



MESTRADO
MULTIMÉDIA - ESPECIALIZAÇÃO EM CULTURA E ARTES

***Evoking a Simulated Past:* technology and manipulation of human memory**

Mariana Vilanova

M

2021

FACULDADES PARTICIPANTES:

FACULDADE DE ENGENHARIA
FACULDADE DE BELAS ARTES
FACULDADE DE CIÊNCIAS
FACULDADE DE ECONOMIA
FACULDADE DE LETRAS





Evoking a Simulated Past: technology and manipulation of human memory

Mariana Vilanova

Mestrado em Multimédia da Universidade do Porto

Orientador: Miguel Carvalhais (PhD)

Coorientador: Luís Arandas (PhD Fellow)

Junho de 2021

© Mariana Vilanova, 2021

Evoking a Simulated Past: technology and manipulation of human memory

Mariana Vilanova

Mestrado em Multimédia da Universidade do Porto

Aprovado em provas públicas pelo Júri:

Presidente: Bruno Giesteira (Professor Doutor)

Vogal Externo: Ana Carvalho (Professora Doutora)

Orientador: Miguel Carvalhais (Professor Doutor)

Resumo

A memória é uma das características fundamentais do ser humano, ela molda a nossa personalidade e permite-nos reagir às experiências da vida. Ao longo da História, os seres humanos têm vindo a procurar formas de melhorar as suas capacidades cognitivas, como a memória, contando com mecanismos e dispositivos externos, como a escrita e a produção de imagens. No século vinte e um, a memória humana não pode ser separada da tecnologia digital, já que armazenamos constantemente registos das nossas experiências em *smartphones* e computadores. Hoje, temos acesso a quase toda a informação do mundo nos nossos bolsos, o que nos leva a confiar demasiado na tecnologia para armazenar as nossas memórias. Mas esse acesso a toda essa informação está a transformar a maneira como formamos, armazenamos e reconstruímos memórias.

Os nossos objectivos principais consistem na criação de uma instalação multimédia que explore processos de memória humana, como a reconstrução e associação de memórias; e na criação de uma reflexão crítica que potencie o questionamento sobre o impacto da tecnologia na memória humana.

A instalação, denominada *Evoking a Simulated Past*, é descrita nesta dissertação, bem como o processo criativo e as contribuições da pesquisa sobre a memória humana e a memória artificial para a implementação do projeto.

Palavras-chave: Memória Humana, Reconstrução, Manipulação, Tecnologia, Instalação Multimédia

Abstract

Memory is one of the fundamental characteristics of human beings, it shapes our personality and allows us to react to life experiences. Throughout History human beings have been looking for ways to enhance their cognitive abilities, such as memory, by relying on mechanisms and external devices, such as writing and picture-making. In the 21st century human memory cannot be separated from digital technology, as we constantly store records of our daily experiences in smartphones and computers. Today, we have access to almost all the information of the world in our pockets which leads us to trust too much on technology to store our memories. But the access to all that information is changing how we form, store and reconstruct memories.

Our main goals are to create a multimedia installation that explores human memory processes, such as reconstruction and association of memories; and to create a critical essay that fosters the questioning about the impact of technology on human memory.

The installation, named *Evoking a Simulated Past*, is described in this dissertation as well as the creative process and how the research on human memory and archival practices contributed to its implementation.

Keywords: Human Memory, Reconstruction, Manipulation, Technology, Multimedia Installation

Acknowledgements

Firstly, I want to thank my supervisor Professor Miguel Carvalhais and my co-supervisor Doctoral Student Luís Arandas for guiding me through the dissertation and asking me more questions than giving answers.

Secondly, I want to thank all those from generation and to all those who made the implementation of the installation possible. Thank you Luís Fernandes, Francisco Quintas, Ilídio Marques, Márcio, Tiago, Rui and Miranda, and a thank you to Andrea Graf.

A thank you to my friends Francisco Oliveira, Diana Lucena, Adriana Garcez, Inês Coelho, Maria Jorge and Ana Carvalho dos Santos.

A special thanks to my friends Danielle Lopes and to Francisca Soares for being so present since the beginning.

A thank you to Jorge Carneiro for all the references and for the discussion on some ideas.

To my father, Manuel Vilanova, a special thanks, for all the knowledge and books that were fundamental for the beginning of the project. To my mother, Maria Nogueira, my brother, António Vilanova, and my sister, Madalena Vilanova, a special thanks for all their support and for letting me film them.

A special thanks to Marcelo Graf Reis, who not only helped me throughout the project, but is also my partner in life.

Finally, a special thanks to my grandmother, Ana Vilanova, to whom I dedicate this dissertation, for supporting me in all my projects and for encouraging me to do better.

Mariana Vilanova

Index

1. Introduction	1
1.1 Context/Motivation	1
1.2 Problem(s) and Research Goals	2
1.3 Methodology	2
1.4 Document Structure	2
2.Literature Review	4
2.1. Human Memory	4
2.1.1 The Human Brain – Evolutionary Context	4
2.1.2 Memory as an Essential Role for Human Evolution	5
2.1.3 How does our Brain Work?	6
2.1.4 Brain Networks	6
2.1.5 Brain Systems	7
2.1.6 How Neuroimaging Helped Us Understand the Brain	8
2.1.7 Mapping the Brain	10
2.1.8 Making Memories	11
2.1.9 How are Memories Formed and Stored?	12
2.1.9.1 The Amygdala	13
2.1.9.2 The Hippocampus	14
2.1.10 How do we Encode, Store and Recollect Memories?	14
2.1.10.1 Encoding and Consolidating	15
2.1.10.2. Recollecting	16
2.1.11 Episodic and Autobiographical Memory	17
2.1.12 Memory and Emotions	19

2.1.12.1 Primary/Basic Emotions	20
2.1.12.2 Secondary Emotions	21
2.1.13 The Making of Memorable Moments	21
2.1.14 False Memories	22
2.2 Artificial Memory	25
2.2.1 From Internal Memory to External Memory	25
2.2.1.1 Human Brain Evolution and Knowledge Sharing	26
2.2.1.2 First Manifestations of External Memory and Knowledge Sharing	27
2.2.1.3 Sites of Storage and Transition to the Modern World	28
2.2.1.4 <i>Prosthetic Mind</i>	30
2.2.2 How Digital Technology changed us and the World	30
2.2.2.1 A Paradigm Shift: World War II and its Technological Advances	31
2.2.2.2 <i>A Personal Database for Everything</i>	33
2.2.2.2.1 Ubiquitous Computing	36
2.2.2.3 Collective Memory	37
2.2.2.3.1 Possible Consequences	38
2.2.2.3.2 Digital Immortality	39
2.2.2.4 The Importance of Forgetting	40
3.State of the Art	43
3.1.Artworks and Multimedia installations	43
3.1.1 Memory Association Machine	44
3.1.2 Pleasant Places	45
3.1.3 Deep Meditations: A Brief History of Almost Everything	46
3.1.4 Melting Memories	47
3.1.5 Neural Zoo	48
3.1.6 Of Ideal	49
3.1.7 Power Plants	51
3.1.8 Phase Shifting Index	52
3.1.9 Regions of Interest	53
3.2.Conclusions	55
4.Evoking a Simulated Past	57
4.1. Introduction	57

4.2. Intentions	58
4.3. Project Development	59
4.3.1 Starting Point	59
4.3.2 First Tests and Technique Explorations	60
4.3.2.1 Datamosh	60
4.3.2.2 Pixel Sorting	61
4.3.2.3 Optic Flow	62
4.3.2.4 Pixel Array	63
4.3.3 Recordings - Sound and Video	66
4.3.4 Selection and Composition	69
4.3.5 Completion	73
4.3.5.1 Technical Visit	73
4.3.5.2 Completion	74
4.4. Implementation	75
4.5 Installation View	77
4.6 <i>Evoking a Simulated Past</i> : a critical view	80
4.7 Results and Discussion	82
5. Conclusions	83
5.1 Summary	83
5.2 Fulfillment of Objectives	84
5.3 Future Work	84
References	85
Annexes	94

List of Figures

Figure 1: Human Brain Anatomy	8
Figure 2: Skull discovered in Jericho, Palestine, dated between 2200 and 2000 BC.	9
Figure 3: The limbic system.	12
Figure 4: Vannevar Bush's Memex.	35
Figure 5: MyLifeBits.	35
Figure 6: Memory Association Machine (Ben Bogart)	44
Figure 7: Pleasant Places (Davide Quayola)	45
Figure 8: Deep Meditations: A Brief History of Almost Everything (Memo Atken)	46
Figure 9: Melting Memories (Refik Anadol)	48
Figure 10: Neural Zoo (Sofia Crespo)	49
Figure 11: Of Ideal (Pierre Huyghe)	50
Figure 12: Power Plants (Hito Steyerl)	52
Figure 13: Phase Shifting Index (Jeremy Shaw)	53
Figure 14: Regions of Interest (Karen ann Donnachie & Andy Simionato)	54
Figure 15: <i>War and the End of Empathy</i> , Installation View	56
Figure 16: <i>War and the End of Empathy</i> , Installation View	56
Figure 17: Stills from the first video tests using datamosh.	61
Figure 18: Stills from the first video tests using datamosh.	61
Figure 19: Stills from Processing running a pixel sorting algorithm.	62
Figure 20: Still from a video using an optic flow algorithm in Processing	63
Figure 21: Stills from a video collage.	64
Figure 22: Stills from a video collage.	64
Figure 23: Stills of video tests with a pixel array in Processing.	65
Figure 24: Stills of video tests with a pixel array in Processing.	65
Figure 25: Stills from recorded videos in Porto.	67
Figure 26: Stills from recorded videos in Porto.	67
Figure 27: Stills from recorded videos in Ofir.	67
Figure 28: Stills from recorded videos in Ofir.	67
Figure 29: <i>Terrain Vague</i> , 35mm black and white film.	67

Figure 30: <i>Terrain Vague</i> , 35mm black and white film.	68
Figure 31: Still of video from the margin of Douro river with the background video from river waves.	69
Figure 32: Still of the same video but now with the background video from a face.	69
Figure 33: Still of video with two overlapping faces.	70
Figure 34: Stills from the same scenario recorded on different days.	71
Figure 35: Stills from the same scenario recorded on different days.	71
Figure 36: Stills from the previous videos in Processing.	71
Figure 37: Stills from the previous videos in Processing.	71
Figure 38: Video stills.	71
Figure 39: Video stills.	71
Figure 40: Video stills.	72
Figure 41: Video stills.	72
Figure 42: Installation drawing	73
Figure 43: Assigned room in gnration.	73
Figure 44: Stills from the same moment of the sequence but with different background videos.	73
Figure 45: Stills from the same moment of the sequence but with different background videos.	73
Figure 46: Stills from the same moment of the sequence but with different background videos.	74
Figure 47: Stills from the same moment of the sequence but with different background videos.	74
Figure 48: Projection screen placed in the room.	75
Figure 49: Installation view.	76
Figure 50: Installation view.	77
Figure 51: Installation view.	77
Figure 52: Installation view.	78
Figure 53: Installation view.	78
Figure 54: Installation view.	79
Figure 55: Poster used for the communication of the installation.	94
Figure 56: Poster used for the communication of the installation.	94
Figure 57: Gallery guide	95
Figure 58: Evoking a Simulated Past website	96
Figure 59: Evoking a Simulated Past website	96
Figure 60: Evoking a Simulated Past website	96

Abbreviations

A.D.H.D	Attention Deficit Hyperactivity Disorder
CT	Computed Tomography
fMRI	Functional Magnetic Resonance Imaging
LTP	Long Term Potentiation
GANs	Generative Adversarial Networks
IBI	International Brain Initiative
MRI	Magnetic Resonance Imaging
PET	Positron Emission Tomography

1. Introduction

1.1 Context and Motivation

Memory is one of the most important characteristics of animals and humans. Memory shapes our behaviour and personality and allows us to create relationships with other people and live in society. Without memory we would not even be able to walk (Herculano-Houzel 2020).

Humans always look for ways to improve and enhance their abilities and capacities. Enhanced memory is a goal of humans that has been getting more attention in the past decades. The increase of demand and supply of memory supplements is one example (Davis 2019). Stimulants like Adderall, prescribed for children and adults diagnosed with attention-deficit hyperactivity disorder (ADHD) are now seen as cognitive enhancers and are being more used by students to become higher-functioning (Talbot 2009).

In the twenty-first century human memory cannot be separated from digital technology. We constantly store records of our daily experiences outside of ourselves, in phones and computers. It is estimated that in 2020 every person produced an average 1.7 MB of data per second (Domo 2018), which corresponds to 146.88 GB a day. According to Viktor Mayer-Schonberger (2011) technology brought us the promise of a “perfect memory”, by storing everything of our daily experiences we are unable to forget. On the other hand, the fast-paced environment we live in has implications, our ability to concentrate is gradually fading away which impairs processes of memory formation.

The evolution of technology has been very close to human evolution. Humans have always changed the world according to their needs, we are starting to change the paradigm as we are changing ourselves according to the world (Harbisson 2020).

Introduction

1.2 Problem(s) and Research Goals

The goal of having an enhanced memory is very present in our society, we usually wish to remember instead of forgetting. Contemporary technologies – such as external memory aids – helped us fulfill this goal, but we are starting to have a full picture of its consequences in human memory. This project focuses on human memory processes and on the impact of technology in them.

We propose to develop a multimedia installation, and a critical essay to foster the questioning about the impact of technology and manipulation of the individual memory. For this, we will start by researching the human brain, human memory and its relationship with emotions; how we developed human memory extensions and how technology changed us and our culture; and finally, the impact of technologies on human memory processes.

1.3 Methodology

The methodology adopted in this dissertation will be *Practice-based Research*, where a creative artifact is the basis of the contribution to knowledge (Candy 2006). This indicates that the main contribution to knowledge will be based on practice and its outcomes, through the production of an artwork. The main stages of this dissertation will be research, experimentation and reflection.

1.4 Document Structure

This document consists of three main chapters. The first is the literature review, where some concepts are studied; the second is the state of the art, with an analysis of a selection of artworks and multimedia installations; and the third describes the production process of the multimedia installation, from its idealization to its implementation.

The literature review is composed of two subchapters, *Human Memory* and *Artificial Memory*. The first subchapter focuses on how the human brain works; the importance of memory for human evolution; and the brain subsystems involved in memory processes such as

Introduction

formation, consolidation and recollection of memories; and the role of emotions. The second subchapter will address artificial memory, and everything humans keep outside of themselves; how humans through centuries have created devices and mechanisms to extend their memory; some cultural changes after World War II and the fast development of technology and ubiquitous computing; possible consequences of the fast and easy access to almost all the information of the world through our small devices; and the importance of forgetting.

The second chapter consists of a selection of artworks and multimedia installations that explore questions related to the human brain, to human memory processes such as recollection.

The third chapter is a detailed description of the production process of the video and sound installation, as well as how the concepts studied in the first and second chapters contributed to its idealization.

2 Literature Review

2.1 Human Memory

This chapter is an introduction to the memory processes that will be explored in the artistic project. Here we identify important concepts related to the working of mind and brain, from synapses to brain regions, starting by the evolution of the human brain and the role of memory for the brain's development. We discuss the making of memories and address the relation between memory and emotions, with a focus on the role of emotions in the formation of long-lasting memories and possible faults.

2.1.1 The Human Brain – Evolutionary Context

“In just nine months we go from 1 to 100 billion neurons. Brains are probably the most complex structures in the universe. Each human brain contains some hundred billion nerve cells (neurons) - more than ten times the earth's human population.” (Rose 2006)

Life is not a static thing, but a changing process (Rose 2006), and our brain has the ability to adapt and transform itself (Levitin 2020), everytime we learn a new skill our brain rewires itself (Kaku 2020).

Literature Review

The evolution of the brain can be divided by three main stages: first the reptilian brain, which is related to understanding our position in space; second the emotional brain (limbic system), related to group behaviour; and finally, the thinking brain (neocortex), responsible for simulating and anticipating the future, and assign meaning to things and events (Kaku 2020). The neocortex is the most recent change in brain anatomy and is what distinguishes us from other animals. It made it possible for us to invent the wheel, to build cities, and to make music and art (Herculano-Houzel 2020).

Humans are social beings, like other primates we live in groups, however, the neocortex allows us to create complex social structures with norms and values (Herculano-Houzel 2020). The development of the neocortex was possible due to energy consumption. It is estimated that our brain consumes about 20% of the total energy used by the body (Fonseca-Azevedo 2012). The ability of humans to cook was found to have a major impact in the development in the brain's anatomy. If we only ate raw food, we would need to spend 9 hours per day eating (Herculano-Houzel 2020). Cooked food bought us time, and time began to be used not only for our survival but also to create relationships and live in society.

Minds deal with meanings imposed by their “hand-wired” ontogenesis, and by the historical personal development of the individual and the society and culture in which that individual is embedded. (Rose 2006)

2.1.2 Memory as an Essential Role for Human Evolution

“We are, after all, our memories. It is our memory that enables us to value everything else we possess... Our memory provides us with an autobiographical record and enables us to understand and react appropriately to changing experiences. Memory is the glue for our existence.” (McGaugh 2003)

All organisms with long-term memory are oriented towards the future (Klein et al. 2010).

Literature Review

The development of the neocortex along with memory allowed us to make decisions and predict the future (Kaku 2020). Based on past experiences, memory allows us to look at a specific event and draw conclusions about the outcome of that event, if it was negative probably, we won't repeat, and if it was positive, we will repeat it. Throughout human evolution, we learned to avoid dangerous situations and seek rewarding ones. This process of learning results in memory, and our brain is constantly learning. Although memories aren't totally accurate, we can strongly trust them, otherwise we would live with constant chaos (McGaugh 2003).

2.1.3 How does our brain work?

The human brain is a complex system (Parnavelas 1998), it coordinates the functioning of all our body, it allows us to walk, to think and to feel things physically and emotionally (Damásio 1995). But how does the human brain work? What happens in this organ? To answer these questions, we propose starting with the basic structure capable of storing information - synapses - and then identify different regions and brain systems. Finally, we address the importance of neuroimaging for the study and understanding of the human brain.

2.1.4 Brain Networks.

The human brain has around 100 thousand million neurons that constantly communicate with each other through chemical and electrical signalling (Parnavelas 1998). Information is transferred from one neuron to another at specialized points of contact, the synapses (Robins 1998). Each of the 100 billion neurons in the brain may have anywhere from a few thousand up to 100,000 synapses (Parnavelas 1998).

Literature Review

The signal generated by a neuron and transported along its axon¹ takes the form of an electrical impulse carried by the charged ions of sodium and potassium but is transmitted chemically from cell to cell across the synapse, in the form of molecules called neurotransmitters (Robins 1998).

Synapses play a central role in memory formation. When neurotransmitters are activated and both neurons are active at the same time the connection between them is strengthened resulting in storage of information. The continuous strengthening of the synaptic activity based on recent patterns is called long-term potentiation (LTP) (Squire, 1998).

2.1.5 Brain Systems.

“Memory is not a single faculty of the mind but is composed of multiple separate systems. Different kinds of memory have different brain organizations and depend on different brain systems.” (Squire 1998)

The human brain coordinates the functioning of all of the body. Each human ability depends on specific brain systems or on the interaction of multiple systems.

The human brain consists of cerebrum, brainstem, and the cerebellum. The brainstem is responsible for basic functions such as breathing, digestion and control of the heart. The cerebellum is responsible for balance and motor coordination. The cerebrum is the largest part and consists of an outline layer of grey matter covering the white matter. The cerebrum has two hemispheres, and each hemisphere has four lobes (Fig.1). Besides the brain is in constant activity the two hemispheres have different functions. The left hemisphere tends to look at details and to dominate focussed and local attention, while the right hemisphere tends to dominate broad and flexible attention (McGilchrist 2010).

