Memory, Time and Language:
A Mental Time Travel Model in a Narrative Discourse

MSc Thesis *(Afstudeerscriptie)*

written by

Federico Schiaffino
(born September 27th, 1994 in Rome, Italy)

under the supervision of **Prof. Dr. Michiel van Lambalgen**, and submitted to the Examinations Board in partial fulfillment of the requirements for the degree of

MSc in Logic

at the *Universiteit van Amsterdam.*

Date of the public defense:	**Members of the Thesis Committee:**
May 13, 2020	Dr. Paul Dekker (Chair)
	Dr Machiel Keestra
	Prof. Dr. Michiel van Lambalgen (Supervisor)
	Dr. Julian Schlöder
	Dr. Katrin Schulz

Institute for Logic, Language and Computation

Abstract

In this thesis, the cognitive implications following the emergence of a memory system capable of locating events in time are discussed. With this evolution individuals have been able to mentally travel in time, which has significantly altered their learning processes and behaviour. In particular, individuals have been able to mentally represent scenes independently of context. Such ability has had far reaching consequences as humans have been able to communicate about non-present objects or events. We argue that this cognitive ability has set the groundwork for the evolution of narratives. This thesis proposes a model to evaluate the cognitive relation between mental time travel and narratives. We undertake such analysis by examining the cognitive processes related to mental time travel and investigate their role in narrations. Finally, empirical data are provided, with the cases of autism and schizophrenia. Both disorders are characterised by an impaired ability to form meta-representations. We analyse the effects of such deficit in relation to their narrative skills.

Acknowledgements

A couple of years back, after graduating in Mathematics, it would have been unthinkable for me to do such an interdisciplinary masters and to write a thesis in such a topic. I thus feel the need to thank everybody in the ILLC, an environment full of talented people to which it has been an insurmountable honour to be part of.

In particular, I would like to thank Michiel, not only for being a great supervisor, but also for the two courses I had the opportunity to undertake, for your meticulous feedback and your encyclopedic knowledge. Most importantly, I would like to thank you for giving me a free reign with this thesis, allowing me to discover a new topic and showing me the path to come across what I like most.

I would also like to express my gratitude to Maria, for being a great program director, who was always available for the students providing insightful advice. A huge thank you goes to Tanja, your support has been invaluable, I will always remember your aid that Monday morning after King's Day a year ago. Finally, I would like to thank Patty, for the soft reminders and for being always open for a good laugh.

On a more personal level, I would like to first and foremost thank my family, especially my parents. Like the poet said, "Mio padre in fondo aveva anche ragione, a dir che la pensione è davvero importante. Mia madre non aveva poi sbagliato, a dir che un laureato conta più d'un cantante." Thank you for giving me the opportunity to study abroad, this thesis was not possible without your encouragement and support. Whatever I did in the past, and whatever I will achieve in the future will always be thanks to you and I will always owe you for this. I would like to thank my brother Filippo, for your help during the application process. I wish you to find what you like most and I encourage you to keep sharing our interests together.

I would also like to thank my close friends Leonardo, Idlir and Leopoldo. The first one, for telling me about the master. The second for your precious help in the years that followed our bachelor. Leopoldo for being there, a great roomie and a good friend. To all three I wish and hope that our careers will keep us close and together we can achieve great things. To my long time friend Guido, the part on animals did not make it into this thesis, it has been a pleasure to confront our ideas nonetheless. Although we are following different career paths, I hope we will keep sharing our opinions and I am curious to know what the future holds for us.

Finally, I would like to thank the amazing city that is Amsterdam and the fantastic people I met during these years. Anna, thank you for your curiosity and your company during the hard working days in the library. Stephanie, thank you for the clear picture and the positive impact you had on this thesis.

Lastly, I would like to thank all my fellow classmates of the MoL. I have never met so many gifted individuals in my life. Sharing this experience with you has made it unforgettable. Thank you for the brainstorming, the Ex Falso adventures, the nice dinners and the amazing concerts. Amongst these I cannot exempt from thanking Julia, for sharing your vision with me and for your endless help even when least expected.

