias can serve as a valuable indicator in preventing relapse, by identifying domains in which patients may benefit from more realistic information input. In addition, a deeper understanding of this topic can provide us with

greater insight into everyday decision-making processes, whether in economic, political, risk assessment, or other contexts.

4.2 Strengths

One of the pioneering aspects of the current study is the extension of this research question to schizophrenia, conducting an investigation grounded in the Predictive Processing models that currently emerge as a promising framework for the study of cognition and psychopathology.

The basic structure of studies in the domain of belief updating typically involves an initial assessment of beliefs before the input of new information, which may either corroborate or contradict the prior beliefs, followed by a second assessment of beliefs (Kube & Rozenkrantz, 2021). Our research followed this methodology, which could mean our results may result in a new perspective for belief updating.

Additionally, it is important to note the absence of comorbidities such as depression, as we have already seen it significantly influences Optimistic Bias on a large scale (Sharot et al., 2012). In this sense, if there were significant differences between control and clinical group, these could be due to depressive symptoms.

4.3 Limitations

The lack of statistically significant findings may be due to several factors. We cannot disregard the perspective that unconfirmed hypotheses may be due to a lack of statistical power, particularly the small sample size, which may have limited our power to detect differences between groups (Kafadar et al., 2020; McCleery et al., 2018).

Another limitation may consist of the lack of a more detailed symptom assessment, which would allow us to relate the presence and/or severity of symptoms to the responses provided by participants in the clinical group. Indeed, the clinical group was heterogeneous in terms of the concrete diagnosis of the patients, with several participants having a confirmed diagnosis of schizophrenia, but other a less specific indication of psychosis.

Although Optimistic Bias has been demonstrated in previous studies for both negative and positive events, in this research we only included negative events. Optimistic

Bias is typically higher for negative events (Gold & de Sousa, 2012; Korn et al., 2013). In addition, there is greater consensus regarding the definition of negative events, as people tend to avoid diseases or accidents, but differ in the definition of positive events, and statistics for positive events are also almost non-existent (Kuzmanovic et al., 2014). Nevertheless, it seems to us that comparing results with positive events could provide us with additional insights.

It could have been important to investigate the impact of reaction times to understand whether participants tried to be accurate in their responses, because an attempt to be accurate requires more time and energy will be expended (Wilkinson et al., 2017). In fact, during the task, several subjects stated that they were making an increased effort to recall the real probabilities demonstrated. This indicates a salience effect, with many participants ("I remember this event because it shocked me" [sic]).

4.4 Future Research

This investigation is modest and conjectural in several aspects. Future investigations should embrace a holistic perspective of processes, approaches, and psychopathology. Moreover, future studies should use larger and more homogeneous samples, both in psychological terms and in sociodemographic variables.

We agree that one important aspect to invest in is longitudinal studies to understand whether an increase in optimistic updating predicts treatment effects, thereby gaining a deeper understanding of the course of the psychopathology and the effects of medication. On the other hand, we encourage future research to recognize the different characteristics of patients that are reflected in a variety of outcomes, taking into account variables, such as medication use, symptomatology, and sociodemographic variables.

It might also be interesting to compare this Optimistic Bias in negative events when comparing for self-related judgments relative to judgments about others. Future projects with individuals who are not on psychotropic treatment and in the early stages of the psychopathology are needed for a more integrated understanding of our outcomes.

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6. Appendices

6.1 Appendix A

List of the original English and the translated Portuguese stimuli

Table 4

List of Stimuli

Trial number	English	Portuguese (translated)
E1	Obesity	Ter obesidade
E2	Death by infection	Morrer por infeção
E3	Asthma	Ter asma
E4	Serious hearing problems	Ter problemas auditivos graves
E5	Domestic burglary	Ser vítima de um assalto doméstico
E6	Infertility	Ser infértil
E7	Gluten intolerance	Ter intolerância ao gluten
E8	Eye cataract (clouding of the lens of the eye)	Ter catarata ocular
E9	Abnormal heart rhythm	Ter arritmia cardíaca
E10	Migraine	Ter enxaqueca
E11	Appendicitis	Ter apendicite
E12	Autoimmune disease	Ter doença autoimune
E13	Alcoholism	Alcoolismo
E14	Gallbladder stones	Litíase das vias biliares (pedra na vesícula)
E15	Fraud when buying something on the internet	Ser vítima de fraude em compra on-line
E16	Being cheated by husband/wife	Ser traído pelo marido/esposa
E17	Osteoporosis (reduced bone density)	Ter osteoporose
E18	Epilepsy	Ter epilepsia