¹ An axon, also called nerve fibre, is responsible for carrying nerve impulses away from the cell body (Britannica n.d.).

Literature Review

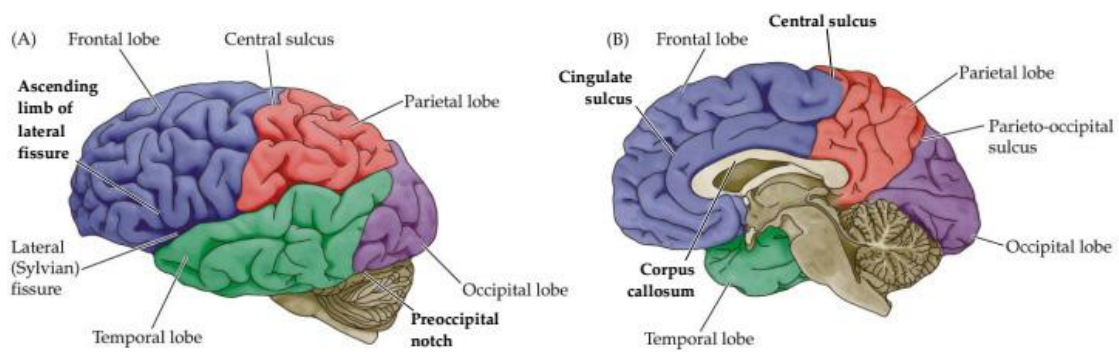


Fig.1: Human Brain Anatomy, retrieved from <https://brain.oit.duke.edu/lab01/lab01.html>

In the context of this research, we will focus on the temporal lobe. The temporal lobe is responsible for memory formation (explicit and implicit) and consists of systems such as the hippocampus and the amygdala (Squire 1998). This system encodes, stores and retrieves memories, with emotional modulation (Robins 1998).

2.1.6 How Neuroimaging helped us understand the Brain.

Throughout history there have been cases of people with brain pathologies, and of people that for some unknown reason changed their behaviours. One of the better known cases was the one of Phineas Gage, a 25-year-old railroad construction foreman that, in 1848, suffered a brain injury caused by an explosion. A large iron rod crossed his skull destroying most of his frontal lobe. Although highly unlikely, this man survived and after recovering from the injury he changed his behaviour profoundly, he developed a new personality, more arrogant, impatient and often using inappropriate language, despite being able to walk and talk. Phineas Gage was no longer Phineas Gage, his friends no longer recognized him or identified with his new personality (Damásio 1995). This case strongly influenced the study of the mind and the brain, it showed that certain brain systems were more involved in reasoning and its social and personal areas than others systems (Damásio 1995).

Literature Review

“Most of the available information about the anatomical structures and connections involved in memory functions has come from analysis of the effects of lesions in memory-impaired patients” (Squire 1998). In the following sections some studies involving cases will be addressed for a better understanding of specific memory functions of processes.

The human brain is an organ that has always been fascinating to us and there are still a lot of questions needing to be answered. The study of the brain is quite old, we can go back to the period of the Neolithic, where the first trephinations² were performed (Wickens 2015). One of the first trepanned skulls (Fig.2) was discovered in 1958 in a tomb in Palestine and is dated from between 2200 and 2000 BC. These interventions were performed possibly due to mystical reasons, to remove evil spirits from the head (Wickens 2015).



Fig.2: Skull discovered in Jericho, Palestine, dated between 2200 and 2000 BC.

Retrieved from: <https://wellcomecollection.org/works/va96ydtu>

However, only in the late 19th century it was possible to observe brain activity. In 1880 Angelo Mosso developed a non-invasive technique called human circulation balance, that could measure the redistribution of blood during emotional and intellectual activity (Sandrone et al. 2012). Only 100 years later with Magnetic Resonance Imaging (MRI) and Computed

² Trephination: surgical intervention to make a hole through the skull to the brain's surface (Wellcome Collection, n. d.).

Literature Review

Tomography (CT) was it possible to map the brain in a less harmful way. The problem with these neuroimaging techniques was that they produced static images. Positron Emission Tomography (PET) later appeared as a functional imaging technique, but it involved radioactive substances. In 1990, Seiji Ogawa discovered the functional Magnetic Resonance Imaging (fMRI) with blood-oxygen-level dependent contrast (Ogawa et al. 1990). It became a non-invasive imaging technique that was able to measure brain activity by mapping the blood flow (Matthews et al. 2004). When a certain area of the brain is in use the blood flow in that area increases. Functional Magnetic Resonance Imaging is the most used technique in contemporary studies, making it possible to map changes in brain activity in real time. Due to this neuroimaging technique, it was possible to study changes in brain activity of specific brain regions while forming and recollecting memories (Squire 1998).

More recently, another neuroimaging technique is emerging, optogenetics. Optogenetics uses “light to control and observe the activity of neurons”, often using a laser beam (Favre-Bulle et al. 2015). Optogenetics allows the manipulation of specific neurons in specific brain regions (Silva 2020). One example of this manipulation will be addressed in the last section of this chapter: false memories.

2.1.7 Mapping the Brain

In the last decades we witnessed major scientific developments such as fMRIs and optogenetics, and today we are investing in brain simulations. This section will mention some recent projects that represent next steps for the study of the brain.

The human brain is considered the most complex system in the universe (Rose 2006) and we have been studying it for centuries. However, there’s still a lot that we don’t know, such as how we get a memory when we need it, or how we make a decision (Costa 2020). In the last decade several countries invested in projects and initiatives that study the brain. In December of 2017 the International Brain Initiative (IBI) presented its Declaration of Intent to “speed up progress on “cracking the brain’s code””. This initiative intends to advance neuroscience research by uniting diverse ambitions and by promoting the share and dissemination of knowledge and the collaboration between countries. One of the members of the initiative is the

Literature Review

European project Human Brain Project³, one of the largest research projects in the world with more than 500 researchers. The Human Brain Project aims to tame the human brain by building a research infrastructure to “help advance neuroscience, medicine, computing and brain-inspired technologies”. The research team focuses on “different aspects of the brain organisation” and on the understanding of “mechanisms behind cognition, learning, or plasticity”. The acquired knowledge is later transferred to medical applications and is used to inspire technological progress. Additionally, the project also focuses on the “ethical and societal implications of the advancement of neuroscience”.

Another project with international acknowledgment is the Blue Brain Project⁴, a swiss brain research initiative that aims to establish “simulation neuroscience as a complementary approach alongside experimental, theoretical and clinical neuroscience to understand the brain”. The Blue Brain Project is currently building the “world’s first biologically detailed digital reconstructions and simulations of the mouse brain” and intends to make a digital reconstruction of the human brain by 2028. Henry Markram (2020), the founder of the Blue Brain Project, notes that while we are mapping the brain we are solving some of the fundamental questions about kinds of neurons, how they are organized and how they connect with each other, so we can start to understand higher brain functions such as actions, perception and memory.

2.1.8 Making Memories

“Memory, in a most general sense, is the lasting consequence of an experience; but it is clearly more than that, as the same can be said for sunburn, blisters and calluses. More specifically, memory is the consequence of learning from an experience - that is, the consequence of acquiring new information.” (McGaugh 2003)

Memory plays an important role in shaping our behaviour, our personality and allows us to create relationships and live in society (McGaugh 2003). Memory is a widely studied brain

³ <https://www.humanbrainproject.eu/en/>

⁴ <https://www.epfl.ch/research/domains/bluebrain/>

Literature Review

faculty by different scientific and social areas. Since it plays a major role in the definition of self the following pages address how we form memories.

Memories are not only neural connections, and synaptic connections also aren't necessarily memories (Bliss 1998). Memories are the result of the connection of a specific set of neurons with another specific set of neurons (McGaugh 2003). But how do these synaptic connections turn into representations of past experiences?

2.1.9 How are Memories Formed and Stored?

The formation and consolidation of memories depend on different regions of the brain. In the context of this research, we considered it more relevant to focus on a specific brain system called the limbic system (Fig.3). This system, also called the social brain, is present in the brain of primates and humans and influences behaviour, emotion and memory (Kaku 2020). It is located beneath the medial temporal lobe and it is composed of different structures. The crosses of these structures are involved in the memory of emotional events and structures that govern our behavioural responses. This consideration emphasizes the idea that the various emotions hardly explain a subjective experience such as euphoria or pleasure with the functioning of a single neurotransmitter system (Robins 1998).

Literature Review

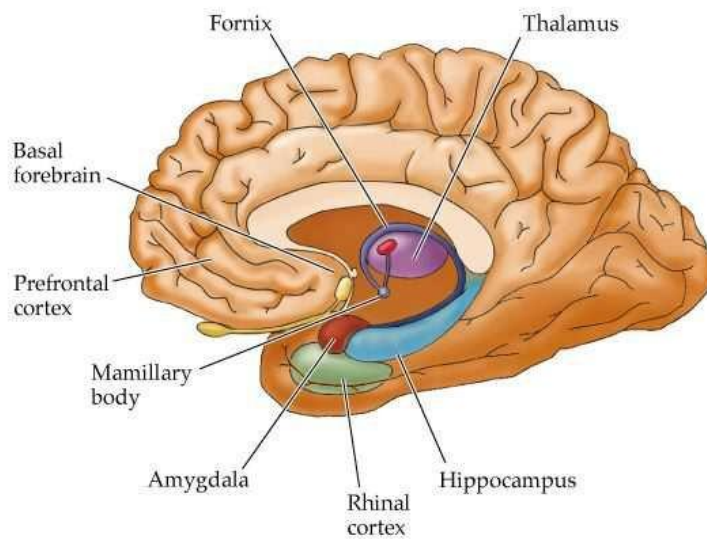


Fig.3: The limbic system. Retrieved from:

https://www.researchgate.net/figure/The-Limbic-System-23_fig9_240799753

Several studies regarding memory and emotion focus on two specific regions of the limbic system: the amygdala and the hippocampus. The amygdala is part of the subcortical areas and it is responsible for the processing of emotions (Phelps 2004). The hippocampus is part of the cortical areas and is necessary for explicit memory. The hippocampus can be thought of as a primary memory system in humans, since it governs the function, we refer to it as memory, that is, the recollection of events at will (Phelps 2004).

These two brain structures play an important role in memory consolidation and recollection and so will be explained next in further detail. Although they can work separately, they also interact in important ways (Zheng et al. 2017).

2.1.9.1 The Amygdala

The amygdala is one of two cluster nuclei that forms the amygdalas, or amygdalae, one is in the left hemisphere, and the other in the right hemisphere. With an almond shape, the amygdala is a brain structure that directly influences aspects of emotional learning and allows

Literature Review

memory operations in other regions, including the hippocampus and prefrontal cortex (LaBar 2006).

Just as both hemispheres have different functionalities (McGilchrist 2010), so do the amygdalas. Despite working together for emotion processing and interpretation the two amygdalas have independent systems. The left amygdala is thought to be responsible for the brain reward system and the right amygdala for negative emotions such as fear and anxiety. The amygdala also triggers the release of stress hormones “which feed back onto memory consolidation and storage sites as well as the amygdala itself to enhance memory over longer time intervals.” (LaBar 2006)

The amygdala modulates memory consolidation by influencing neuroplasticity in other brain regions (Davis 2001). When we are forming a memory, the amygdala responds faster to emotional stimuli than our consciousness. Emotional events have priority due to the influence of the amygdala in perception and attention (Phelps 2004). Memories of significant experiences depend on the amygdala (McGaugh) and are related to its level of activation during the original encoding (Cahill 1996).

1.1.9.2 The Hippocampus

The hippocampus is a seahorse-shaped area of the brain located on both hemispheres. The hippocampus enables long-term consolidation of explicit memory (McGaugh 2003), or, in other words, it is the region of the brain known for turning short-term memories into long-term ones. Explicit information – personal experiences and events – is first retained in the hippocampus and then transferred to the cortex. The hippocampus is a temporary storage site, as memories mature, they become more dependent on other brain regions such as the cortex (Frankland 2005).

The amygdala and the hippocampus are considered independent memory systems but in emotional events they interact in important ways. The amygdala can modulate both the encoding and the storage of hippocampal-dependent memories. The hippocampus, by forming episodic representations of the emotional significance and interpretation of events, can influence the amygdala response when emotional stimuli are encountered (Phelps 2004). Once again, memory is a function of the brain that is too complex to rely only on one system, so it depends on the interaction of multiple systems.

2.1.10 How do we encode, store and recollect memories?

In life, we are constantly going through experiences that are later stored and recalled in our brains. There are events that mark us in such a way that we remember throughout life, and others we forget a few moments later.

When we experience or learn something, we are acquiring new information that needs to be stored. From the moment we perceive a situation or an object with our senses (through vision, touch, etc.) to the moment we remember that same situation, memory goes through different stages and processes. Memory is first encoded, stored and then retrieved, we encode new information, and we can recall the same events several times (Phelps 2004). The act of remembering the same events can sometimes suffer changes and result in false memories (McGaugh 2003). False memories will be discussed further ahead but for now we will try to clarify the three stages of memory.

2.1.10.1 Encoding and Consolidating

“The first stage of memory is encoding, when a stimulus is encountered for the first time. Although several factors can influence how well a stimulus is encoded, the ability to perceive and attend to the stimulus is a primary factor.” (Phelps 2004)

The hippocampus is normally active when processing the external environment. However, when new information matches a previously stored memory, the prefrontal cortex activity “inhibits hippocampal activity by either direct or indirect connections to prevent encoding of redundant information” (Frankland 2005). This process prevents the encoding of the same memory.

The second stage of memory formation is consolidation, after being encoded memories must be classified, organized and moved for other brain regions. After encoding, there is a

Literature Review

period in which these memories are fragile and can be erased or damaged. Usually, after a cerebral injury⁵, recent memory loss is induced, which shows that recent memories are fragile (McGaugh 2000). “It takes time for these memories to become more or less “set”, at which point their retrieval is less dependent on the hippocampus” (Phelps 2004). The process of transferring memories from hippocampal to non-hippocampal stores is called consolidation (Bliss 1998).

To understand better memory consolidation and the role of the hippocampus let's take the case of the patient H.M. Henry Molaison, an American man with a severe form of epilepsy. In 1953 he was subjected to a brain surgery to remove a section of the brain with about 5cm long of the medial temporal lobes (including the hippocampus) in both hemispheres. His seizures decreased but he developed anterograde amnesia, a condition that unables new memories formation (Squire 1998). H.M. remembered quite well everything from its life until 1953 but the ability to form new explicit memories was impaired (Squire 1998). “This impairment included an inability to form lasting memories of events (episodic memory) or to acquire new general knowledge or facts normally (semantic memory).” (Frankland, 2005) The case of H.M. strongly influenced the study of memory formation and memory organization. In the 1970 the Neuroscientist David Marr proposed that the hippocampus is a temporary memory storage region, it stores the day's events and experiences before they are transferred to other brain regions such as the cortex for reorganization. The hippocampus is considered a fast learner as it stores very rapidly the day's memories, but in order to avoid the replacement of these memories by more recent ones the hippocampus needs to transfer them to the cortex.

“Consolidation involves reorganization at both the synaptic and system levels.” (Frankland 2005) Synaptic consolidation refers to synaptic stabilization in synaptic circuits and it can be complete within hours. System consolidation is related to a gradual reorganization of brain regions and it is a long time-dependent process. There is still no certainty regarding the time memories need to be consolidated, studies indicate that this process occurs within 24 hours after being encoded, but they can consolidate over months or years (Roesler 2010).

⁵ Traumatic Brain Injury (TBI), is an injury that affects brain functioning (CDC n.d.), usually caused by external force.

Literature Review

2.1.10.2 Recollecting

Recollection is the last stage of memory formation. Sometimes we recollect memories without any effort, other times it is triggered by a photograph, a sound or a smell. Recollection can be defined as episodic retrieval that is accompanied by recovery of specific contextual details about a past event (LaBar 2006), or, in other words it refers to the act most known as remembering. When we make the representation in our brain of yesterday's dinner we are remembering, or recollecting. Each time we remember something we are making reconstructions of a past experience. Sometimes there are details that disappear and others that added, however, highly emotionally significant experiences are less susceptible to the many influences of the reconstructive act of remembering (McGaugh 2003). "Emotional memories are retrieved with an accompanying sense of recollection rather than familiarity, an effect that depends on co-activation of the amygdala and hippocampus" (LaBar 2006).

The prefrontal cortex is thought to be important in the retrieval of stored memories. Different regions of the prefrontal cortex are reciprocally connected to sensory, motor and limbic cortices, and are preferably situated to integrate and synthesize information from several different sources (Frankland 2005). This potential for integration indicates that the ability of the prefrontal cortex to process remote memories can correspond to that of the hippocampus to process recent memories (Frankland 2005).

"Emotion has powerful influences on learning and memory that involve multiple brain systems engaged at different stages of information processing. Studies of declarative emotional memory show how frontotemporal brain regions act conjointly to promote the retention of emotionally arousing events and retrieve them from long-term stores. "(LaBar 2006)

2.1.11 Episodic and autobiographical memory

When we remember the capital of Spain, the end of the movie we saw yesterday, the day we learned to ride a bike, or the moment when our parents told us our grandfather passed away, we are speaking of specific moments of our lives. These moments are part of what is called explicit or declarative memory which is a type of long-term memory that benefits from repetition and requires continuous and gradual learning. Explicit memory refers to conscious recollection of facts and events and depends on limbic structures, implicit memory refers to a heterogeneous collection of abilities. In the case of implicit memory, experience alters behaviour non-consciously without providing access to any memory content (Squire 1998).

Explicit memory is divided in two major types: episodic and semantic. Episodic memory is the recollection of specific events of life and is related to dates, places and experienced emotions, while semantic memory refers to the recollection of facts and general knowledge about the world (Lum et al. 2012).

The combination of episodic and semantic memory results in autobiographical memory (Williams et al. 2008), and is what determines us as individuals. It is related to our social interactions and plays a major role in defining our identity. Autobiographical memory is a collection of individual experiences and events that influences our future decisions and actions (Williams et al. 2008).

Sometimes, after a severe brain injury, the other hemisphere is forced to develop and enhance its functions (McGaugh 2020). This event can result in *savant syndrome*, a condition where a person's abilities change dramatically and exceed the average, especially in the fields of music, art, mathematics and calendar calculations, and mechanical or spatial skills (Treffert 2009). These skills are accompanied by a remarkable memory (Treffert 2009). One example is the case of Jill Price, a woman who from the age of 12 or 13 remembers everything that happened nationally and internationally. This specific condition is called *Highly Superior Autobiographical Memory*, each person remembers each day of its life as if it had happened the day before (McGaugh 2020). Either through her own experience or through things she watched on the television or heard on the radio, she can remember what she ate on the 22nd of April of 1990 or what happened in Japan. Frequently we get fascinated with such conditions, we think by remembering everything we could improve our capacities and excel more easily. However, this can also be negative for our life. Jill (2020) notes that when she was at school it was

Literature Review

difficult for her to study and concentrate, or more recently, even years after her husband's death she feels like such loss occurred the day before. "The past becomes very traumatic if you remember every single thing." (Markram 2020). "We need to forget in order to remember the important things." (McGaugh 2020)

Forgetting is usually seen as a flaw or weakness, but sometimes the ability to forget is a virtue. Memory selection allows us to keep significant memories and forget the others (McGaugh 2003). Remembering everything could result in chaos. In the next chapter, the importance of forgetting will be revisited but for now we will discuss the role of emotions in consolidating and recollecting memories.