Contents

Frequently used abbreviations

AC: Autonoetic Consciousness

AG: Achievement Goal

AM: Autobiographical Memory

DM: Declarative Memory

EFT: Episodic Future Thinking

EM: Episodic Memory

MG: Maintenance Goal

MTT: Mental Time Travel

MW: Mind Wandering

SFT: Semantic Future Thinking

SM: Semantic Memory

ToM: Theory of Mind

1
Memory, Time and Language

In Greek mythology, the creation of the world is attributed to Prometheus, who stole fire from the Gods and gave it to humanity. His name means *forethought*. According to the legend, Prometheus is the origin of human intelligence, having taken the power of the Gods and distributed it to humans in order to elevate their minds. He taught them astronomy, mathematics, self-care and is regarded as the hero that enabled humankind to take control over other species (Sakoulas, 2002).

Despite its ancient history, Prometheus' myth, similar to many other ancient Greek legends, is curiously very relevant to our times. Predicting the future is still a highly valued characteristic and plays a role in most everyday activities. As a matter of fact, our society rewards individuals who manage to predict the future most accurately. For example, in chess, the player able to foresee the most moves is more likely to win. Likewise, in the stock market, an investor's main goal is to predict the outcome of certain market share values. Indeed, the importance of forethought is evident by the fact that most civilisations have fortune-teller practices.

This prominence on anticipatory behaviours has arisen following the emergence of an awareness of time. Here we embrace the definition given by Aristotle, who defined time as a measure of change (Mooij, 2005). Without change we cannot perceive time. It is indeed from this powerful force of time, which alters everything around us including ourselves, that humans have developed an inherent ability to try to *read* time, both in retrospect and in forethought.

In Western societies, even at an early age, children are asked what they want to become as adults, what they would like to do next weekend or how their day at school went (Martin-Ordas, 2016). Moreover, after acquiring the first linguistic practices, children are urged to make predictions about the future and form beliefs about the past. More importantly, in many cultures the ability to think of the consequences of an action is a crucial step into adulthood. Children often make mistakes because of their immature behaviour as they omit to realise that an action can have unfortunate effects.

Once again, our society greatly favours individuals capable of foreseeing future outcomes. Moreover, responsible agents are those that can properly think of the consequences of their actions. Thus, an awareness of time is immediately called for in the early stages of childhood. The environment in which children are brought up causes it to develop almost naturally. However, such importance of time in our daily lives is often neglected, not only do our lives depend on it, but our day-to-day behaviour is dominated by time. Interestingly, among the different mental scenes that people can imagine, it seems inconceivable to think of a world without time. One can imagine worlds without the sun or even without oneself, but it appears to be unreasonable to think of a world without time.

Thus, developing a consciousness of time has great implications for individuals. The focus of this thesis is on the cognitive implications that followed the emergence of the awareness of time. What does it mean for human beings to be cognitively able to represent things in time? How do humans relate themselves face to the constant changes in the world? As time is unidirectional and physical time travel may arguably never be possible, a cognitive approach emerged in order to mentally travel in time, that is, the capacity to mentally project oneself in a future scenario or to mentally reconstruct a past event.

Such ability is known as Mental Time Travel (MTT henceforth), first forged by Tulving (1985b) and later reconsidered by T. Suddendorf and Corballis (1997). In this thesis, we attempt to demonstrate that the human ability to predict the future is among their most important skills and allowed the development of other essential properties. The possibility to simulate the past and the future equipped human beings with a considerable adaptability function which can be considered a crucial feature on a par with opposing thumbs or language.

Specifically, MTT allows humans to reconstruct and revaluate past episodes as well as creating expectations and sensations about the future. An impaired MTT ability implies an impossibility to re-experience the past and to foresee the future, in other words, it entails a significant impediment to orient oneself in time. Without MTT capacities, individuals do not have a proper image of themselves, not being able to remember their past. They also face great issues in understanding other individuals and the world around themselves. In more specific detail, as discussed later, a deficit in MTT entails an impairment in the ability to form meta-representations, hence severely restricting one's thought process.