E19	-	Morrer entre os 50 e 69 anos
E20	-	Ter dor abdominal/problemas urinários

6.2 Appendix B

Questionnaire for the Control Group

Questionário Sociodemográfico

Codificação: _____

Data: _____

Preencha, por favor, as informações abaixo solicitadas. Será atribuído um código, de forma a garantir a confidencialidade das suas respostas.

1) Idade: _____

2) Nacionalidade: _____

3) Sexo:

☐ Feminino

☐ Masculino

☐ Prefiro não dizer

4) Habilitações académicas (último ano de ensino concluído):

☐ Sem estudos ou com ensino primário incompleto

☐ Primeiro ciclo (1º- 4º ano)

☐ Segundo Ciclo (5º - 6º ano)

☐ Terceiro ciclo (7º - 9º ano)

☐ Ensino secundário (10º - 12º ano)

☐ Ensino superior

5) Tem algum problema de visão?

☐ Sim. Qual? _____

☐ Não

5.1) Se respondeu "sim" na questão anterior, tem o problema de visão corrigido ou controlado?

☐ Sim.

☐ Não

6) Já teve ou tem algum diagnóstico de psicopatologia?

☐ Sim. Qual? _____

☐ Não

Obrigada pela sua participação.

6.3 Appendix C

Questionnaire for the Clinical group

Questionário Sociodemográfico

Codificação: _____

Data: _____

Preencha, por favor, as informações abaixo solicitadas. Será atribuído um código, de forma a garantir a confidencialidade das suas respostas.

7) Idade: _____

8) Nacionalidade: _____

9) Sexo:

☐ Feminino

☐ Masculino

☐ Prefiro não dizer

10) Habilitações académicas (último ano de ensino concluído):

☐ Sem estudos ou com ensino primário incompleto

☐ Primeiro ciclo (1º- 4º ano)

☐ Segundo Ciclo (5º - 6º ano)

☐ Terceiro ciclo (7º - 9º ano)

☐ Ensino secundário (10º - 12º ano)

☐ Ensino superior

11) Tem algum problema de visão?

☐ Sim. Qual? _____

☐ Não

5.1) Se respondeu "sim" na questão anterior, tem o problema de visão corrigido ou controlado?

☐ Sim.

☐ Não

Obrigada pela sua participação.

6.4 Appendix D

Protocol

Protocolo

- Serão apresentados alguns eventos de vida negativos.
- Vai ser pedido que estime a probabilidade desse mesmo evento acontecer pelo **menos uma vez nos próximos 10 anos**. Terá de escrever esse valor no computador. Posteriormente, será apresentada a probabilidade real desse evento.
- A probabilidade de ocorrência destes eventos, a uma pessoa do mesmo ambiente sociocultural, situa-se entre 1% e 99%.
- Antes de começarmos, vamos fazer um exemplo. Qual acha que seria a probabilidade de ter Doença de Parkinson? Quanto mais baixo este valor será

muito pouco provável que aconteça; valores elevados significam que será bastante provável; *resposta* a probabilidade de uma pessoa, que viva no mesmo ambiente sociocultural, ter doença de Parkinson nos próximos 10 anos é de 2%.

- Nesta primeira parte, vai fazer um treino no computador, com três exemplos. De seguida, responderá aos eventos da tarefa propriamente dita e verá as probabilidades reais.
- Num segundo momento, vai ser pedido novamente que forneça uma probabilidade para os eventos anteriores, mas, desta vez, **não será demonstrada a probabilidade real.** Ou seja, voltando ao exemplo anterior, vai-lhe ser perguntada a probabilidade da doença de Parkinson, mas não lhe será dito que é 2%.