2.1.12 Memory and Emotions

The word "emotion" doesn't have a common definition but is often used to describe a mental or physical state. The origin of the word comes from the Latin *emovere*, which means "out" "move" (Oxford Learner's Dictionary 2021). According to the James-Lange theory of emotions, first proposed by James in the 1880s and later developed by Lange, states that the "immediate, primary cause of an emotion is physical", external stimuli induce body changes and physiological processes that consequently "evoke certain feelings in the conscious mind" (Coleman 2011). For James, emotions as fear wouldn't occur without the sensation of acceleration of the heart rhythm, weakened legs, or tightness in the stomach (Damásio 1995).

More recent definitions state that "emotion is the combination of a mental assessment process, simple or complex, with dispositional responses to that process, mostly directed at the body itself, resulting in an emotional state of the body, but also directed at the brain itself, resulting in additional mental changes" (Damásio 1995). And according to LeDoux (2012) "Introspections from personal subjective experiences tell us that some mental states have a certain "feeling" associated with them and others do not. Those states that humans associate with feelings are often called emotions".

Literature Review

Emotions have not always received much attention, but more and more emotions have proved to be fundamental for the understanding of human beings, particularly to the study of human interactions and human memory. Emotions allow us to think of possible outcomes and to choose which is best for us (Kaku 2020). “Emotion-memory interactions occur at various stages of information processing, from the initial encoding and consolidation of memory traces to their long-term retrieval”, and memories with emotional significance are retrieved more successfully than ones with more neutral stimuli (LaBar 2006).

Up to this point we saw how the brain works, the role of memory for human evolution, and how different brain systems are involved in memory encoding, consolidation and recollection. We also know that emotionally significant experiences create strong memories. To finish this first chapter, we now focus on the relation between memory and emotions, how we create memorable moments and possible flaws, such as false memories.

2.1.12.1 Primary/Basic Emotions

Since our birth, we are programmed to react to different characteristics of stimuli (Damásio 1995). When we are faced with a big animal or a silhouette in the dark, we experience differences in our body such as the acceleration of cardiac rate, tightness of stomach or difficulty breathing. Size, certain sounds, and types of movement are characteristics processed by the brain’s limbic system, more specifically, the amygdala. “Its neuronal nuclei have a representation of dispositions that triggers the activation of a state of the body, characteristic of the emotion of fear and that alters the cognitive processing in order to correspond to that state of fear.” (Damásio 1995)

In a very simple way primary emotions are fast reactions to external events. According to Paul Ekman (1999) there are six primary emotions: fear, happiness, sadness, anger, disgust and surprise. However, the list was later increased, with the introduction of amusement, contempt, contentment, embarrassment, excitement, guilt, pride in achievement, relief, satisfaction, sensory pleasure, and shame (Prinz 2004).

Literature Review

All these emotions depend on the activation of the amygdala, after a given stimuli the amygdala is activated and different responses are followed, internal, muscular, visceral, and responses for neurotransmitters nuclei and hypothalamus (Damásio 1995).

However, these emotions represent only a percentage of all the emotional behaviour. Later in life, when we start to develop connections between object categories and life situations or experiences, the limbic system itself is not capable of supporting secondary emotions and needs the intervention of other brain systems (Damásio 1995).

2.1.12.2 Secondary Emotions

Secondary emotions are complex reactions to external events, they persist after the event and they afford the ability to reason about current events. One difference between primary and secondary emotions is related to speed of processing, secondary emotions are slower to process than primary. When we think of a close friend that we haven't seen in a while we feel an emotion, and when we picture our reunion, we can experience differences in our body. These mental images that surge in our brain induce changes in our body state, such as blushing or feeling our heart beating faster. Whether positive or negative there are changes in the parameters related to the functioning of our body.

Emotions can be seen as the set of changes in the body induced by electrical and chemical responses under the control of the brain, which is the translation of thoughts directed to an entity or an event. Emotions are simple or complex mental responses to external stimuli. In its majority these responses are directed to the body, resulting in a physical emotional state, but they are also directed to the brain, resulting in additional mental changes (Damásio 1995).

2.1.13 The Making of Memorable Moments

Emotionally significant experiences create strong memories (McGaugh 2003). In life, we tend to remember more easily events associated with a high level of happiness, sadness or fear. As mentioned in the previous section these are examples of basic emotions, they are fast reactions to external stimuli and can evolve later to complex reactions.

There are moments that will remain in our memory for years. To make this idea clearer we can look at the example of phobias.

“An experience very early in life can affect subsequent behaviour by causing a phobia.” (Squire 1998) Phobias create a particular behavioural disposition towards an object or animal and it can be explained by the fact that long-term memory only develops after the first two years of life. “The persistence of the phobia does not imply that a record of the event itself has also persisted” (Squire 1998), what remains is the change in behaviour.

Phobias are one example of memorable moments but there are others such as *flashbulb memories*. Roger Brown and James Kulik (1977) coined the term flashbulb memories to refer to the circumstances in which one first learned of a very surprising and consequential (or emotionally arousing) event. These memories are long-lasting and significant experiences shared by many (McGaugh 2003). If we look at the attack on the World Trade Center in 2001 it was experienced not by the thousands of people working in the towers and near them, but it was also experienced worldwide with live broadcast on the radio and television. Significant events such as the attack of the World Trade Center last over time. Sometimes the memories are incomplete, but people tend to remember specific details that are long-lasting. Subjects’ personal reactions to the event, including emotional responses, appear to play a major role in influencing the strength of the memories (McGaugh 2003).

Although flashbulb memories are shared by many people and last for months or years it doesn't necessarily mean that they are accurate, like other memories they can weaken over time. Our constant recollection of these events can lead to changes in the details, and consequently to changes in memories (McGaugh 2003). This last idea will be discussed in the next section, false memories.

2.1.14 False Memories

“Emotion provides no guarantee of permanent or perfectly accurate recall - emotional memories will contain errors...”. (McGaugh 2003)

False memories can result from small errors in memory encoding, and they can be associated with trauma or sleep deprivation. When we store incomplete memories, we tend to complete them in later recollections. “It doesn’t matter how sure we are, our brain is only guessing, and it can be wrong” (Kaku 2020). Also, there can occur errors in the transition from short to long-term memory. Almost all of us have false memories and almost all of them are harmless. False memories can be individual or collective. The Mandela Effect is an example of collective false memory that “typically refers to pop culture or current event references”. The term was first used regarding a mistake in Nelson Mandela’s death. Thousands of people believed Mandela had died several times from the 1980s to the 2000s, when in fact, his death was in 2013 (Loving 2019). To address individual false memories let’s first look at the example of *the broken telephone* game. In this game a person tells the other a sentence, that person tells the other the same sentence and so on. In the end, the last person hearing the sentence has to say it out loud and often the sentence is completely different in structure, grammar, sense, and punctuation. When we tell a story, we tend to add new details. With memories the same happens, every time we remember a specific experience, we make a reconstruction of that experience. “Remembering is usually, at least to some degree, creative mis-remembering.” (McGaugh 2003). Emotional significant events tend to be remembered accurately, they are less susceptible to changes, but even those memories can fade over time. Only memories of traumatic experiences prevail for years, “although most memories fade over time, traumatic memories may last a lifetime.” (McGaugh 2003)

The process of remembering a memory is not only retrieving a specific event of experience. It is also associated with semantic knowledge. Our childhood memories can sometimes be false. We may have a memory of our 4th anniversary, but these memories usually are constructions of our brain from things our parents told us and photographs we saw, we make constant associations.

Literature Review

Weak memories are easily influenced, they can rapidly become false memories. On the other hand, strong memories are less likely to suffer changes and are more resistant to being forgotten. Our memory is complex, and it isn't perfect.

In the past few years we have witnessed some scientific advances regarding implanted memories. One of the better known cases was the experiment led by Steve Ramirez and Xu Liu, who successfully implanted a false memory on a mouse brain. In the paper *Creating a False Memory in the Hippocampus* (2013), the two researchers note that it is possible to generate an “internally represented and behaviorally expressed fear memory” through “artificial means”. A mouse was placed in a box and instead of moving around the mouse froze, as if he had taken a shock. But it wasn't a shock, it was a false memory of a shock optogenetically implanted in the hippocampus.

Another case is memory implants that can boost our memory. Ezzyat et. al (2018) conducted a study in 25 patients with epilepsy where the application of targeted stimulation in the lateral temporal cortex rescued periods of poor memory encoding. The results suggested that such systems may “provide a therapeutic approach for treating memory dysfunction” (Ezzyat et. al 2018).

According to Carey (2018) the researchers are “currently in discussions to commercialize the technology”, and “its broad application is yet unknown”. Experts cautioned that the possible misuse of any memory booster can be enormous (Carey 2018). For example, A.D.H.D drugs, such as Adderall or Ritalin are widely being used by healthy students to enhance memory and attention, but prolonged use can result in sleep difficulties, depression, anxiety, paranoia, among others (American Addiction Center 2021).

2.2 Artificial Memory

2.2.1 From internal memory to external memory: Historical context

“ Since the beginning of time, forgetting has been the norm and remembering the exception... because of digital technology, society’s ability to forget has become suspended, replaced by perfect memory”. (Mayer-Schonberger 2011)

In his book *Delete* (2011), Viktor Mayer-Schonberger looks at the importance of forgetting, since technology brought us the ability to remember today is easier to remember than to forget. The easy and cheap storage encourages people “to keep more and more of their memories in digital form” (Czerwinski et al. 2006). Current research in Deep Neural Networks is focused on overcoming catastrophic forgetting, a feature in which the algorithm tends to forget previous tasks when learning new ones (Kirkpatrick 2017).

Forgetting is often seen as a flaw, but forgetting is as important as remembering (McGaugh 2003). Remembering everything might make our lives unlivable (Roberts 2016). Through the millennia humans sought for ways to enhance their memory and realized that external mechanisms and devices were an essential aid. Language was the first way to do it, since it allowed us to share knowledge and preserve memories.

“We are now in the position to invent a new human reality, just as at the end of the Neolithic period mankind evolved by inventing agriculture, the town, the state and writing”, however this present change is happening much faster (Lévy 2005).

In this chapter we explore how we have been trying to expand our own memory through external sources. We start by an historical context of the first ways we found to share knowledge and enhance our memory. We explore how digital technology is changing our lives and culture,

Literature Review

then we discuss the idea of a global brain, how we managed to implement it and possible consequences that may arise. To close the chapter we discuss the importance of forgetting.

2.2.1.1 Human Brain Evolution and Knowledge Sharing

The human brain evolved in parallel with technology (McGilchrist 2020), “human biological and cultural evolution are closely linked to technological innovations” (Ambrose 2001).

“Stone tool technology, robust australopithecines, and the genus *Homo*” appeared almost simultaneously 2.5 million years ago (Ambrose 2001). The technological evolution was accompanied by increased brain size, population size, and geographical range (Ambrose 2001).

Larger mammals tend to have larger brains, but somehow “humans are the primates with the largest brain and number of neurons, but not the largest body mass” (Fonseca-Azevedo 2012). As noted in the first chapter, the human brain suffered a major change when *Homo erectus* shifted from great apes to a cooked diet. Without the need to spend most available hours of the day eating “the combination of newly freed time and a large number of brain neurons affordable on a cooked diet” may have been a major force to the rapid increase in brain size in human evolution (Fonseca-Azevedo 2012). Cooking also contributed to increasing the time available for “social and more cognitive demanding activities”, which in turn would also increase the number of neurons (Fonseca-Azevedo and Herculano Houzel 2012). The increase in brain size brought the development of the most recent part in the human brain, the neocortex, or the *thinking brain*, since it allows us to predict and simulate the future (Kaku 2020) and thus make decisions for what we think is the best for us. This event is related to the evolution of memory, we make decisions based on past experiences (Klein et al. 2010).

“For millennia, humans have tried to improve their capacity to remember, to increase the amount of information they can store and successfully recall...

Remembering helps us cope with our lives. Every day we are confronted with choices without knowing exactly what these choices will entail.” (Mayer-Schonberger 2011)

Literature Review

Memory is one of the fundamental capacities for human survival, it is essential that we preserve records of our experiences (McGaugh 2003). There's considerable adaptive value in being able to remember significant events. It helps us to avoid dangerous and disgusting situations and to create future successes based on memories of successful events (McGaugh 2003).

Our ancestors have long appreciated how the ability to remember, a superior information recall, such as remembering directions and the movements of the sun, could improve one's chance of survival (Mayer-Schonberger 2011). Human memory has always had limitations, one was the ability to pass knowledge from one person to another. An expert in something could only pass his or her knowledge through the training of another human. Probably the only way for humans to preserve some of their existence was by having children, and thus passing genes (Mayer-Schonberger 2011).

As we saw, memory is essential for human evolution, it allows us to make decisions, create social connections and to pass on knowledge between generations. But if memories are only in our minds it is more difficult to do it, so humans developed ways to outsource memories. Communication and language were the first ways to do so. In the next sections we will focus on the first manifestations of external memory: writing and painting.

2.2.1.2 First manifestations of external memory and knowledge sharing

“Language, as our ancestors quickly discovered, is superbly powerful ... Language unlocked the potential of individual human memory” (Mayer-Schonberger 2011).

Language was the superior way to pass information from one person to another, language allowed us to know and learn without the need to experience it. Language enables humans to preserve memory by passing it from one generation to the next. It also helps to

Literature Review

realize history and sense time, “to understand a past beyond their own, and to contribute to it” (Mayer-Schonberger 2011).

When humans communicate with each other, experiences can be shared. As language eased this communication our ancestors could pursue abstract thinking and develop general ideas about life and nature (Mayer-Schonberger 2011). Without communication our memories can get lost, sharing keeps memories alive. The shared knowledge allowed humans to enhance their individual cognition and thus create a complex culture (Culotta 2010). When we recall a memory, ideas and details about a past experience reemerge in our minds (LaBar 2006). But, as we saw in the first chapter this recollection can not always be accurate, memories can fade over time (McGaugh 2003). Human memory and oral communication may “preserve the central gist of a story, but it’s unlikely that precise details will be maintained over time” (Mayer-Schonberger 2011). If human remembering can be fallible maybe it needs to move from our brains to some external storage device. To facilitate the construction of shared memory humans started to use their own memory with the help of external memory.

Painting is perhaps the oldest manifestation we have in record of external memory, it creates an image of an event, emotion or thought and thus enables remembering. As we saw, emotional significant experiences create strong memories (McGaugh 2003). The oldest known paintings were found in an Indonesian island and date back to at least 45,500 years (Brumm 2021). Cave paintings were a way to communicate between different groups. These paintings often portrayed large animals and it is believed that the represented species and the direction they were facing indicated where these animals could be found.

Many years later paintings were used to chronicle events, linked to supernatural, religious motives and then society’s important events such as wars or natural catastrophes. For example, “Pharaohs and their families hoped paintings would introduce them to the Gods after their deaths”, but paintings were costly, both in time and means, and this is probably how the script was born (Mayer-Schonberger 2011). Trading societies needed a new way to store and retrieve information that wouldn’t be susceptible to alteration (Mayer-Schonberger 2011). Script was a breakthrough for remembering, as writing was established knowledge could be stored outside the human mind and to be recalled with accuracy (Mayer-Schonberger 2011).

2.2.1.3 Sites of storage and transition to the modern world

Writing enabled a new source of power: preserved knowledge. Leaders began to institutionalize collections of writings for their purposes. In the book *Delete* (2011), Viktor Mayer-Schonberger speaks of the Ptolemy, a dynasty of Alexandria. Ptolemy I was a pharaoh of Egypt and created a remarkable collection of externalized memory, the Library of Alexandria. It is believed that at its peak it was the largest library in the world, housing an estimated half million works. Ptolemy I had meticulous and beautiful copies made mainly of Athenian documents; he kept the originals and sent away the copies, because he believed that the copies could introduce errors. Ptolemy's policies make explicit a process that had begun millennia earlier: the desire to have at people's disposal a comprehensive, nearly perfect memory (Mayer-Schonberger 2011). Copying required exclusive scribes due to the specialized training that was costly and time-consuming. Writing continued to spread and libraries continued to flourish but books remained very costly, they were one of a kind.

In the Middle-Ages remembering became more expensive for most people. The Catholic Church became the keeper of knowledge, reading and writing was taught to monks in monasteries (Murray 2009). At that time not even all the kings and queens knew how to read or write. The Church became responsible for deciding which books were to be copied and by whom. The Church was also responsible for the knowledge of the common people. In the porches of churches there were sculpted figures and scenes that could tell stories, all related to Catholicism.

In 1450, a relatively simple invention combined with sociological factors facilitated an important change: Gutenberg's printing press with movable type, allowing the mass production of books. With the printing revolution, states began to emancipate themselves from the Church. But even with the printing press and the Reformation movement, for most people using "books remained an elusive mechanism of enhancing their memory" (Mayer-Schonberger 2011). Only in the beginning of the twentieth century, with social reforms of the working class after years of mass production resulting from the Industrial Revolution, the work hours were reduced, increasing their living standards, the prices of books and newspapers decreased and readership increased. The transition to manual production to machine manufacturing also had an impact in forms of record. In addition to drawing and engraving, photography and cinema were added. Family portraits were one of the broader uses of photography. In the 1980s both recording

Literature Review

machines, using film and later tapes became cheaper and people started to record hours and hours of their lives' events. But a new problem arrived, space for storage and effective retrieval. People started to make albums and fill their shelves, but this was still costly and time-consuming. As Mayer-Schonberger (2011) notes "remembering remained quite a bit harder than forgetting".

2.2.1.4 *Prosthetic Mind*

Humans are beings who, throughout history, have recorded their life in different ways. As seen above, cave paintings, and later, writing and books were the means of record.

Since the beginning of humankind, we have tried to preserve our knowledge and keep our memories, and we have developed different ways and mechanisms to aid us (Mayer-Schonberger 2011). Our brains and cognitive abilities have evolved in parallel with technological improvements. Freud called us prosthetic gods, since we "look for 'palliative measures' and 'auxiliary constructions' to negate the painful limitations of our human condition" (Groes 2016). Groes (2016) speaks of the 21st century as *The Age of The Prosthetic Mind*. We are always looking for ways and tools to extend and enhance our bodies and minds. However, "forgetting has remained just a bit easier and cheaper than remembering", and only recently this is starting to change.

As we noted, language was the first powerful way to remember. Language allowed a new life of signs, culture and technology, and later with writing, language acquired an independent memory (Lévy 2005). "As language passes through the different phases of its evolution, human culture also becomes more powerful, creative, rapid" (Lévy 2005). We are now in another phase of evolution, digital technology and the advent of the internet is changing not only our lives and culture but also our brain and our memory. The next sections explore how and why these technologies are trying to enhance our memory but at the same time are interfering with our own memory.

2.2.2 How Digital Technology changed us and the world

“Things appear to be changing very fast, perhaps too fast.” (Gere 2008). In his book *Digital Culture*, Charlie Gere notes that humans extend and augment the capacity to manipulate their environment “through their technological prostheses, from flint tools through to computers”. He also notes that technology is not a product of human beings but instead a precondition of their existence. Humans and technology have evolved in parallel (McGilchrist 2020). Throughout human evolution we have used our brains differently, “with the shift from oral to written culture in the middle ages, the human mind had to be retrained. Whilst formerly it had to rely on rote learning, it then had to learn how to retrieve archived knowledge via indexing” (Groes 2016). Like in the shift from oral to written culture we now see other shifts occurring, our memory is increasingly becoming collective and shared (Groes 2016). We are now on the verge of a much more rapid new reality, we see a “convergence of life - which is increasingly genetically modified and artificial - and technology - which is increasingly alive and intelligent” (Lévy 2005). “Biological memory is increasingly just one part in the make-up of this distributed cognition, which is aided by non-biological forms of memory” (Groes 2016). The advent of the internet with “sophisticated algorithmic search engines” made it possible to access a large amount of information with just lifting a finger (Sparrow et al. 2011). We now rely more on our “external memory” than our own memory, since we can “Google” almost everything and have quick answers to our questions. “The Internet has become a primary form of external or transactive memory, where information is stored collectively outside ourselves” (Sparrow et al. 2011). However, as we will discuss later in this chapter this can represent an irony, at the same time we have all the information available, we are impairing our biological memory, making us more forgetful.