MTT is a key cognitive mechanism highly based on our memory system that helps us pertain a conception of time and deal with its powerful force. As time passes, memories are what remain in terms of the past, without them, there would be no past. With this in mind, the psychologist Daniel Kahneman, in his notable work "Thinking, fast and slow", distinguished two types of selves: the experiencing self and the remembering self (Kahneman, 2011). The former lives only in the present and can retrieve the past, whereas the latter is the record of our experiences. He proposed such distinction to illustrate the importance that humans assign to memories.

Kahneman claims that humans considerably emphasise memories because this is what remains of the experiencing selves. While the experiencing self answers questions referring to present states, e.g. "How are you today?", the remembering self keeps a record of the past and answers questions such as "How was your summer?". In other words, the remembering self is a storyteller, our memories narrate stories, and stories are precisely what we share of our experiences (Kahneman, 2010). Interestingly, stories are concerned with memorable events, so humans tend to give more value to memories than actual experiences as they serve as content for future stories.

Specifically, narrations allow us to include non-present objects or events, in particular, humans spend a significant amount of time narrating the past. Furthermore, like time, humans seem to possess an instinctive attraction for narratives. For instance, when we look at a static picture such as in Figure 1.1 (Wong, 2012), we do not simply see a ship, we see a *ship wrecking*. Although a brief moment is captured in the image, we can easily perceive a time before and after the depicted moment, specifically, see a narrative time which includes a succession of events that led to the represented moment (Abbott, 2008).

Likewise, when children are asked to share their predictions of the future, or their understanding of the past, they are precisely asked to narrate a story. In other words, narrative, memory and time are intricately connected, as the former is a form of communication that allows to represent events unfolding in time. This thesis argues that humans' MTT and narrative abilities are cognitively related. Given that narratives allow the sharing of past events, they are highly reliant on mental constructions. In effective communication, the mental constructions of hearers and speakers correspond, whereas a deficit in MTT results in a limited ability to form mental scenes.

Thus, this thesis evaluates how an impaired sense of oneself in time alters narratives' understanding. Precisely, the emergence of MTT in the human cognitive system considerably changed the communication means as well as their behaviour. As discussed later, MTT develops during childhood, at around the age of four, in parallel with other cognitive functions and a specific memory system. The purpose of this thesis is to analyse the cognitive relation between MTT and narrations.

Despite its importance in everyday life, MTT is subject to different interpretations

Figure 1.1: Sinking Boat

and its definition is still somewhat ambiguous. Distinguishing MTT to other future-oriented behaviours remains particularly challenging. For instance, Tulving emphasised the role of temporal self-consciousness to differentiate MTT from other cognitive processes such as *daydreaming* or planning, claiming that MTT is not achievable without a conscious awareness of the self in time (Tulving, 2002a). In contrast, T. Suddendorf and Corballis (1997) argued that MTT, unlike anticipatory behaviours, requires the inhibition of feelings of the current mental state to form a mental picture of an imagined past or future. Following their train of thoughts, meta-representations are key to the MTT process. They state that anticipatory behaviours, such as doing groceries, do not involve any construction of future scenes, hence should not be classified as MTT.

Finally, other authors have proposed their explanation of MTT. D'Argembeau (2016), for example, insisted that MTT is self-involved only when it includes autobiographical knowledge such as personal goals or future expectations. Conversely, Atance and O'Neill (2001) claimed that true MTT into the future is involved with the *pre-experiencing* of an event. The aim is thus to shed light on the definition of MTT, what it is, what it is not and what are its cognitive requirements.

It is noteworthy that it is also possible to lose MTT abilities, in particular, amnesiac patients have reported defective MTT capacities (Tulving, 1985b). Amnesia involves brain damage that causes a deficit in the memory system, so affected individuals lose their ability to recall specific memories, substantially limiting their MTT skills. In addition, some mental disorders, notably autism and schizophrenia, come with an impaired MTT ability and researchers have studied such cases in relation to their deficits in social and communicative systems.

For these reasons, the significance of MTT in humankind will be evaluated, investigating the capacity to navigate in time in relation to other cognitive abilities such as navigation in space or in other people's minds. In addition, the contributions of these cognitive processes to the communication system will be considered, providing evidence that the advent of a memory system capable of retaining personal information of the past, considerably altered human cognition and consequently their behaviour. MTT allows for the possibility to form expectations and predictions about the future, specifically, it has enabled humans to construct goals towards the future. This thesis will examine how such characteristics are reflected in different human features, demonstrating how future thinking abilities have represented an authentic milestone in human evolution.