2.2.2.1. A paradigm shift: World War II and its technological advances

From Ancient Greece to the contemporary era humans used metaphors to help them understand memory, “metaphors have been used to offer models designed to illuminate a process so central to our understanding” (Depper 2016).

Literature Review

The invention of the computer after the 1940s led to changes in our perception of memory (Epstein 2016). Engineers, scientists, mathematicians, linguists and psychologists have been comparing the functioning of the human brain with the functioning of the computer (Epstein 2016). The mathematician John von Neumann, in the second part of his book *The Computer and the Brain* (1958) compares the human brain, which he refers to as a *natural automata*, to the computer, which refers to as *artificial automata*. Von Neumann argues that the nervous system has a “*prima facie* digital character”⁶, and speaks of the nervous pulses as a two-value makers, where the “absence of a pulse” represents a value (the binary digit 0) and the “presence of one” pulse represents the other value (the binary digit 1). Von Neumann further compares human memory with computer machines’ capacity, arguing that the human memory can retain a “certain amount of information” that can “always be converted into an aggregation of binary digits”; and that transistors can be used as “memory elements” like active nerve cells “constitute memories”.

In the 21st century the idea of the human brain as a computer is being criticized, “a computer database and biological memory are not the same things” (Carr 2016). Epstein (2016) notes that we are not born with information, data, rules, software, algorithms, programs, models, processors, symbols, encoders and decoders, and instead with senses, reflexes and learning mechanisms. “Often our metaphors of memory are constrained by an attention to storage and retrieval, when play, emotion, imagination and other aspects are equally important” (Childs 2016). When we consolidate a personal memory we also form associations between that memory and many other memories of facts, experiences and emotions that are already placed in our minds. These unique connections are “indispensable to the development of deep, conceptual knowledge” and are continuously changing as we “learn more and experience more” (Carr 2016). “The essence of personal memory is not the discrete facts or experiences we store in our mind but the endless mingling of those facts and experiences” (Carr 2016).

We are increasingly dependent “on the vast stores of data inside our computers and out on the internet” and we have “begun to blur the distinction between computer memory and biological memory” (Childs 2016).

The invention of the computer resulted in a major shift in our lives, the concept of a computer, with information, wires and networks changed our perspective and how we interact

⁶ *Prima Facie* is a latin expression meaning at first sight, based on what seems to be the truth when first seen or heard

Literature Review

with each other. In the following sections we focus on how the computer shaped our lives in the 21st century and possible future consequences of that. As we saw above, the invention of the computer not only changed our daily life but also our way of thinking. Before exploring these shifts and changes with more detail we first present a brief context of the invention of the first computational machines.

The computer is now a device almost each one of us have in our homes. There's still no consensus on which was the first computer but we know it was invented to solve mathematical problems (Pottenger et al. 2020). At the end of the 19th century, at the peak of the second industrial revolution, and with the vast number of factories there was an urgent need to invent machines capable of making fast calculations. In the 1820s Charles Babbage built a section of the *Difference Engine*, a machine capable of producing mathematical tables, and designed the *Analytical Engine*, a machine that would have been programmable and capable of calculating any formula. Both were considered prototypical computers (Gere 2008). During the Second World War there was also an urgent need to build machines capable of encrypting and decrypting. One of the most famous designed machines, the *Universal Machine*, by Alan Turing was considered to have a major impact on the development of the modern computers since it could, at least in theory, be programmed to undertake any mathematical problem (Gere 2008). A few years later, in the Victoria Manchester University, Manchester Mk1 was built, thought to be one of the first digital computers because of its capacity to store data. The Manchester Mk1 "marks the beginning of the digital age, it is a machine capable of storing data and of being reconfigured to undertake different tasks" (Gere 2008).

2.2.2.2 *A Personal Database for Everything*

In 1945 the Atlantic published the article *As We May Think* by Vannevar Bush. In his article Bush argues that "for years inventions have extended man's physical powers rather than the powers of his mind", and proposes future advances in technology. Bush notes that humans have "built a civilization so complex that he needs to mechanize his records" and that we could

Literature Review

take advantage of forgetting by having the possibility of finding things later if they are considered important. Bush notes that data is stored alphabetically or numerically and that information is found “by tracing it down from subclass to subclass”. He further notes that the human brain doesn’t work the same way, but rather by association. When we have something in mind “it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain” (Bush 1945). More close to the end Bush proposes the creation of “a future device for individual use, which is a sort of mechanized private file and library” (Fig. 4).

“A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory”. (Bush 1945)

Bush further notes that the essential feature of the memex would be associative indexing, tying two different items and creating trails of items. From one item it would be possible to select “immediately and automatically” another. The memex would also have a keyboard so that books could be “consulted with far greater facility than if it were taken from a shelf”, and the users could add comments and notes. Another feature of the *memex* would be the possibility for exchange trails. One memex user could photograph a trail of items and share it with another person to include the trail in his own *memex*.

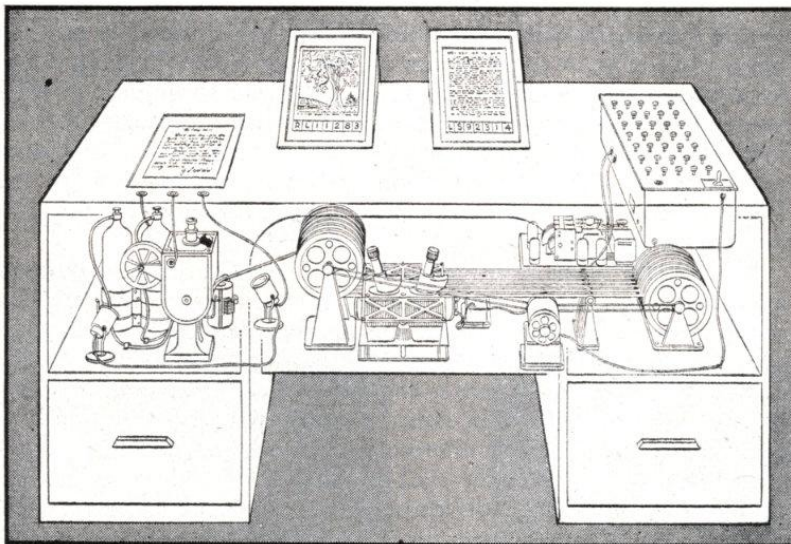
The memex is considered to have influenced computation and technology in the last decades. Jim Gray in his paper *What Next?* (1999) points to twelve research goals for the future, and one of them is the memex. Gray notes that, almost 50 years later, the *memex* vision is almost fulfilled, due to information created online and the books and publications available online.

One particular project that tried to fulfill the *memex* vision was the project entitled MyLifeBits, a “personal database for everything” and a project that could be a “tremendous memory aid” (Gemmell et al. 2006). According to Gemmell et al. (2006) Bush correctly saw the two essential features: “annotation and links” despite not seeing the exact technology to accomplish it.

MyLifeBits (Fig.5) “has at its heart a structured query language (SQL) server database that can store content and metadata for a variety of item types, including contacts, documents, email, events, photos, music and video” (Gemmell et al. 2006). The project was divided in two parts: an experiment in life storage and a software research. The experiment was led by Gordon Bell, who began in 1999 capturing his life digitally (Microsoft n.d.). In 2003 Bell started using

Literature Review

the Microsoft SenseCam, a small camera with a fisheye lens that automatically takes a picture roughly every 20 seconds, which corresponds to 180 photos per hour (Bell 2012). By recording almost every moment of his life Bell intends to give a “glimpse of all our lives in the future” (Sample 2005). Gemmell et al. (2006) describe the project of MyLife Bits as an assistant with “perfect memory” that gives us the feeling of security since the capture is increasingly automatic. However, if we trust all of our memories to the digital we can suffer consequences, for example, as Gemmell et al. (2006) note the “failure of one author’s hard drive” resulted in the loss of “four months of captured Web pages” which represented a “severe emotional blow - perhaps like having one’s memories taken away”.



MEMEX in the form of a desk would instantly bring files and material on any subject to the operator's fingertips. Slanting translucent viewing screens magnify supermicro-film filed by code numbers. At left is a mechanism which automatically photographs longhand notes, pictures and letters, then files them in the desk for future reference.

Fig. 4: Vannevar Bush's Memex. Retrieved from:

https://monoskop.org/Vannevar_Bush#/media/File:Bush_Vannevar_1945_Memex.jpg

Literature Review

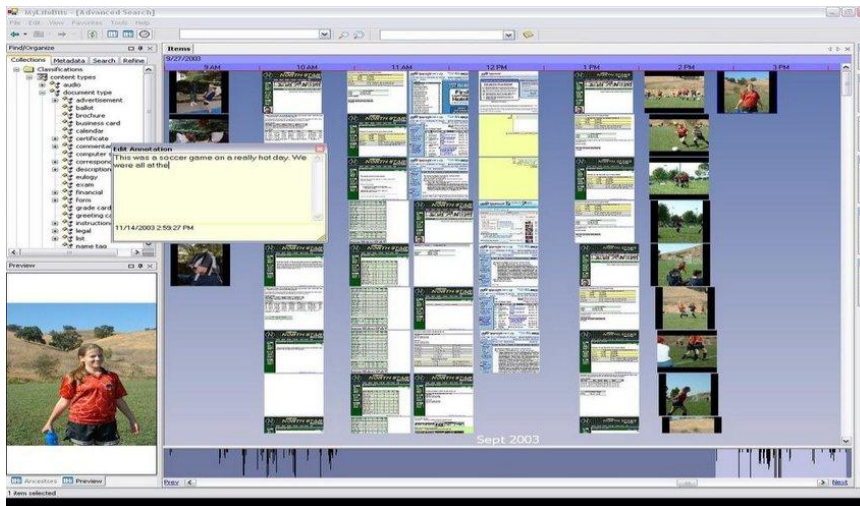


Fig.5: MyLifeBits. Retrieved from:

https://www.researchgate.net/figure/Figure-42-MyLifeBits-query-result-interface-Reprinted-from-MyLife-Bits-Fulfilling-the_fig6_321713284

2.2.2.2.1 Ubiquitous computing

As we have seen in the previous sections, the twenty-first century is characterized by more and more information and the increasing use of small devices that help us to remember. Today's low-cost abundant storage makes it possible to record most life experiences involving audio, video, and other types of data (Czerwinski et al. 2006). People now record almost every moment of their lives mainly with the help of smartphones and other small devices. "Embedded processors and network connectivity are being added to refrigerators, pens, meeting rooms, and living rooms. Audio/visual capture is becoming wearable, as is biometric sensing for health applications" (Czerwinski et al. 2006). In 2007 Steve Jobs introduced three "revolutionary products... an iPod, a phone and an internet device" all in one device, the iPhone. It represented a big change in mobile phones due to the fact that it would "allow users to watch films and download songs, store photos, as well as offering email, calendar and contacts services" (Johnson and Glendinning 2007). Since the launch of the first iPhone until today much has changed, now in 2021 we can talk to our coffee machine or control our house lights from work with our watch. All these small mobile devices, present in our everyday life are known as Ubiquitous computing, "very small, wirelessly intercommunicating microprocessors, which can

Literature Review

be more or less invisibly embedded into objects”. These computers are equipped with sensors that record “the environment of the object in which they are embedded and provide it with information processing and communication capabilities” (Friedewald and Raabe 2010).

Since the first iPhone people started to carry a “palm-size device” that grants instant access to the totality of human knowledge, as archived online. Everything that humanity has achieved, learned and thought can be ‘remembered’ by us at the touch of our fingers on the glass screen (Roberts 2016).

Today, the idea of smart objects is very present, we not only have cellphones but also smart watches, smart glasses, fridges and houses. However, this tendency and new way of life is also becoming dangerous especially for our privacy. Shoshana Zuboff in her book *The Age of Surveillance Capitalism* (2019) speaks of the dangers of this new technological world, dominated by few companies. Google, Facebook and Amazon, through the small devices we all own and the internet, know where we are, what we buy, what we talk about and then can predict what we will want, profiting from our behaviour. As Mayer-Schonberger (2011) notes “Google knows more about us than we can remember ourselves”.

2.2.2.3 Collective Memory

The idea of a Global Brain is probably older than we think, in 1937, H.G. Wells wrote the book *World Brain*, where he proposed a freely and widely available *World Encyclopedia* that would summarize the verified reality. At the beginning of 20th century Eduard Le Roy and Pierre Teilhard de Chardin spoke of the *noosphere*, the thinking layer of the biosphere (Svoboda 1999). The *noosphere* would be the place for connected human minds that interact through communication (Svoboda 1999).

The rise of the internet in the 1990s turned these ideas more convincing and led to more theories of superhuman consciousness based on the emerging worldwide computer networks (Besser 2016). We are now entering a new reality where we send our memories, projects and dreams out into Cyberspace (Lévy 2005). According to Lévy (2005) our reality is becoming more alive, intelligent and collective, and we are all in the “process of thinking within the same network”. The Internet has become the place where human dialogue can grow and

Literature Review

expand. Writing, the alphabet, the printing press, the audiovisual media and now Cyberspace have increased language's power and thus leading to new collective creations (Lévy 2005).

The internet is a wonderful supplement to memory, but humans have often had external information stores to supplement our biological memory (Carr 2016). These stores can be books, maps but also the brains of other people. In any long-term relationship, teamwork and other groups we usually develop a group or transactive memory, where we can use our own memories but also the ones from our friends or colleagues (Sparrow et al. 2011). If, for example, we have a friend who is an expert in gardening we will probably use his or her knowledge to supplement our own memory (Carr 2016). With the internet and "sophisticated searching engines" we now have all the information available at our fingertips (Sparrow et al. 2011). We no longer need to make costly efforts to access the things we want (Sparrow et al. 2011). Driven by our desire to know, we will learn everything possible to learn. (Lévy 2005)

We've never had an *external memory* so capacious, available and so easily searched as the Internet, however, the way we form memories is being influenced by these "outside information stores", that are leading us to an era where "we will store fewer and fewer memories inside our own brains" (Carr 2016). If we use the internet as a substitute for our memory we risk losing something important about ourselves (Carr 2016).

2.2.2.3.1 Possible Consequences

As seen above, having a collective memory, with easy and cheap access to it can also bring consequences for our lives. The internet has become "a primary form of external and transactive memory, where information is stored collectively outside ourselves" (Sparrow et al. 2011). However, this practice of outsourcing our memories can lead to changes in our brains and thus influencing our cognitive capabilities (Dedyukhina 2020). In this section we will look at a study made in 2011 by Sparrow et al., showing how the processes of human memory are changing and adapting to new computing and communication technology.

This study was divided into four experiments. The first experiment showed that people share information easily because they rapidly think of computers to acquire knowledge. When people are faced with a difficult question or have a gap in their knowledge, they tend to look at

Literature Review

the computer for an answer or to rectify their guess. The second and third experiments showed that people tend to forget items they think will be available externally and tend to remember items they think will not be available on the internet. Participants “apparently did not make the effort to remember when they thought they could later look up” what they read. Search engines make us not feel the need to encode the information internally, it appears that we just need to look it up. If we believe we won’t have access to the information in the future our memory is enhanced. The fourth and last experiment showed that people seem to better remember where an item was stored than the content of the item. This suggests that when people expect information will remain available, they are more likely to remember where to find an item than to remember the details of it. The study also concludes that “this is an adaptive use of memory—to include the computer and online search engines as an external memory system that can be accessed at will”.

We trust our memory to external sources and we are using less and less of our memory. The human brain is an adaptive organ, if we stop writing, our brain will soon not know how to write (Caldas 2020). When we outsource too much information and use less of our memory we may start interfering with our creativity (Dedyukhina 2020). Alexandre Caldas (2020) argues that we should have our memories inside our brain and not our pocket because we need to mix and remix the information and make new meanings and associations. We believe that information will remain available forever, but we cannot forget the fact that information is not only virtual. Although we see the virtual world as a dematerialisation of experience, the digital world is built on a profound materiality, all of our cellphones are made of electrical components made of minerals such as gold or lithium (Groes 2016). Information can be deleted or lost, as we saw in section *A Personal Database for Everything* the loss of a hard drive resulted in a “severe emotional blow - perhaps like having one’s memories taken away”. We have become more and more dependent on our gadgets, remembering less by knowing where the information can be found, but the experience of losing our internet connection becomes more and more like losing a friend (Sparrow et al. 2011). In *Mediated Memories in the Digital Age* (2007), José van Dijck suggests that there “is a link between our ability to remember and our desire to not be forgotten, but the irony is that the tools that grant us the illusions of permanence might actually make us forgetful”.

2.2.2.3.2 Digital Immortality

It is estimated that in 2020 every person produced an average 1.7 MB of data per second (Domo 2018), which corresponds to 146.88 GB a day. Either through Facebook posts, work emails, card payments we are constantly leaving a digital trace of ourselves.

All the content each individual creates or participates in generates a digital life. This content is spread across multiple devices such as smartphones, laptops and cloud storage (Moncur 2016). This raises some questions regarding the future of our information. What happens to our lives after we are biologically dead, but live on, digitally? According to Moncur (2016) “the concept of digital death is even less precise than that of social death”, since there isn’t a mechanism to notify our physical death to the internet and, “as a result, we can linger on in cyberspace indefinitely” (Moncur 2016). “The body does not disappear in Cyberculture: it is instead transformed into a hyper-body, just as our minds all join together in the network’s hyper cortex”(Lévy 2005).

One important factor that contributed to this was the cheap storage. As seen above, in the 1970s and even in the 1990s storage was expensive. “With cheap data storage, there is no incentive to clear out old digital content” (Moncur 2016).

The post-self can remain dynamic after physical death, subject to change based on input by others. Moncur (2016) further notes that we trust our memories to the digital world, placing them within our digital lives and that after our death these memories will remain “in a life of their own”.

There are now apps that can simulate a deceased and make interactions with his or her death. *mygoodbyemessage.com* is an app created for people to automatically send text messages after their death. Last year Microsoft patented a chat bot to digitally reincarnate a person, whose profile would be created from social data such as images, voice data, social media posts and electronic messages (Collins 2021). The chat bot can have a voice sounding like the person in question and also have a 2D or a 3D model. The patent states that the chat bot will be trained according to the “conversational attributes” of the person, “such as style, diction, tone, voice, intent, sentence/dialogue length and complexity, topic and consistency”. The patent also notes that the chat bot is not only of deceased but can also be of living people. This raises some questions regarding our future and our mental health. In situations such as the death of a family

Literature Review

member or a breakup we are encouraged to move on. But if we have the possibility to perpetuate the presence of a person, what will be the consequences?

2.2.2.4 The Importance of Forgetting

“Since the beginning of time, forgetting has been the norm and remembering the exception”, but “because of digital technology, society’s ability to forget has become suspended, replaced by perfect memory” (Mayer-Schonberger 2011). “Although we don’t usually think of it in this way, the ability to forget is also important” (McGaugh 2003). In this section we present some ideas that verify why forgetting plays a central role in our lives.

In his book *Delete* (2011) Viktor Mayer-Schonberger reminds us that forgetting is a characteristic of us humans, and the advent of digital technologies is impairing us from forgetting. Mayer-Schonberger starts by presenting the case of Stacy Snyder, a 25-year-old woman who wanted to become a teacher but the internet took the opportunity. Although she had passed all exams and completed her training her teaching certificate was denied, allegedly because of her behaviour. This referred to a photo, named “drunken pirate” posted online on MySpace where Stacy was wearing a pirate costume holding a plastic cup. Although this photo was posted on her account the university argued it was unprofessional, since the students could see the photo of a teacher drinking alcohol. Stacy thought of taking the photo offline, but the search engines had been archiving it. “The Internet remembered what Stacy wanted to have forgotten” (Mayer-Schonberger 2011).