The functioning of MTT is analysed in depth in the second chapter of this thesis, detailing how the memory system operates. Specifically, memory functions are considered, particularly in amnesiac patients, discussing why memories of past experiences are prone to error and susceptible to reinterpretations. Interestingly, the adaptability of the memory system is associated with the flexibility of the human mind, in particular, the cognitive capacity to retrieve a past allows us to form mental pictures independently of the present context. In the final section of the chapter, other cognitive processes that require the construction of mental scenes are analysed.

The third chapter investigates the relationship between MTT and narration. The awareness of time forced language to include a time dimension, thus how MTT allowed for the development of new forms of communication is considered. The case of narrative communication is analysed in great detail, particularly, how narratives and MTT operate in parallel. Consequently, their common properties, as well as their evolutionary origins are discussed. Finally, how detaching from actual contexts to form mental pictures is crucial in narration is presented.

In the fourth chapter, an analysis of the development of MTT capacities and other cognitive skills in children is provided, with a focus on MTT abilities in comparison to narrative skills in autism and schizophrenia. These cases will serve as proof of the close cognitive connection of MTT and narration. Finally, in the fifth chapter, a model of MTT is proposed to help clarify its definition and its relationship to other cognitive processes.

2
Time and Cognition

This chapter is dedicated to the perception of time, particularly, how humans understand and relate to it. MTT is the cognitive capacity to revive a past episode or to imagine a future one which enables humans to form a conception of time. First, its structure will be analysed, namely which memory system is involved in it, then from that, the distinctive properties that make it a fundamental mechanism will be examined. Lastly, the similar cognitive processes to MTT are discussed. Such evidence will help form a clearer definition of MTT.

2.1 Components of Mental Time Travel

In the following section, the role of MTT and the cognitive functions it involves are studied. As mentioned earlier, MTT is highly based on memory, in the first part, the kinds of memory that are related to it will be analysed. Researchers have determined that humans possess various kinds of memory systems and the prevailing idea is that each of them comes with a better understanding of the world (Tulving, 1985a). MTT comes with a better understanding of the self, also known as *autonoetic consciousness* (AC). In this section, the characteristics and functioning of AC are investigated. Finally, an introspective examination of the process of MTT will be given.

2.1.1 Declarative Memory

Short-term memory is the knowledge which only endures for a relatively brief period (up to 30 seconds), as opposed to long-term memory which is the knowledge that is retained indefinitely. Here we will discuss the latter, particularly its division into two components, declarative (DM) and non-declarative memory, also referred to as explicit and implicit memory, respectively. DM is the knowledge about facts and personal experiences, and as the name itself suggests, it provides the basis for language semantics, allowing us to understand and develop a perception of the world, as well as comparing pieces of knowledge and choosing knowledge relevant to a particular activity (Corballis

& Suddendorf, 2007). This thesis will focus on DM, which is neurally implemented in the hippocampal region, situated in the medial temporal lobe (Ullman, 2004).

The Canadian neurocognitive scientist, Endel Tulving, identified two major components within DM, semantic and episodic memory (SM and EM respectively) (Tulving et al., 1972). The former is the knowledge of the world, for example, knowing that a week is composed of seven days. It consists of knowledge from past events, which are not necessarily capable of being retrieved. One illustration is, we know Tuesdays follow Mondays, but we are not capable of recalling when we acquired such a fact. SM is the kind of memory that serves the future without requiring any representation of the past. The knowledge of the world helps us in everyday actions as well as future planning, in other words, SM is a future-oriented memory.

On the contrary, EM is a memory related to personal experiences. It is a self-centred memory system that provides a sense of time and oneself. For instance, knowing that Rome is the capital of Italy belongs to our knowledge of the world. However, recalling the first time we visited the city, who we travelled with or in which restaurants we ate belongs to our individual memory, i.e. the EM. As a result, EM locates events along a time dimension, therefore, is time-dependent.

For this reason, it plays a pivotal role in the conception of time and it is related to one's past. The distinction between EM and SM is often indicated as the difference between *knowing* and *remembering*. SM is thus the knowledge from an event, as opposed to EM, which is the personal experience from past events. It is interesting to note that in the learning process, students first remember notions such as definitions or theorems, thus relying on their memory knowledge. With time, they will not need to associate such notions to a memory, but they will acquire knowledge of such a fact (Conway, 2010). For example, students first memorise what the Pythagorean theorem states, later, they will simply know that the square of the hypotenuse is equal to the sum of the square of its opposing sides.

Moreover, not only does EM enable us to relive the past, but it also allows us to form a perception of the future. In 1985, Tulving showed that the cognitive skills for retrieving the past and imagining the future are strictly connected (Tulving & Murray, 1985). Neuroimaging results have supported this idea, as Carr and Viskontas (2007) identified that the hippocampus is activated in the recollection of past events and the conceptualisation of a possible future. Consequently, the hippocampus is often said to work in a 4-dimensional space-time and our understanding of the continuous flow of time relies on it.

Finally, when Tulving distinguished these two kinds of memory systems, he argued that

EM is unique to human beings (Tulving et al., 1972), claiming that what makes humans so unique is not DM itself, but rather its division into EM and SM. Given that many animals have some knowledge of the world, Tulving perceived EM as an extension of SM, more precisely, a sophisticated system that appeared at a later stage in humankind. Following his train of thoughts, the advent of EM radically transformed human cognition, learning and its surroundings. In particular, EM enabled the development of other cognitive skills which demonstrates the significant role of EM in human history (Tulving, 2002b). Lastly, while EM relies on SM, the converse does not hold.

2.1.2 Autonoetic Consciousness

The various memory systems that have been proposed are all associated with different levels of knowing (Tulving, 1985a). If memory is the capacity that allows us to learn from the past, each memory system gives us a different perspective in understanding it. Within DM, both SM and EM come with different forms of consciousness. Tulving proposed noetic consciousness as an aspect deriving from SM, defining noetic consciousness as the awareness of the internal and external world. He further claimed that animals and young children have such knowledge.

By contrast, AC is the awareness related to EM, the capacity to see one's identity and existence through time. It follows that EM comes with a better understanding of the self. The case study provided by Tulving (1985b), in which he examined the case of a patient (known as KC) with a compromised EM due to brain damage, evidenced the role of AC. Although KC had a sound general knowledge of the world, he was unable to either recall episodes from his past or imagine future scenarios. The patient lacked any self-centred memory, and with that, he suffered a loss in the ability to conceive future images. He was characterised as being *trapped* in the present moment.

Most importantly, his language skills were relatively intact, but the patient lost the capacity to remember and lacked a sense of himself in time. Tulving thus concluded that AC is the critical tool that allows humans to mentally travel in time. At the centre of the issue is the notion that the way we conceive ourselves in the past affects how we look at ourselves in the present and future. Therefore, AC influences the way individuals shape their character and identity, in other words, it plays a substantial function in the perception of oneself.

2.1.3 MTT and EM

Finally, after examining the role of EM and the kind of awareness it comes with, this section considers more practical aspects of its function.

The ability to mentally relive past events, as well as foreseeing future ones, heavily relies on EM and AC. As we cannot alter the past, we tend to create expectations about the future. This ability to anticipate the future and plan accordingly is one of the fundamental aspects that enables the flexibility of the human mind. Basic examples are actors that rehearse their parts before going on stage, or an individual that prepares for different topics that may arise in a job interview. Humans have developed a day-to-day dependence on time, and their nature rests on the temporal structure they have established.

Nevertheless, the future is never identical to the past, thus humans need to adapt to new scenarios and MTT encourages this adaptability. When remembering the past, we tend to forget details of it, creating mental images constructed on basic facts causing them to become malleable. Therefore, the past itself does not play such a decisive role, but rather the way we recollect old episodes which is crucial to our understanding of time, that is, MTT is an act of reconstruction rather than reproduction (T. Suddendorf & Corballis, 1997). Remembering consists of organising a storyline, rather than reproducing an episode like a videotape.