Another case related to the permanence of data is China’s “social credit” system. The system “aims to incentivise “trustworthy” behaviour through penalties as well as rewards”, and once a person is on the government’s black list for a social offence he or she cannot buy plane and train tickets (Kuo 2019). The social offences include not paying individual taxes, spreading false information, smoking on a train, taking drugs or even walking a dog without leash.

A “complete memory would probably render life unliveable” (Roberts 2016). In the first chapter, *Human Memory*, we presented an example of a person who remembers more than she can forget. The case of Jill Price showed us how hard it was for her to concentrate in school with so many memories in her head, and how hard the loss of her husband is to her, even though

Literature Review

his death was years ago she feels like he was gone just a few days ago. Jorge Luís Borges in his short story *Funes, the Memorius*, argues that with a perfect memory we may remain lost in the details of our past. The life of Jill Price illustrates quite well what it is to be lost in the past. Remembering everything doesn't necessarily make us happier or smarter, because if we remember everything we will remember sad, or negative experiences, the same way we will remember the good and happy experiences. Once again "if we remember everything our past becomes traumatic" (Markram 2020).

For Roberts (2016) this perfect memory "would enable us to recall not just the things that had happened to us, but the things that happened to everyone and everything with which we came into contact". According to Groes (2016) "we'd need to reconsider the classical division between "real" memory, the memory of artifice (films we have seen, books we have read) and actual artificial memory itself".

Ubiquitous computing and especially the internet brought us the possibility to keep everything, "all our efforts are now focused on attempting to make our memory better", when we should "be pondering how we can, most creatively", "make it *worse*" (Roberts 2016). The shift from forgetting to remembering is becoming inevitable. According to Mayer-Schonberger (2011), it is not technology that forces us to remember, but only facilitates it, and it is we who are causing the demise of forgetting.

Remember everything may bring some problems in the future, Roberts (2016) asks us some questions, such as what can happen if we put a filter that allows us to access only happy memories? Would this change ourselves in a way where we become more happier? For Roberts (2016) the problem becomes ethical, "reality is both good and bad, and fidelity to actuality requires us to balance happy memories with sad ones". Sad and dangerous memories are also important in a way that they help "avoid making costly and dangerous mistakes twice" (Mayer-Schonberger 2011).

3 State of the Art

3.1 Artworks and Multimedia Installations

Taking into consideration concepts and ideas presented in the previous chapter the following pages address artworks and multimedia installations that explore questions related to the human brain, human memory and memory processes such as recollection. The selection was based on how the concepts and ideas were materialized, on formal aspects such as image and sound processing, and also on which solutions the artists found to implement the artworks on site. Furthermore, all of the selected works have been produced in the 21st century and were also selected for being contemporary and for using current technological tools such as Generative Adversarial Networks (GANs) and functional Magnetic Resonance Imaging (fMRI).

As we noted in the previous chapter the human brain has been fascinating us for centuries and, especially the human memory has been a basis of work in different areas, from science to arts and literature.

The artworks and multimedia installations are organized in chronological order.

3.1.1 Memory Association Machine

Ben Bogart

2007

Video installation

This installation intends to be a *creative* machine that shows how free association can occur in the human memory. Through a large window the public can see a triptych of screens (Fig.6). One of the screens shows a live-feed of images captured by a robot-camera. On another screen there are abstract collages from the surrounding area and on the third screen there's a cinematic montage of images with free association that evolve continuously.

Memory Association Machine has an implemented model of human creativity, inspired by the work of the cognitive scientist Liane Gabora that considers human creativity as a controlled form of free-association. Each captured image is stored and similar images are shown later in a flow of images that tries to resemble how association of memories could work in the human mind.

This work is relevant by the approach to the association of memories, a key-point to the developed work.

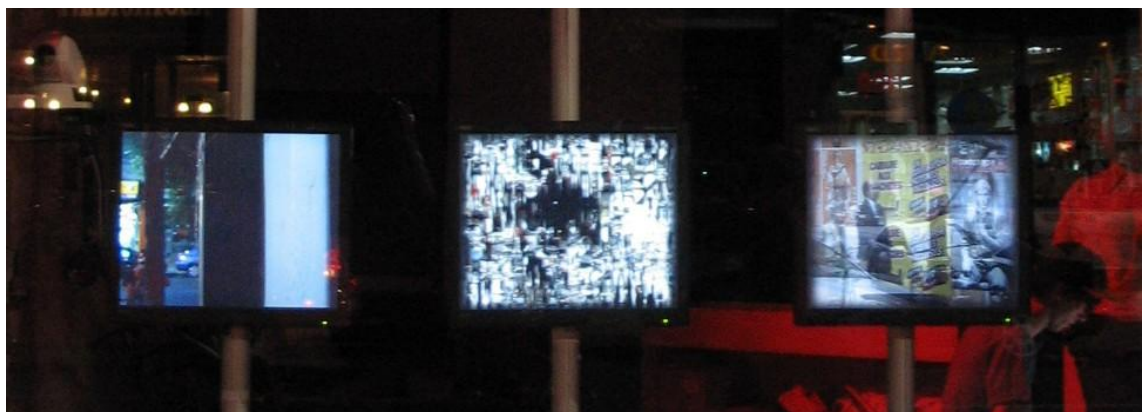


Fig. 6: Memory Association Machine (Ben Bogart)

Retrieved from:

<https://www.ekran.org/ben/portfolio/2007/07/self-other-organizing-structure-1-2007/>

3.1.2 Pleasant Places

Davide Quayola

2015

4K video

Duration: 28' 12''

Titled after the first series of landscape prints produced in Holland in the 17th century, *Pleasant Places* consists of a series of digital paintings exploring the boundary between representation and abstraction. Inspired by the work of Vincent Van Gogh, Quayola has returned to the same countryside of Provence some 125 years later. The landscapes serve as a point of departure – a pretext from which to shape an inner motion and vision. Through the misuse of image-analysis and manipulation algorithms, *Pleasant Places* challenges the notion of the photographic image and proposes alternative modes of vision and synthesis.

This installation had a major influence on the visual component of my work, mainly for the attention to movement and to how landscapes turn into color trails.



Fig. 7: Pleasant Places (Davide Quayola)

Retrieved from: <https://quayola.com/work/selected/pleasant-places.php>

3.1.3 Deep Meditations: A Brief History of Almost Everything

Memo Atken

2018

Immersive, large-scale video and sound installation

Duration: 60 minute loop

Deep Meditations: A Brief History of Almost Everything is a video and sound installation that celebrates life, nature, the universe and our subjective experience of it. According to Atken (2018) the work takes us on a spiritual journey through slow, meditative and continuously evolving images and sounds, told through the imagination of a deep artificial neural network. The work invites us to acknowledge our role as humans as part of a complex ecosystem dependent on the balanced interconnectedness of all living and non-living forms. The work is intended for introspection and self-reflection, as a mirror to ourselves and how we see the world but also as a window to the mind of the machine, since it tries to make sense of its observations and memories.

For the construction of the narrative the artist trained an artificial neural network with our subjective representations of things such as faith and religion, i.e. from images on the Flickr website tagged with those words, since they haven't an objective and clear representation. The artificial neural network analyses and learns only on surface aesthetics and has no semantic information. Swarms of bacteria blend with clouds of a nebula, and flowers become sunsets. The sound was also generated by an artificial neural network with samples scraped from YouTube of hours of religious and spiritual chants, prayers and rituals.

This installation is relevant to my work for the constant visual transformation and evolution of the images. In the previous work, *Pleasant Places*, footage from landscapes turn into color trails. In *Deep Meditations*, images of landscapes, plants and galaxies quickly turn into abstract shapes. The relation between reality and abstraction was a key-point to the development of the visual component of my work.

State of the Art

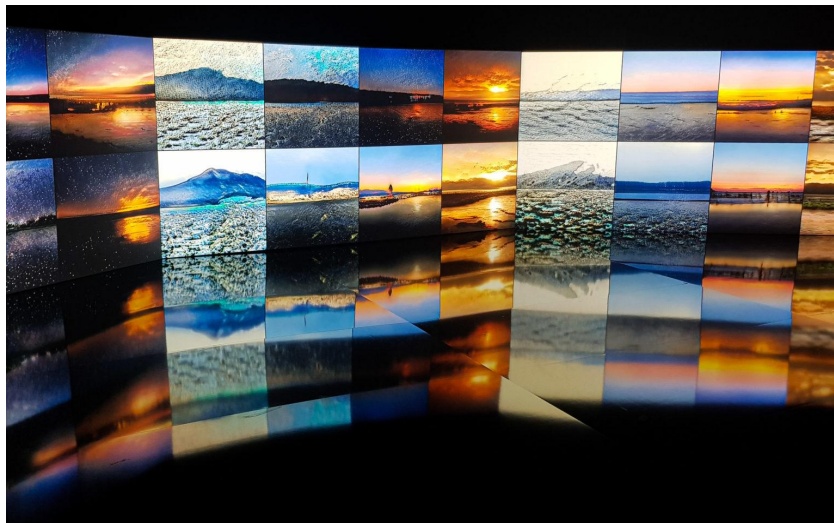


Fig. 8: Deep Meditations: A Brief History of Almost Everything (Memo Atken)

Retrieved from: <https://www.memo.tv/works/deep-meditations/>

3.1.4 Melting Memories

Refik Anadol

2018

Installation

Data Sculptures + Data Paintings

Melting Memories is a video installation about the materiality of memories that translates the elusive process of memory retrieval into data collections. The work enables visitors to experience aesthetic interpretations of motor movements inside a human brain and reflects the melting of neuroscience and technology into these centuries-long philosophical debates questioning the emergence of a new space where artificial intelligence is not in conflict with individuality and intimacy.

The artist gathered data on the neural mechanisms of cognitive control from an electroencephalogram (EEG) that measures changes in brain wave activity and provides

State of the Art

evidence of how the brain functions over time. These data sets were later used for the algorithms for the multidimensional visual structures on display.

This installation was selected by the working process, how the artist transposed the human brain's activity to abstract images.



Fig. 9: Melting Memories (Refik Anadol)

Retrieved from: <https://refikanadol.com/works/melting-memories/>

3.1.5 Neural Zoo

Sofia Crespo

2018 - 2021

Series of images

Neural Zoo is a visual exploration of ways creativity works, especially the recombination of known elements into new ones. The artist notes that our visual cortex recognizes the textures, but the brain is simultaneously aware that those elements don't belong to any arrangement of reality that it has access to. The colorful images resemble nature, but an

State of the Art

imagined one that has been rearranged. The work proposes us to think of our known reality and use it as a basis for the digitization of cognitive processes, and utilizing them to give new inputs into the biological world. The artist further notes that tools such as computer vision and machine learning could offer a bridge between us and speculative natures.

This work was selected due to the way fragments of images and textures were composed into new ones, in a combination between reality and abstraction.



Fig. 10: Neural Zoo (Sofía Crespo)

Retrieved from: <https://neuralzoo.com/>

3.1.6 Of Ideal

Pierre Huyghe

2019

Multimedia Installation

State of the Art

Of Ideal is an installation that results from a collective production of imagination, both human and artificial. What is imagined by an individual is made visual through an artificial neural network that learns and reconstructs mental images. Human imagination is being externalised without the subject predetermining the outcome.

Of Ideal is a one of Pierre Huyghe's mental image works. In the first work of this series, named *Umwelt*, the artist gave images or descriptions to people to be imagined, while they were scanned by fMRI. In *Of Ideal*, what was imagined came from personal recurring memories and situations.

Just as Refik Anadol's work was selected by the working process, so was this installation from Pierre Huyghe. *Of Ideal* makes human imagination visible by an artificial neural network, making me think of ways of artificial replication of human memory processes.



Fig. 11: *Of Ideal* (Pierre Huyghe)

Retrieved from:

<https://www.hauserwirth.com/hauser-wirth-exhibitions/30409-pierre-huygheof-ideal>

2.1.7 Power Plants

Hito Steyerl

2020

Power Plants is an installation of a series of three projects about the idea of *power*, from the premise that power is the necessary condition for any digital technology.

The installation was inspired by the idea of the ruderal garden, plants that grow in places of waste. It can be described as a future garden with plants that have various ecological, medicinal and political powers predicted by Steyerl's neural networks. The work also has speculative descriptions of future plants, fictitious quotes dated in the future and human testimony on iPads with augmented reality suspended from the ceiling.

Power Plants were generated by neural networks: computer systems modelled on the human brain and nervous system, which were programmed to predict the future by calculating the next frame in the video. Steyerl used this Artificial Intelligence to create a series of "predicted" plants that are located precisely 0.04 seconds in the future.

Steyerl intended to reverse the promise of technology as beneficial to human evolution, but instead considering how such tools could impact our natural environment.

This work was selected because of working on the impact of technology on our natural environment. It was also selected as another form of digital technology to replicate natural elements and simulate new ones.

State of the Art



Fig. 12: Power Plants (Hito Steyerl)

Retrieved from: <https://www.serpentinegalleries.org/whats-on/hito-steyerl-power-plants/>

3.1.8 Phase Shifting Index

Jeremy Shaw

2020

Phase Shifting Index is an immersive, seven-channel video installation where footage of subcultures from the future are displayed. The subcultures engage movement-based beliefs systems as tools towards inducing parallel realities. The images go from technical to somatic and from meditative to ecstatic.

Each 25 minutes a soundtrack invades the room and independent clips become a synchronous choreography. These moments of dance span across different decades of time and media and overwhelms the viewers. Suddenly, all screens melt with digital visual effects devolving from para-fictional documentary compilation to an immersive and psychedelic moment within seconds.

This installation was selected because of the color and abstract-figurative relation, and also due to the way the artist assembled the work in the museum.

State of the Art

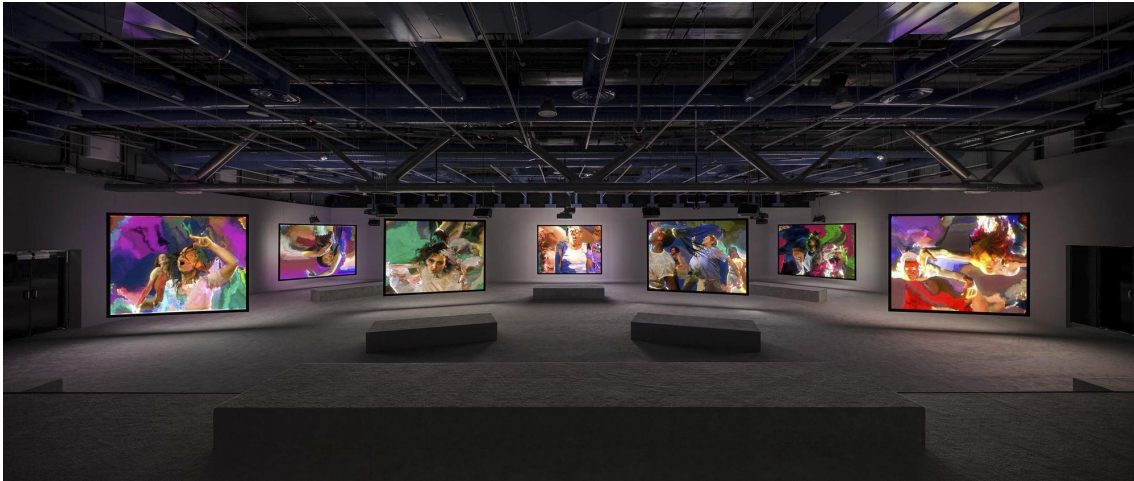


Fig. 13: Phase Shifting Index (Jeremy Shaw)

Retrieved from: <https://www.koeniggalerie.com/exhibitions/25475/phase-shifting-index/>

3.1.9 Regions of Interest

Karen Ann Donnachie & Andy Simionato

2020

Digital collage

Regions of Interest is an algorithmic collage that creates new scenes existing between the familiar and alien of places that can not be visited. The name results from the classification by the artists as “regions of interest” to be archived in a rapidly growing atlas of nonhuman destinations.

The artwork explores early 20th century art techniques of collage, frottage and decalcomania where Donnachie and Simionato cut and combine source imagery according to algorithmic gestures conditioned through the procedural processing of the archive with computer vision and machine learning. The artwork results from an *autonomous-art-system* that

State of the Art

creates imagery based on source images from digital archives (open source libraries, web-cams and video-feeds).

This project was also extended to picture books with the collages with an additional paratextual element of nonhuman typography, also subjected to the same processes of collage, frontage, *découpage* and decalcomania.

This work was selected mainly due to the exploration of collage technique, related to the association of memories, and how fragments of images can turn into unique compositions, another key-point to the development of the work.



Fig. 14: Regions of Interest (Karen Ann Donnachie & Andy Simionato)

Retrieved from:

<http://www.aiartonline.com/highlights-2020/karen-ann-donnachie-andy-simionato-2/>

3.2 Conclusions

Despite the differences in theme, form, tools and media, all of the presented works contributed to the development of the art project from this research. Since one of the main goals of this dissertation is the production of an artwork that fosters the questioning on the impact of technology in the human memory it was relevant to gather works from artists and scientists about the same issues.

Works such as *Memory Association Machine* shows a representation of how our mind works. The association between different moments was a key-point to the following developed work.

Melting Memories and *Of Ideal* are works that approach memory processes and imagination with contemporary technological tools such as GANs and fMRIs.

As our research focuses on the impact of technology on the human memory, the installation *Power Plants* focuses on the impact of technology on our natural environment, presenting us with a simulation of new plant species. The concept of simulation was also a key-point to the developed work.

Works such as *Neural Zoo* and *Regions of Interest* were important to understand how different visual fragments became a unifying composition, and the work *Pleasant Places* was a significant reference to understand how movement in video could be explored.

At last, *Phase Shifting Index*, a work about the human brain, was a reference in regard with the implementation of the work in the museum space.

The interest in studying the impact of technology and its destructive capacity began a few years ago and was explored in some of my works such as *War and the End of Empathy*, a video and sound installation with footage from the Gulf War and Google Earth, presented in 2019 in Galeria Municipal do Porto. The presented locations are real-world images, through an automated eye, an eye in a higher position, an eye that dives into the target. These images represent some of the ideas of Kino-eye and robo-eye, proposed by Dziga Vertov and Harun Farocki. The two ideas are similar in concept but differ in their relation to the technological means, kino-eye is related to 1940 cinema and robo-eye is related to digital video and computer vision. Both concepts speak of an eye that goes beyond human vision, an eye like a microscope or telescope of reality, an automated eye that no longer uses the human eye as the decisive one. With archival images, these videos reflect on one of the dangers of automation in a warfare context, the growing loss of empathy, just as the use of autonomous weapons in the battlefield is

State of the Art

increasing as they can be remotely monitored. This work was influenced by the work of Harun Farocki, not only regarding the footage but also editing techniques, such as cuts, transitions, and loops.

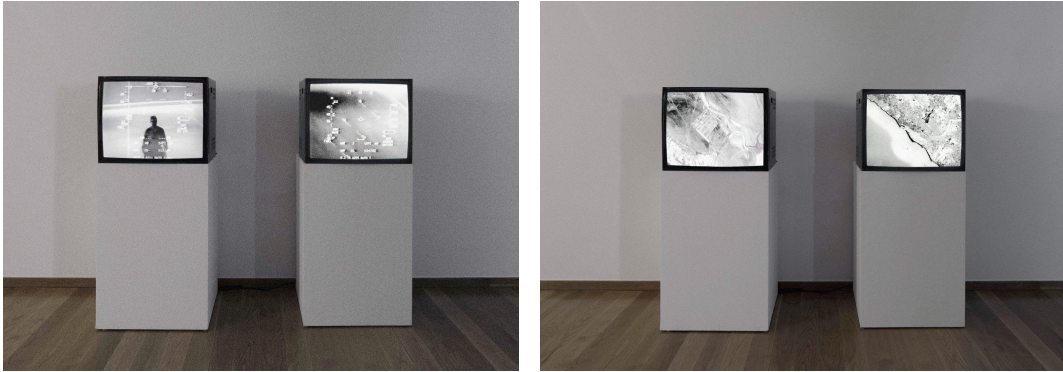


Fig. 15, 16: *War and the End of Empathy*, Installation View

In this dissertation, the research is about another kind of impact, more specifically, the effects of technology in human memory processes and how it can be explored and made visible to the public through a multimedia installation. The references mentioned above were important to understand how certain concepts were translated into artworks.

4 *Evoking a Simulated Past*

4.1 Introduction

From the formation of memories to their reconstruction and remembering, our brain undergoes various processes. As previously mentioned, memories with emotional significance are the ones that last longer while the others gradually fade (McGaugh 2003). Throughout History Humans have always looked for ways to enhance their memory, relying on external devices and mechanisms. Today, with digital technology brought us the promise of a perfect memory, since we can store and retrieve a large amount of “memories” in our devices. These conclusions were the first main ideas to start thinking of the production of the artworks. How to put these ideas in practice? How to present these ideas for the public? How to design an exhibition that *includes* these ideas?

Since my work as an artist is mainly visual, all my thoughts were going in the same direction. It made sense that the exhibition would consist of one installation, with sound and a video projection on a screen in the center of the room, to make it more inviting to the public. A central object can put less emphasis on the room’s architecture, and also a projection screen reflects less light than a white wall. For this project memories were created through recorded footage and sound, which were later composed in a narrative, using Premiere Pro⁷ and Reaper⁸ to compose and edit video and sound, and Processing to create visual transformations. The installation is entitled *Evoking a Simulated Past*, since the presented memories are simulations of a past.

This chapter will discuss the process of creation and implementation of the installation, which were the intentions, starting points, the process of recording and later selection and composition of sound and video and finally the implementation on site. *Evoking a Simulated Past* was presented in Gnration⁹, a space for creation, performance and exhibition in Braga, from June 9 to 19, 2021.

⁷ <https://www.adobe.com/pt/products/premiere>

⁸ <https://www.reaper.fm/>

⁹ <https://www.gnration.pt/>

4.2 Intentions

When we remember something, usually we make a visual representation of a specific moment in our mind. This representation can arise through a stimulus and be triggered by a smell, a conversation or a photograph. In that process we quickly move from one memory to another, and many times we don't even know why, but the truth is that we can be thinking about what we had for lunch and suddenly we are playing in our heads the same excerpt of a song in loop while thinking of the way we will take for getting the train. When we remember certain moments and events, we make new combinations between the past and simulations of the future. This happens because our memory works by association and because it is neither fixed nor static (Bridge 2012; Rose 2006). Throughout life some memories may be forgotten and the most significant ones are more likely to stay, although some details may change (McGaugh 2003).

This installation represents the process of memory association, and association of different fragments that move quickly into others, where technology appears with an active role in selecting the next fragments. As said above, we trust too much on technology to keep our memories. What could happen if an algorithm chooses to delete some of our memories? What consequences could emerge? Will we forget too?

4.3 Project Development

4.3.1 Starting Point



Fig. 10: *Rua da Póvoa*, a digital collage made from around 20 different pictures of the same place at different times of the day and perspectives. The photographs were made with a Minolta x-300 and kodak color film 35mm.

Rua da Póvoa is a collage created for another context but it illustrates my initial ideas concerning fragments of memories and their connections. While thinking about memory association and navigation between memories this image emerged as a possible approach to the production of an artwork.

Considering my artistic practice, thinking about producing an artwork became a visual thought process. I started to think about memory association and memory navigation, how we move from one memory to another, why we make connections between situations with different times and spaces. This led me to pay more attention to what goes on in my mind when I'm in the act of remembering. I noted that the visual representations of our memories easily get

Evoking a Simulated Past

distorted, twisted, blurred and move quickly to others. At this stage, the works from Memo Atken (Fig.8) and Pierre Huyghe (Fig. 11) played a central role by the way the images are constantly evolving. Memo Atken's *Deep Meditations* made me think on how figurative images turn into abstract shapes, and Pierre Huyghe's *Of Ideal*, made me think about distortions that happen while we are imagining and remembering.

4.3.2 First Tests and Technique explorations

With the ideas of fragments of memories and possible transitions between them I started by exploring techniques such as datamosh and pixel sorting, using video editing softwares and Processing. These techniques emerged as a way to replicate visual transformations that occur when we are in the process of remembering. When we move from one memory to another the transition can be more or less abrupt, and the images we produce in our minds can be more or less blurred and fragmented. Since these techniques relate to the fragmentation of an image it seemed a suitable approach for the visual component of the installation. Datamosh allows errors to occur and pixel sorting provides a new arrangement of a frame. Both techniques will be explained below.

4.3.2.1 Datamosh

The first technique used was datamosh. Some videos were collected from the internet of a Portuguese man-of-war and edited in Premiere Pro and Avidemux 2.5. Taking Sofia Crespo's *Neural Zoo* as a reference, I looked for footage of living organisms and animals with multiple colors and particular physical features, such as tentacles.

Datamosh consists of manipulating data from media files and it can be done with several means, for example with text files to directly manipulate the media file, or with video editing softwares. Videos are compressed with algorithms targeting different frame types, usually they are compressed using I, P and B frames. The I-frames (Intra-coded) are frames that store an entire picture. P-frames (Predicted picture) and B-frames (Bidirectional predicted

Evoking a Simulated Past

picture) contain only data of the differences between the previous and the next frame. When a video is compressed, if the I-frames are corrupted or deleted there will occur visual changes. In Avidemux it is possible to delete the I-frames before exporting a video file. The figures 17 and 18 show changes that occurred, resulting from the corruption of I-frames.



Fig. 17, 18: Stills from the first video tests using datamosh.

4.3.2.2 Pixel Sorting

At the same time I was doing tests with datamosh I made other tests in Processing using pixel sorting. Pixel sorting is a technique where the pixels of an image are rearranged, in this case, by hue and brightness. The used code was written by Daniel Shiffman.¹⁰

¹⁰ https://github.com/CodingTrain/website/tree/main/CodingChallenges/CC_047_PixelSorting/Processing

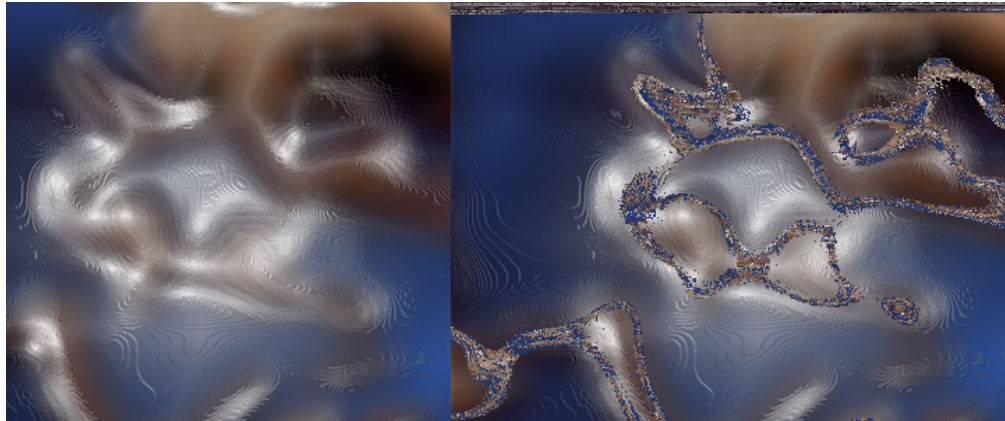


Fig. 19: Stills from Processing running a pixel sorting algorithm. On the left is the original image and on the right is the image being sorted by hue and brightness.

With some tests with datamosh and pixel sorting I realised that these techniques were limiting in terms of visual exploration and diversification and the occurred changes on the images and videos could become tiring, since the results would turn out to be similar.

4.3.2.3 Optic Flow

At this point, it was important to revisit some of the references shown in the previous chapter. The work from Davide Quayola played an important role in determining the course of the work. In *Pleasant Places* (Fig. 7), the artist presents videos of natural landscapes that turn into color trails, misusing image-analysis and manipulation algorithms. This led to research about optic flow and the human interest in movement. Optic flow is the pattern of apparent motion of an object and is a “key signal for heading perception” (Bremmer 2008). In humans, vision plays a central role in self-motion. When we move on the environment we induce a “flow of the image of the outside world” in the retina (Bremmer 2008), and this flow can tell where we are heading. These ideas led me to think more about movement and how it could be explored visually. I recorded some short videos in the margins of Douro river with attention to small details in movement such as the wave pattern on the river or the motion of tree leaves. Figure 20

Evoking a Simulated Past

is a still from a video test using an optic flow algorithm in Processing, developed by Thomas Diewald¹¹.



Fig. 20: Still from a video using an optic flow algorithm in Processing

4.3.2.4 Pixel Array

Another experiment was developed thinking about the work from Karen Ann Donnachie and Andy Simionato (Fig. 14) and my starting point (Fig.15), where, instead of using static images I used videos to create a collage with footage from the Douro river (Fig. 21, 22).

¹¹ <https://github.com/diwi/PixelFlow>

Evoking a Simulated Past



Fig. 21, 22: Stills from a video collage.

The tests had potential but once again I realised they could be limiting. Just as our memory is neither fixed nor static I intended to create an artwork that would evolve in time, so it would need to have factors of change, such as a random sequence of multiple videos. I went back to Processing and adapted a code of a pixel array developed by Marcelo Reis. The code consists of an array of pixels with two overlapping videos where the pixels of one video move around its original position according to the brightness values of the other video. A lot of tests were made to realise the potential of the videos, in terms of color, movement, texture and scale (Fig. 23, 24). This code was chosen to continue developing the project. It corresponded to my

Evoking a Simulated Past

goals of evolving images with a combination of figurative images from real scenes and abstract and distorted shapes.

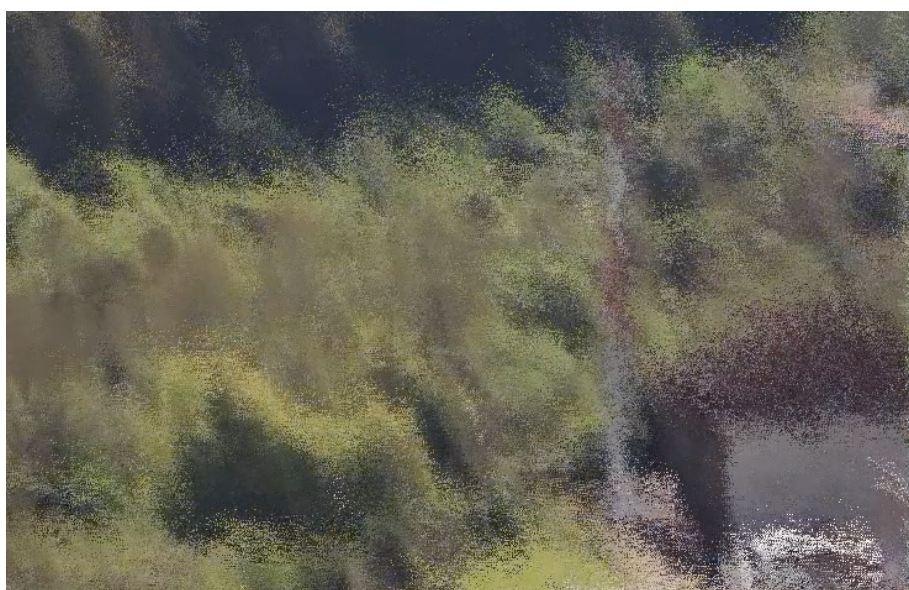


Fig. 23, 24: Stills of video tests with a pixel array in Processing.

4.3.3 Recordings - Video and Sound

With part of the code running I started to think about what videos I would record and include. Since one of the main goals was the creation of a simulated past I had to produce footage of places and people as memories. For that, I recorded videos and sounds of natural and urban landscapes and characters. These landscapes were from different cities and places such as Porto (Fig. 25, 26), Santo Tirso and Ofir (Fig. 27, 28), all these locations with personal significance.

The video recordings in Porto include the Douro river, the margin of Vila Nova de Gaia, old railway trails, streets and houses of Bonfim. The recordings in Santo Tirso include mainly videos from plants and gardens. The recordings of Ofir include the beach (details of sand and water), the river and recordings of my family. Most of the videos were recorded in Ofir, a place I know since I have memories of myself. In the last few years I have been documenting the river estuary, the beaches, the pine forest and the surrounding houses. As being a coastal local it is subject to change, especially now with climate changes. In order to preserve the ecosystems and to delay the advance of the sea and consequently the destruction of the dunes, the beach was the target of a major intervention in 2016, where large geotextile sandbags were placed. Of a remarkable amount of around thirty sandbags, only 1 or 2 remain, while the others were torn and taken by the sea. In 2018 I started a photographic project¹² (Fig. 29, 30) as a portrait of a place that is changing and disappearing as I originally know.

Sound was recorded in Ofir and Porto. The recordings consist mainly, in Ofir, of ambient sounds with birds and wind, and in Porto, of ambient sounds with music playing in the back in a house, people talking and children playing. The sound is in line with the videos, they were recorded on different days but in the same places. I intended to create a long track of ambient sound, to improve the relation of the public with the visual component of the installation.

The video recordings were made with a Canon Eos 700D and the audio recordings with a Tascam DR-07X and a Tascam DR-40X.

These recordings were made on different days over three months. I ended up with about 100 videos of 1 minute each and 10 sound recordings of 20 minutes each.

¹² <https://cargocollective.com/marianavilanova/photography>

Evoking a Simulated Past



Fig. 25, 26: Stills from recorded videos in Porto.



Fig. 27, 28: Stills from recorded videos in Ofir.



Fig. 29: *Terrain Vague*, 35mm black and white film.



Fig. 30: *Terrain Vague*, 35mm black and white film.

4.3.4 Selection and Composition

The selection of the videos was made according to their relevance in terms of form and type. Videos with distinct characteristics, such as different scales, colors and movements were favoured. The selection criteria of the background videos differed from the ones on the front. For the background, videos with few colors and repetitive movement such as the river were selected so the content of the front video was perceived more easily (Fig. 31). On the other hand, having a big shape, detached from the background, such as a close up of a face, showed interesting distortions on the front video (Fig.32).

Evoking a Simulated Past



Fig. 31: Still of video from the margin of Douro river with the background video from river waves.

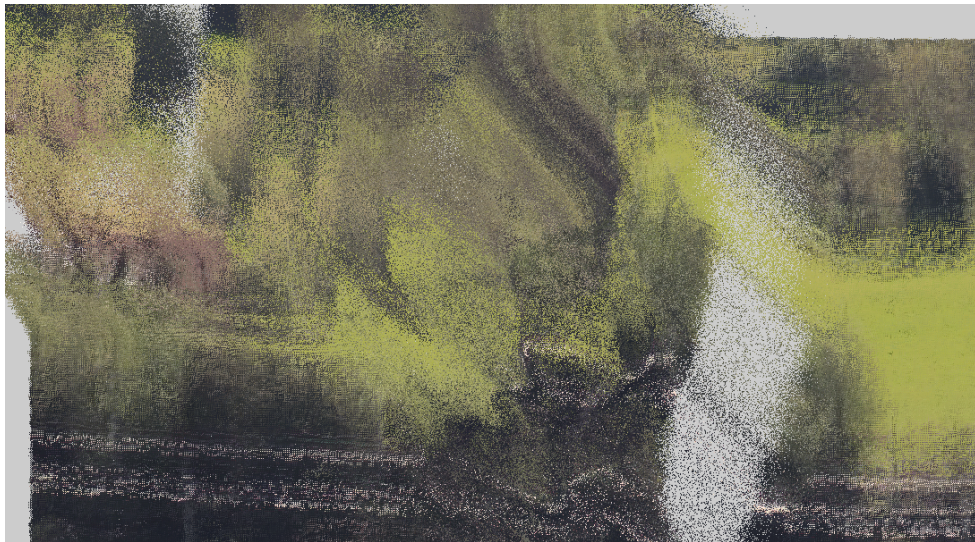


Fig. 32: Still of the same video but now with the background video from a face.

For the front videos the selection criteria was wider. Natural landscapes from forests, beaches and gardens; urban landscapes; people; plants and flowers were recorded. When introducing the videos in Processing I noticed that color and light contrasts worked well, just as small movements on the scenes and the juxtaposition of faces (Fig.33).

Evoking a Simulated Past



Fig. 33: Still of video with two overlapping faces.

With a selection of around 100 videos, I passed on to their organization. It was made mainly according to the recording days, but, to start editing the videos it was more adequate to have them organized by the content of each scene. For example, videos of gardens were all gathered in the same folder, videos of faces went to another folder, and so on.

One of the goals was having a collection of around 20 video sequences, (each one a composition of 3 or 4 videos) to be played on Processing in random order, just as we don't remember each moment in the same order. The idea was to create a database of videos that would play in random order, both background and front videos, to allow more possibilities.

While editing, issues such as movement and color were important. The figures 34 and 35 are from a sequence of 5 videos of a house, recorded on different days. The editing process focused mainly on the selection of the videos and their transitions. The transitions were made with a simple cross-fade, and with attention to strong lines. The 5 videos of the same house were recorded in different perspectives, and while editing the transitions there was a special attention to match the edges of the house.

Evoking a Simulated Past



Fig. 34, 35: Stills from the same scenario recorded on different days.



Fig. 36, 37: Stills from the previous videos in Processing.

With four video sequences ready it was time to continue the editing process. These four sequences, two of natural and urban landscapes (Fig. 32), one of faces (Fig. 33) and one of multiple perspectives of the same house (Fig. 34, 35) were the basis for the next sequences.

As mentioned above, most of the videos were recorded in Ofir and therefore most of the sequences were compositions of videos from the house (Fig. 38), my family (Fig.39), the beach (Fig.40), and its surroundings (Fig. 41).



Fig. 38, 39: Video stills.

Evoking a Simulated Past



Fig. 40, 41: Video stills.

4.3.5 Completion

4.3.5.1 Technical Visit

At this point it was important to decide how the installation would be assembled in the room. Thinking about Jeremy Shaw's *Phase Shifting Index*, and how the projection screens were arranged in the museum room, my idea was to have a projection off the walls, suspended or supported on the floor, in order to make it more inviting to the public (Fig. 42). While visiting the room (Fig.43) in gnration I decided to suspend a screen in the center of the room. Since the room's dimensions were 15 meters long and 4,5 meters wide and, in order to have a screen that would correspond proportionally to a 16:9 projection I decided on a projection screen with 3,50 meters long and 1,90 meters high.

Evoking a Simulated Past

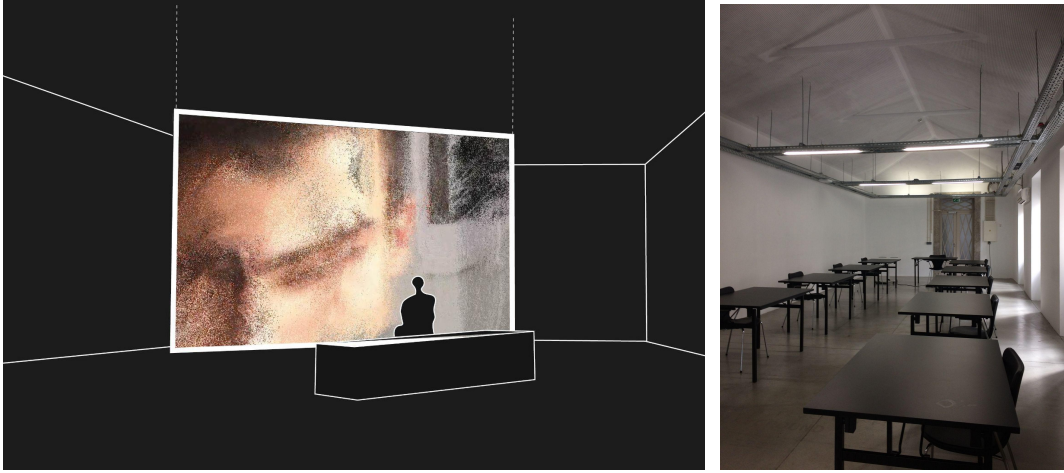


Fig. 42: Installation drawing, Fig. 43: Assigned room in gnrnation.

4.3.5.2 Completion

With fourteen sequences completed (eleven from Ofir and three from Porto) I passed them to Processing and made some tests juxtapositioning different sequences. These fourteen resulted in 21 sequences. Some of the sequences were repeated but with different background videos (Fig. 44, 45, 46, 47).

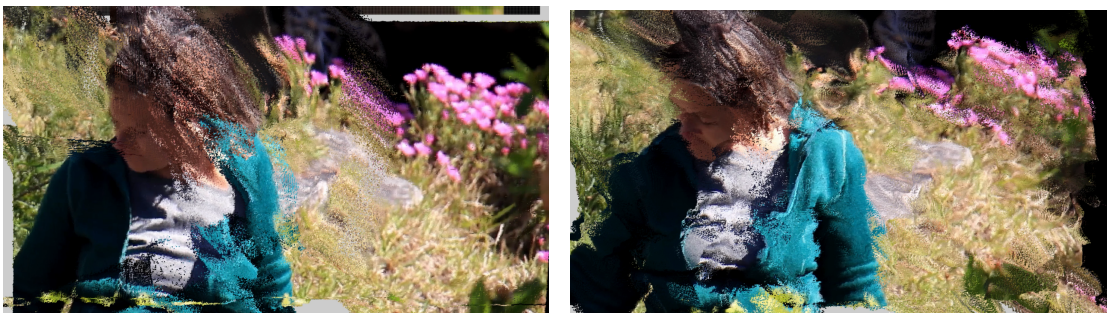


Fig. 44, 45: Stills from the same moment of the sequence but with different background videos.

Evoking a Simulated Past



Fig. 46, 47: Stills from the same moment of the sequence but with different background videos.

At the same time I edited the sound to have a background track playing in loop and different tracks for each video. The background track was a recording with around 25 minutes on my balcony in Porto, at night. With an equalization the track ended up as something barely noticeable, as a background noise that sometimes can be confused with drone music. This track was important to have an element that could connect the different elements. For each video I edited ambient sounds of birds, trees, wind, and also some songs being played in the background from a neighbor's house. Some of the videos had the sound from the same location and the others from other locations. For example, the sound of the video from figure 45 was from birds, recorded in Ofir, while the sound of the video from figure 46 was from children playing in the background, recorded in Porto. The sound of the videos from figures 46 and 47 were both from birds recorded in Ofir. All these choices support the idea that when we are remembering an event we make a reconstruction, and that reconstruction can be different over time.

4.4 Implementation

Already on site, it was necessary to start by placing the projection screen. One of the space constraints was that the screen and the video projector could only be suspended on technical rails, but it was possible to place them almost on the idealized spot (Fig.48). Another constraint was light that entered through the windows but it was quickly resolved by covering them with blackout fabric.

Regarding the solution for playing the sequences and sounds I had two options. The first was to have a MacBook Pro running VLC player with the videos on shuffle and other software, playing the background track in loop. Due to technical constraints it wasn't possible, the computer couldn't run the video sequences effectively so I had to go for the second option, that was having a Raspberry pi 4 running VLC player for the video sequences and OMXplayer for the background track.

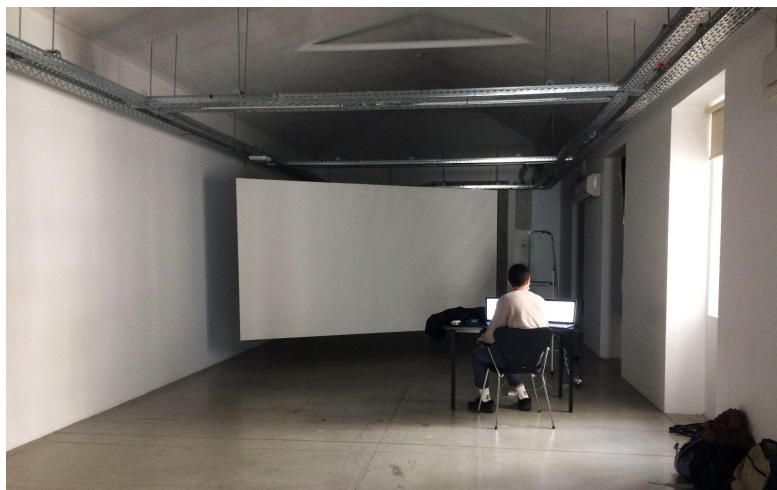


Fig. 48: Projection screen placed in the room.

It was also important to have an online complement (also due to the pandemic) of the installation, so I created a website¹³ where the audience could know more about the research, the creative process and also have access to the audiovisual documentation of the installation.

¹³ www.evokingasimulatedpast.com

4.5 Installation View

This section is for the photographic documentation of the installation (Fig. 49, 50, 51, 52, 53). The video documentation is available on evokingasimulatedpast.com or on <https://vimeo.com/manage/videos/565526411>.

The audiovisual documentation, as well as some of the video files used in the installation are available for download on¹⁴:
<https://drive.google.com/drive/folders/1h2drD12qPFe-QSjFhSJ7w5hFs1SfxEb0?usp=sharing>.



Fig.49: Installation view.

¹⁴ Note: the files can be downloaded but their copying or distribution is not authorized.

Evoking a Simulated Past



Fig.50: Installation view.



Fig.51: Installation view.

Evoking a Simulated Past

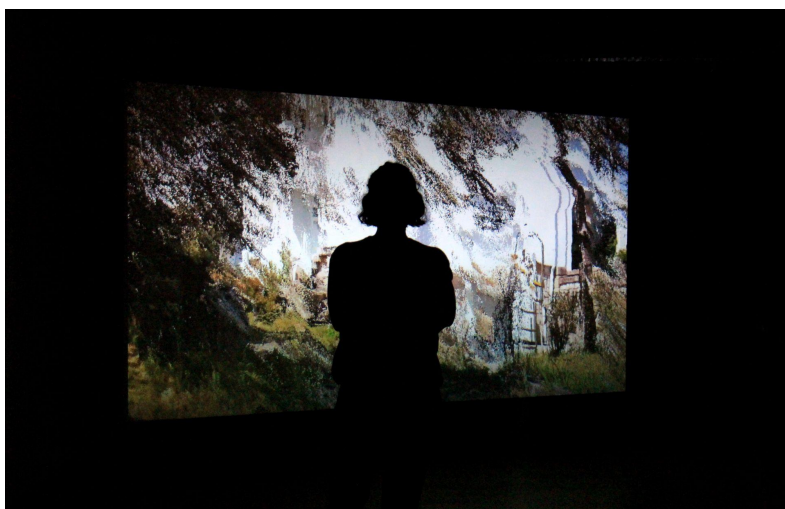


Fig.52: Installation view.



Fig.53: Installation view.

4.6 *Evoking a Simulated Past: a critical view*

For centuries, humans have been looking for ways to enhance their cognitive abilities, especially memory. When we were kids we wished we could remember the dynasties well before an History test, and when we are older, occasionally we wish we could remember well where we put our glasses or the car keys. Sometimes we feel frustrated when a friend is talking about a specific day spent together and we cannot recall any part of it. But, some centuries ago, or even millennia, when we were living in caves, it was really important to remember which plants weren't poisonous so we could eat, and how to build tools to hunt. We were focused on surviving. When fire was discovered we started to have free time, and time began to be used for other things, such as making music and art (Houzel 2020).

Memory is one of the most important skills we have. It played a part in the development of language and writing, on passing on knowledge and culture through generations, and on getting to where we are today, surrounded by small devices that keep on remembering us and for us. If you own an iPhone you know that from time to time it will automatically create a "memory" with your stored photos. With contemporary technologies we are more likely to remember than to forget (Mayer-Schonberger 2011). Even when we die we leave a digital trail that can turn into a chatbot and speak with our friends and relatives (Collins 2021).

In the past 8 years research was published of false memories implanted in mice and snails (Ramirez et al. 2013) and on brain implants that boost our memory (Ezzyat et. al 2018). Will this lead to the creation of humans with a super memory? Will we be able to store more memories than we now do? If so, will they be happy and sad memories? Or will they be just happy memories? There are a lot of questions to be answered. Sad memories are as important as happy memories, so we don't make the same mistakes twice and to avoid dangerous situations. On the one hand, remembering everything can make our lives unbearable (Roberts 2016).

Forgetting is as important as remembering. On the other hand, 21st century technologies have made us remember more. On average, we spend two hours per day scrolling down on our Facebook and Instagram feeds (Consciously-Digital n.d.), watching everyone's memories passively. There has been an increase on the information available about the effects of screens in our health. For example, we know that small screens are bad for our vision and that if we spend time on our smartphones before falling asleep it will affect our sleep. We still don't know what are the long-term effects of it in our memory. Since smartphones, tablets and smartwatches are quite recent in our lives, it is hard to predict their impact, but we are starting to see studies (Sparrow et al. 2011) on these matters. It is estimated that children who spend more than two

Evoking a Simulated Past

hours per day in front of a screen are seven times more likely to develop Attention Deficit Hyperactivity Disorder (ADHD) symptoms (Consciously-Digital n.d.). With almost all of the information of the world available to us in our pockets we are becoming more distracted and therefore impairing the formation of new memories in our brains.

At the same time we use technology as an extension of our memory with written notes, photographs, etc., it is responsible for making us more forgetful.

So, to which extent technology enhances or impairs our memory?

This project does not intend to answer these questions but instead it starts a dialogue between each individual with its own memories: their existence, the apparent connections and associations, how they came to mind and why they were stored.

Evoking a Simulated Past invites the audience to revisit their own memories and to come across with what is more intimate in them. Technology appears as a means to reach a state of immersion. By using technology we realize its existence. Recording devices (video cameras and sound recorders), editing softwares and display devices (computer, video projector and speakers) allowed to materialize the ideas presented above and to create a relation between them and the audience.

Impressions and representations of one's memories take the audience to think about their memories, stored somewhere on the boundaries of the mind and that emerge now. The remote sound, the muffled music by the apparent distance of a closed door, and the present sound of birds expands the perception, as a trigger to our own past. Suddenly, we gain consciousness and retreat from the sensorial world to encounter our interior. The images, sometimes blurred and distorted, are representations of the world we live in. The cold architecture fills the screen with grey areas and strong lines that refer to an impersonal space, almost to an urban dystopia. Right after we are confronted with a colourful Nature that takes us to our childhood memories, the feel of our feet on wet grass, the smell of the ocean or the heat of the sun entering our skin. The characters that inhabit the video bring a sense of anonymity but at the same time bring a sense of familiarity as we identify with them.

In this introspection and immersion in our thoughts, we find ourselves recognizing our lives through the presented images. The revival of our childhood, our vacations leads us to familiarize ourselves with the artwork.

4.7 Results and Discussion

Through the research made in the first stage of the project it was possible to gather some significant concepts, from the neurosciences to the arts, to think on them and to create an artwork. Contributions from neuroscientists and biologists such as Steven Rose, Larry Squire, Suzanna Herculano-Houzel, Elizabeth Phelps, James McGaugh and António Damásio were fundamental to understand the functioning of the human brain, human memory processes and the role of emotions in memory formation and recollection. How we form memories, how we retrieve them, why we remember better some moments than others were the starting points to artistic creation. Contributions from authors and researchers such as Viktor Mayer-Schonberger, Sebastian Groes, Pierre Lévy, Charlie Gere, Gordon Bell were fundamental to reflect on how technology, as an extension of our memory, is present in our culture and how it shapes our society.

In order to foster the questioning about these subjects and to start a dialogue between each individual with its own memories, *Evoking a Simulated Past* was created. A construction and reconstruction of memories, made from images and sounds of natural and urban landscapes, was displayed on a screen in a room to foster that dialogue.

According to the observation of the audience during the opening and to the feedback from some of the audience, the installation had a good reception. Despite the video sequences playing in random order, with no beginning or end, the public, on average, stayed in the room for 30 minutes. There were videos where the audience paid more attention to the visual changes and to the movement of the scenes. In other videos the audience entered into a more introspective state and after started a discussion on what they were seeing and how it related to the act of remembering. One person from the audience mentioned that the image of a young character in a video triggered her to a childhood memory, from a day she was playing in her garden and drawing a tree. She also mentioned that she remembers exactly what she was drawing although she cannot locate the memory in time.

5 Conclusions

5.1 Summary

Memory is one of the fundamental characteristics of human beings, it shapes our personality and allows us to react to life experiences. The goal of having an enhanced memory is very present in our society, we usually wish to remember instead of forgetting. Contemporary technologies – such as external memory aids – helped us fulfill this goal, but we are starting to understand some of its consequences in human memory. The access to almost all the information is changing how we form, store and reconstruct memories, making us more forgetful. This project focused on the impact of technology in human memory. A multimedia installation was produced about how we reconstruct and make associations between memories, as well as a critical essay to foster the questioning about technology and manipulation of the individual memory.

This dissertation was divided into three main chapters, the first was the literature review, where concepts and ideas were studied; the second was the state of the art, with an analysis and discussion of a selection of artworks; and the third was a detailed description of the production of the installation, from its idealization to the implementation making connections with concepts and ideas studied on the first and second chapters.

The first chapter was divided into two subchapters, in the first we researched on the human brain; how it works; how we form, store and reconstruct memories; the importance of emotions; and false memories. We based our research on scientific papers and books from neuroscientists such as Steven Rose, Larry Squire, James McGaugh, Suzana Herculano Houzel and António Damásio. We noted that the human is a complex system and that different functions of the human memory depend on different brain regions, but also on their connection. The hippocampus is necessary for the recollection of events while the amygdala is responsible for

Conclusions

the processing of emotions. We noted that experiences with high emotional significance are the ones that last longer and that the reconstruction of the same memories can result in the loss of some details over time, generating false memories. In the second subchapter we researched on human archivist practices; how we have been outsourcing our memory over the centuries; how digital technology changed our habits and culture, and possible outcomes; and the importance of forgetting. We based our research on books and papers from authors, engineers and researchers such as Viktor Mayer-Schonberger, Sebastian Groes, Pierre Lévy, Charlie Gere, Gordon Bell, and Anastasia Dedyukhina. We noted that for centuries we have been relying our memory on external mechanisms and devices from the development of language to picture-making and printed books. We tried to understand some cultural changes after World War II, regarding the fast development of technology and how we got to where we are today, with small devices that can access almost all of the world's information in seconds. We noted that at the same time we have this access it is changing how we form and store memories, making us more forgetful.

In the second chapter we selected nine artworks and multimedia installations that explored questions related to the human brain, to human memory processes such as recollection. The selection was based on how the concepts and ideas were materialized, on formal aspects such as image and sound processing, and also on their year of production. All the selected works were produced by contemporary artists such as Davide Quayola, Refik Anadol and Pierre Huyghe.

The third chapter consisted on a detailed description of the production process of the video and sound installation, as well as how the concepts studied on the first and second chapters contributed to its creation. The installation, named *Evoking a Simulated Past*, is a simulation of memories that were intentionally created using video footage and sound recordings. It explores processes of memory reconstruction and association, given that when we remember certain moments, experiences and people we tend to form a mental representation combining past memories and simulations of the future. The installation consisted of a video projection in the center of the room that displayed visual fragments in constant evolution and transformation, leading the viewer on a journey through the dynamic condition of the human memory. As a complement of the installation a critical essay was made and became available on the website, so the public could read more about the project, the research and the artists' intentions. This essay was created in order to foster the questioning about the impact of technology on the human memory and its possible outcomes in the near future.

5.2 Fulfillment of objectives

This dissertation was developed in the area of Culture and Arts and presents a contribution to the artistic community and is accessible to the general public, with the creation of a multimedia installation and its respective documentation available online.

The main goals were the creation of an original artwork about the processes of memory reconstruction and association, and the creation of an critical essay that would foster the questioning on the impact of technology on the human memory. The installation, presented in a cultural space, allowed the public to get closer to the ideas discussed along this dissertation. Through the observation at the opening and the collected feedback it was possible to note that the public got involved with the artwork, and in some cases started a discussion from the synopsis, at the room entrance.

In this regard, the main goals were fulfilled, but we cannot conclude the reach of the project beyond the installation room.

5.3 Future Work

The installation was presented in a cultural space in order to get closer to the general public. In this way, we intend to take the installation to other cultural spaces, such as galleries, museums and festivals, so we can have a wider reach and generate more awareness and discussion on the impact of technology on the human memory. Allied to this, we will continue to update the website.

Since the study of human memory is under research, and the study of the impact of digital technology in cognitive processes (such as learning, reasoning, creativity and memory) is relatively recent, we intend to continue our research. In this regard, we leave open the possibility of continuity of the multimedia installation and its evolution into a new artwork.

References

Ambrose, Stanley H. 2001. "Paleolithic Technology and Human Evolution." *Science* **291** (5509). doi: 10.1126/science.1059487.

Baars, Bernard, and Nicole Gage. 2010. *Cognition, Brain, and Consciousness: Introduction to Cognitive Neuroscience*. Elsevier.

Besser, Stephan. 2016. "Calling Gaia: World Brains and Global Memory." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*.: Palgrave Mcmillan.

Bliss, Tim. 1998. "The Physiological Basis of Memory." In *From Brains to Consciousness? Essays on the new Sciences of the Mind*. Penguin Books.

Brown, Roger, and James Kulik. 1977. "Flashbulb memories." *Cognition* 5 (1):73-99. doi: [https://doi.org/10.1016/0010-0277\(77\)90018-X](https://doi.org/10.1016/0010-0277(77)90018-X).

Brumm, Adam, Adhi Agus Oktavianna, Basran Burhan, Budianto Hakim, Rustan Lebe, Jian-xin Zhao, Priyatno Sulistyarto, Marlon Ririmasse, Shinatria Adhityatama, Iwan Sumantri, and Maxime Aubert. 2021. "Oldest cave art found in Sulawesi." *Science Advances* 7 (3). doi: 10.1126/sciadv.abd4648.

Bush, Vannevar. 1945. "As We May Think." *The Atlantic*.

Cahill, Larry, Richard Haier, James Fallon, Michael Alkire, Cheuk Tang, David Keator, Joseph Wu, and James McGaugh. 1996. "Amygdala activity at encoding correlated with long-term, free recall of emotional information." *Proceedings of the National Academy of Sciences* 93. doi: 10.1073/pnas.93.15.8016.

Caldas, Alexandre. 2020. Deus Cérebro. In *Inesgotável*, edited by António José de Almeida: Panavideo.

Candy, Linda. 2006. "Practice Based Research: A Guide." *CCS Report*: V1.0 November.

Carey, Benedict. 2018. "A Brain Implant Improved Memory, Scientists Report." *The New York Times*, 6 February 2018. Accessed 27/01/2021. <https://nyti.ms/2Ek9q5R>

Carr, Nicolas. 2016. "Misled by Metaphor." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*.: Palgrave Mcmillan.

Childs, Peter. 2016. "Memory and the Fictional Imagination: Creating Memories." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*.: Palgrave Macmillan.

Coleman, Ashley, and John Snarey. 2011. "James-Lange Theory." *Encyclopedia of Child Behavior and Development* 2:844-846.

Collins, Barry. 2021. Microsoft Could Bring You Back From The Dead... As A Chat Bot. Accessed 30/03/2021.

Culotta, Elizabeth. 2010. "Did Modern Humans Get Smart Or just Get Together?" *Science* **328** (5975). doi: 10.1126/science.328.5975.164.

Costa, Rui. 2020. Deus Cérebro. In *A Peça que Falta*, edited by António José de Almeida: Panavideo.

Czerwinski, Mary, Douglas W. Gage, Jim Gemmell, Catherine C. Marshall, Manuel Pérez-Quinones, Meredith M. Skeels, and Tiziana Catarci. 2006. "Digital Memories in an Era of Ubiquitous Computing and Abundant Storage." *Communications of the ACM* **49**. doi: 10.1145/1107458.1107489.

Damásio, António. 1995. *O erro de Descartes: emoção, razão e cérebro humano*: Publicações 86

Europa-América.

Damásio, António. 2020. Deus Cérebro. In *Maquinaria das Emoções*, edited by António José de Almeida: Panavideo.

Davis, M., and P. Whalen. 2001. "The amygdala: vigilance and emotion." *Molecular Psychiatry* 6. doi: <https://doi.org/10.1038/sj.mp.4000812>.

Davis, Nicola. 2019. "'Save your money': no evidence brain health supplements work, say experts." *The Guardian*.

Dedyukhina, Anastasia. 2020. Deus Cérebro. In *Inesgotável*, edited by António José de Almeida: Panavideo.

Depper, Corin. 2016. "Metaphors of Memory: From the Classical World to Modernity." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*. Palgrave Macmillan.

Domo. 2018. Data Never Sleeps 6.0.

Ekman, Paul, and Daniel Cordaro. 2011. "What is Meant by Calling Emotions Basic." *Sage: Emotion Review* 3. doi: <https://doi.org/10.1177/1754073911410740>.

Epley, Nicholas, Adam Waytz, and John Cacioppo. 2007. "On Seeing Human: A Three-Factor Theory of Anthropomorphism." *Psychological review* 114:864-86. doi: 10.1037/0033-295X.114.4.864.

Epstein, Robert. 2016. "The empty brain." *aeon*, May 18, 2016. Accessed February 9, 2021. <https://aeon.co/essays/your-brain-does-not-process-information-and-it-is-not-a-computer>.

Ezzyat, Youssef, Paul A. Wanda, Deborah F. Levy, Allison Kadel, Ada Aka, Isaac Pedisich, Michael R. Sperling, Ashwini D. Sharan, Bradley C. Lega, Alexis Burks, Robert E. Gross, Cory S. Inman, Barbara C. Jobst, Mark A. Gorenstein, Kathryn A. Davis, Gregory A. Worrell, Michal T. Kucewicz, Joel M. Stein, Richard Gorniak, Sandhitsu R. Das, Daniel S. Rizzuto, and Michael J. Kahana. 2018. "Closed-loop stimulation of temporal cortex rescues functional networks and improves memory." *Nature Communications* 9 (1):365. doi: 10.1038/s41467-017-02753-0.

Favre-Bulle, Itia A., Daryl Preece, Timo A. Nieminen, Lucy A. Heap, Ethan K. Scott, and Halina Rubinsztein-Dunlop. 2015. "Scattering of Sculpted Light in Intact Brain Tissue, with implications for Optogenetics." *Scientific Reports* 5 (1):11501. doi: 10.1038/srep11501.

Fonseca-Azevedo, Karina, and Suzana Herculano-Houzel. 2012. "Metabolic constraint imposes tradeoff between body size and number of brain neurons in human evolution." *PNAS* 109. doi: [www.pnas.org/cgi/doi/10.1073/pnas.1206390109](https://doi.org/10.1073/pnas.1206390109).

Frankland, Paul W., and Bruno Bontempi. 2005. "The Organization of Recent and Remote Memories." *Nature Reviews: Neuroscience* 7. doi: <https://doi.org/10.1038/nrn1825>.

Friedewald, Michael, and Oliver Raabe. 2011. "Ubiquitous computing: An overview of technology impacts," *Telematics and Informatics* 28 (2):55-65. doi: <https://doi.org/10.1016/j.tele.2010.09.001>.

Gemmell, Jim, Gordon Bell, and Roger Lueder. 2006. "MyLifeBits: A Personal Database for Everything." *Communications of the ACM* 49.

Gemmell, Jim, Gordon Bell, Roger Lueder, Steven Drucker, and Curtis Wong. 2002. "MyLifeBits: Fulfilling the Memex Vision." *Microsoft Research*. doi: 10.1145/641007.641053.

Gere, Charlie. 2008. *Digital Culture*: Reaktion Books.

Gray, Jim. 1999. "What next? A dozen information-technology research goals." ACM.

Groes, Sebastian. 2016. *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*: Palgrave Macmillan.

Harbisson, Neil. 2020. Deus Cérebro. In *Inesgotável*, edited by António José de Almeida: Panavideo.

Herculano-Houzel, Suzana. 2020. Deus Cérebro. In *Maquinaria das Emoções*, edited by António José de Almeida: Panavideo.

Jeffries, Stuart. 2011. Why we must remember to delete- and forget- in the digital age. Accessed 25/09/2020.

Johnson, Bobbie, and Lee Glendinning. 2007. Apple proclaims its revolution: a camera, an iPod ... oh, and a phone. Accessed 30/03/2021.

Kaku, Michio. 2020. Deus Cérebro. In *A Peça que Falta*, edited by António José de Almeida: Panavideo.

LaBar, Kevin S., and Roberto Cabeza. 2006. "Cognitive neuroscience of emotional memory." *Nature Reviews: Neuroscience* 7(1). doi: 10.1038/nrn1825.

Levitin, Daniel. 2020. Deus Cérebro. In *Em Construção*, edited by António José de Almeida: Panavideo.

Lévy, Pierre. 2005. "Collective Intelligence, A Civilization: Towards a Method of Positive Interpretation." *Journal of Politics Culture and Society*. doi: 10.1007/s10767-006-9003-z

Lovinger, Caitlin. 2019. "Don't Quote Me." *The New York Times*.

Kirkpatrick, James, Razvan Pascanu, Neil Rabinowitz, Joel Veness, Guillaume Desjardins, Andrei A. Rusu, Kieran Milan, John Quan, Tiago Ramalho, Agnieszka Grabska-Barwinska, Demis Hassabis, Claudia Clopath, Dharshan Kumaran, and Raia Hadsell. 2017. "Overcoming catastrophic forgetting in neural networks." *Proceedings of the National Academy of Sciences* 114 (13):3521. doi: 10.1073/pnas.1611835114.

Klein, Stanley B., Theresa E. Robertson, and Andrew W. Delton. 2010. "Facing the future: memory as an evolved system for planning future acts." *Memory & cognition* 38 (1):13-22. doi: 10.3758/MC.38.1.13.

Kuo, Lily. 2019. "China bans 23m from buying travel tickets as part of 'social credit' system." *The Guardian*.

Lautieri, Amanda. 2012. "Long-Term Effects of Adderall Use." <https://americanaddictioncenters.org/adderall/long-term-effects>.

LeDoux, Joseph. 2012. "Rethinking the Emotional Brain." *Neuron* 73 (4):653-676. doi: <https://doi.org/10.1016/j.neuron.2012.02.004>.

Lesk, Michael. 1997. How Much Information is There in the World? Accessed 5/10/2020.

Lum, Jarrad A. G., Gina Conti-Ramsden, Debra Page, and Michael T. Ullman. 2012. "Working, declarative and procedural memory in specific language impairment." *Cortex* 48 (9):1138-1154. doi: <https://doi.org/10.1016/j.cortex.2011.06.001>.

Markram, Henry. 2020. Deus Cérebro. In *Em Construção*, edited by António José de Almeida: Panavideo.

Matthews, P M, and P Jezzard. 2004. "Functional magnetic resonance imaging." *Journal of Neurology, Neurosurgery & Psychiatry* 75 (1):6-12.

Mayer-Schonberger, Viktor. 2011. *Delete: The Virtue Of Forgetting In The Digital Age*: Princeton University Press.

McGaugh, James L. 2003. *Memory and Emotion*: Weidenfeld & Nicolson.

McGaugh, James. 2000. "Memory - a Century of Consolidation." *Science* **287**. doi:10.1126/science.287.5451.248.

McGaugh, James. 2020. Deus Cérebro. In *Em Construção*, edited by António José de Almeida.

McGilchrist, Iain. 2010. "Reciprocal organization of the cerebral hemispheres." *Dialogues in clinical neuroscience* 12 (4):503-515. doi: 10.31887/DCNS.2010.12.4/imcgilchrist.

McGilchrist, Iain. 2020. Deus Cérebro. In *Inesgotável*, edited by António José de Almeida: Panavideo.

Miller, Kenneth. 2015. "Will You Ever Be Able to Upload Your Brain?" *The New York Times*, October 10, 2015. Accessed September 23, 2020. <https://nyti.ms/1VLghZ4>.

Moncur, Wendy. 2016. "Living Digitally." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences*.: Palgrave Mcmillan.

Murray, Stuart. 2009. *The Library: An Illustrated History*: New York, NY: Skyhorse Publishing.

Neumann, John Von. 1958. *The Computer & the Brain*: Yale University Press.

N. d. Axon. In Encyclopedia Britannica.

Ogawa, S., T. M. Lee, A. R. Kay, and D. W. Tank. 1990. "Brain magnetic resonance imaging with contrast dependent on blood oxygenation." *Proceedings of the National Academy of Sciences of the United States of America* 87 (24):9868-9872. doi: 10.1073/pnas.87.24.9868.

Panavideo. 2020. Deus Cérebro. In *Maquinaria das Emoções*, edited by António José de Almeida.

Panavideo. 2020. Deus Cérebro. In *Em Construção*, edited by António José de Almeida.

Panavideo. 2020. Deus Cérebro. In *Inesgotável*, edited by António José de Almeida.

Parnavelas, John. 1998. "The Human Brain: 100 Billion Connected Cells." In *From Brains to Consciousness? Essays on the new Sciences of the Mind*, edited by Steven Rose. Penguin Books.

Phelps, Elizabeth. 2004. "Human Emotion and memory: interactions of the amygdala and hippocampal complex." *Current Opinion in Neurobiology* 14. doi: 10.1016/j.conb.2004.03.015.

Pottenger, W. Morton , Swaine, . Michael R. , Freiburger, . Paul A. and Hemmendinger, . David. "Computer." Encyclopedia Britannica, September 22, 2020.
<https://www.britannica.com/technology/computer>.

Prinz, Jesse. 2004. "Which Emotions are Basic?" In *Emotion, Evolution, and Rationality*. Oxford University Press.

Ramirez, Steve, Xu Liu, Pei-Ann Lin, Junghyup Suh, Michele Pignatelli, Roger Redondo, Tomás Ryan, and Susumu Tonegawa. 2013. "Creating a False Memory in the Hippocampus." *Science (New York, N.Y.)* 341:387-91. doi: 10.1126/science.1239073.

Richardson, Mark P., Bryan A. Strange, and Raymond J. Dolan. 2004. "Encoding of emotional memories depends on amygdala and hippocampus and their interactions." *Nature Neuroscience* 7 (3):278-285. doi: 10.1038/nn1190.

Roberts, Adam. 2016. "'We Can Remember It, Funes, Wholesale': Borges, Total Recall and the Logic of Memory." In *Memory in the Twenty-First Century: New Critical Perspectives from the Arts, Humanities, and Sciences.*: Palgrave Mcmillan.

- Robins, Trevor. 1998. "The Pharmacology of Thought and Emotion." In *From Brains to Consciousness? Essays on the new Sciences of the Mind*. Penguin Books.
- Roesler, R., and J. L. McGaugh. 2010. "Memory Consolidation." In *Encyclopedia of Behavioral Neuroscience*, edited by George F. Koob, Michel Le Moal and Richard F. Thompson, 206-214. Oxford: Academic Press.
- Rose, Steven. 2006. *The 21st Century Brain: Explaining, Mending and Manipulating the Mind*. Vintage.
- Sample, Ian. 2005. "The man with the perfect memory - just don't ask him to remember what's in it." *The Guardian*. Accessed February 16, 2021.
<https://www.theguardian.com/science/2005/dec/28/research.highereducation>.
- Sandrone, Stefano, Marco Bacigaluppi, Marco R. Galloni, and Gianvito Martino. 2012. "Angelo Mosso (1846–1910)." *Journal of Neurology* 259 (11):2513-2514. doi: 10.1007/s00415-012-6632-1.
- Silva, Alcino. 2020. Deus Cérebro. In *A Peça que Falta*, edited by António José de Almeida: Panavideo.
- Sparrow, Betsy, Jenny Liu, and Daniel M. Wegner. 2011. "Google Effects on Memory: Cognitive Consequences of Having Information at Our Fingertips." *Science* 333 (776). doi: 10.1126/science.1207745.
- Squire, Lary R. 1998. "Memory and Brain Systems." In *From Brains to Consciousness? Essays on the new Sciences of the Mind*. Penguin Books.
- Svoboda, Josef, and Doris Nabert. 1999. "Noosphere." In *Environmental Geology*, 438-440. Dordrecht: Springer Netherlands.
- Talbot, Margaret. 2009. "Can a daily pill really boost your brain power?" *The Guardian*, 20 September 2009.
<https://www.theguardian.com/science/2009/sep/20/neuroenhancers-us-brain-power-drugs>.

Treffert, Darold A. 2009. "The savant syndrome: an extraordinary condition. A synopsis: past, present, future." *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 364 (1522):1351-1357. doi: 10.1098/rstb.2008.0326.

Ullman, Michael T. 2004. "Contributions of memory circuits to language: the declarative/procedural model." *Cognition* 92 (1):231-270. doi: <https://doi.org/10.1016/j.cognition.2003.10.008>.

Wickens, Andrew. 2015. *A History of the Brain: From Stone Age Surgery to Modern Neuroscience*. Psychology Press.

Williams, H. L., Conway, M. A., & Cohen, G. (2008). Autobiographical memory. In G. Cohen & M. A. Conway (Eds.), *Memory in the real world* (pp. 21–90). Psychology Press.

Zabolocki, Michael, Kasandra McCormack, Mark van den Hurk, Bridget Milky, Andrew P. Shoubridge, Robert Adams, Jenne Tran, Anita Mahadevan-Jansen, Philipp Reineck, Jacob Thomas, Mark R. Hutchinson, Carmen K. H. Mak, Adam Añonuevo, Leon H. Chew, Adam J. Hirst, Vivian M. Lee, Erin Knock, and Cedric Bardy. 2020. "BrainPhys neuronal medium optimized for imaging and optogenetics in vitro." *Nature Communications* 11 (1):5550. doi: 10.1038/s41467-020-19275-x.

Zheng, Jie, Kristopher L. Anderson, Stephanie L. Leal, Avgusta Shestyuk, Gultekin Gulsen, Lilit Mnatsakanyan, Sumeet Vadera, Frank P. K. Hsu, Michael A. Yassa, Robert T. Knight, and Jack J. Lin. 2017. "Amygdala-hippocampal dynamics during salient information processing." *Nature Communications* 8 (1):14413. doi: 10.1038/ncomms14413.

Zuboff, Shoshana. 2019. *The Age of Surveillance Capitalism*. London: Profile Books.

2001. "MyLifeBits." <https://www.microsoft.com/en-us/research/project/mylifebits/>.

Annexes



Fig. 55, 56: Poster used for the communication of the installation.

evoking a simulated past

por Mariana Vilanova

gnration

instalação 9 – 19 junho 2021

Ao longo da História o ser humano foi procurando formas de melhorar as suas capacidades cognitivas, como a memória, apoiando-se para isso em mecanismos e dispositivos externos, como a escrita ou a produção de imagens. Hoje temos acesso a quase toda a informação do mundo nos nossos bolsos o que nos leva a confiar demasiado na tecnologia para guardar as nossas memórias. Aquilo que nos dá acesso a toda essa informação está a transformar o modo como formamos, armazenamos e reconstruímos memórias.

Quando nos lembramos de certos momentos, experiências e pessoas geralmente formamos uma representação mental ao combinar memórias passadas e simulações do futuro, e esta associação faz com que as nossas memórias não sejam fixas nem estáticas.

Esta instalação explora os processos de reconstrução e associação de memórias. A projeção disposta no centro da sala, mostra fragmentos visuais em constante evolução e transformação, conduzindo o espectador por uma viagem sobre a condição dinâmica da memória humana.

Mariana Vilanova é uma artista que vive e trabalha na cidade do Porto. A ideia da tecnologia enquanto extensão do ser humano e como meio de criação e destruição constituem o corpo da sua prática artística. Em 2020 começou a desenvolver trabalho sobre a memória humana e como esta se relaciona com as tecnologias do século XXI. Recentemente apresentou a obra *Hiato* no Festival Semibreve e em colaboração com Francisco Oliveira; a obra *War and the End of Empathy*, na Galeria Municipal do Porto, no âmbito da exposição coletiva *Depois do Estouro*; e a performance *Máxima Intrínseca*, com Francisco Antão, no Planetário do Porto, em colaboração com a OLEC.

www.evokingasimulatedpast.com

Throughout History human beings have been looking for ways to enhance their cognitive abilities by relying on mechanisms and external devices, such as writing and picture-making. Today, we have access to almost all the information of the world in our pockets which leads us to trust too much on technology to store our memories. The access to all that information is changing how we form, store and reconstruct memories.

When we remember certain moments, experiences and people we tend to form a mental representation combining past memories and simulations of the future, and this association makes our memories neither fixed or static.

This installation explores processes of memory reconstruction and association. The projection arranged in the center of the room displays visual fragments in constant evolution and transformation, leading the viewer on a journey through the dynamic condition of the human memory.

Mariana Vilanova is an artist currently living and working in Porto. The idea of technology as an extension of the human being and as means for creation and destruction is a major subject for her work. In 2020 she began to work on human memory and how it relates to 21st century technologies. Recently she presented the work *Hiato* at the Monastery of Tibães, in collaboration with Francisco Oliveira for Semibreve Festival; *War and the End of Empathy* at Galeria Municipal do Porto for the collective exhibition *Depois do Estouro*; and the performance *Máxima Intrínseca*, with Francisco Antão at Planetário do Porto, in collaboration with OLEC.



www.gnration.pt

Fig. 57: Gallery guide.

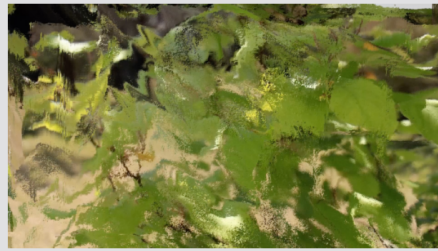
EVOKING A SIMULATED PAST

a video and sound installation by Mariana Vilanova

Documentation



How many memories I bring with me from this place... the light and colors so unique, the smell of the ocean, green wood, sunscreen, the feeling of salt on the skin, sand on the feet, and the uninterrupted sound of the ocean at distance.



This apple tree must be a little younger than me, every year it only grows one or two apples, but they are so tiny I haven't tasted them yet.

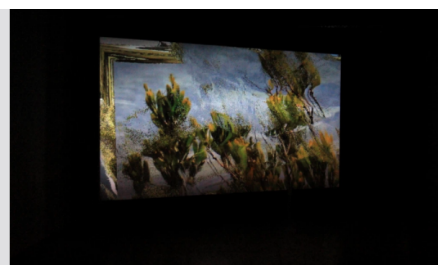


Fig. 58, 59, 60: Evoking a Simulated Past website: evokingasimulatedpast.com.