Although EM may be unreliable and MTT imprecise, they are both useful and allow us to develop an awareness of the past and the future. MTT has become vital in our everyday lives, faced with daily planning or the amount of time we spend talking about non-present moments. It has allowed the development of fundamental aspects of our society, such as law, education and religion (T. Suddendorf & Corballis, 2007), each of which are intrinsically based on the human ability to predict a future and remember the past. In short, EM and MTT changed human nature and its civilisation.

2.1.4 MTT into the future

So far, we have only discussed the distinction between EM and SM, however, as proposed by Atance and O'Neill (2001), a more definite difference between episodic future thinking (EFT) and semantic future thinking (SFT) should also be formulated. Almost every species possesses future thinking abilities, but the way humans can imagine the future, e.g. how far into the future we can see, is unique among other animals. It is thus useful to introduce a distinction between EFT and SFT.

EFT is the type of plan based on one's specific action, whereas SFT is geared towards daily routine. For example, suppose that upon your arrival home, you need to take your medication, to achieve your task, you decide to place the drugs by the kitchen sink before leaving. Nevertheless, you may want to keep in mind that today is Monday and watching your favourite TV show is the first thing you will do when you get home. Consequently, to make sure your plan is successful, it would be more efficient to leave the medications by the living room near the television (Atance & O'Neill, 2001).

The two plans proposed above are excellent illustrations of the distinction between EFT and SFT. The first plan based on script-like activity is part of SFT, whereas placing the medications in the living room is considered as EFT since it involves foreseeing one's future actions. In other words, SFT is concerned with future public events such as the effect of climate change, whereas EFT refers to the capacity to project oneself into the future to *pre-experience* a specific event (Martin-Ordas, 2016).

Interestingly, no specific mental representation of the self emerges from SM (or from noetic consciousness). For instance, knowing that Rome is the capital of Italy does not generate any feeling of past experience nor requires any mental construction. Conversely, AC triggers a sense of self and a mental representation of it. Consequently, AC and meta-representations are key ingredients of MTT. Henceforth, we will consider the construction of a mental scene involving oneself as a cognitive requirement for MTT.

Furthermore, the distinction between SFT and EFT is compatible with the various findings on patients with damaged hippocampal area. For instance, in the case study by Tulving (1985b), the subject had an overall intact semantic future knowledge, even if he was unable to report possible personal future episodes. It thus seems possible to lose the ability to foresee one's future while maintaining a good knowledge of the *future world*.

A final point worthy of consideration is the extent to which human beings are capable of future thinking. Not only are we capable of imagining a future beyond our reach (e.g. life after death), our planning abilities are substantially more complicated than that of any other species. In particular, long-term planning such as saving for the retirement or the creation of a doomsday Seed Vault in Norway designed to preserve all kinds of plant seeds are good examples of the complexity of our planning capacities. Future thinking is thus among the cognitive skills that makes human beings so unique.

To sum up, the distinction between EM and SM seems to hold for MTT into the future as well. Incorporating oneself in the construction of the future or of the past yields a different cognitive characteristic to future thinking, namely an episodic one. MTT consists of mental constructions involving self-representations that enable humans to flexibly adapt to new scenarios. In the next section, we will analyse the cognitive nature of MTT.

2.2 Nature of MTT

Given the significance of MTT in the daily lives of human beings, the nature of MTT will be discussed in this section, more specifically, how memory and MTT operate, as well as the different factors that influence them. Firstly, an analysis of the unreliability of EM compared to that of SM will be proposed, then, the characteristics involved in MTT are investigated to help define its true nature.

2.2.1 Fallibility of EM

> All happenings are in the mind. Whatever happens in all minds, truly happens (Orwell, 1950).

In the following section, the unreliability of EM in contrast to the efficiency of SM is discussed. In his dystopian novel "1984", the English author Orwell proposed that only what occurs in all minds is truthful. This quote is particularly interesting given the correctness of SM as opposed to that of EM, commonly acknowledged as faulty. SM is the common knowledge of the world, shared among all individuals, these facts are selfless and timeless. Conversely, EM is very often imprecise, as remembering is not like playing a video, consequently, memory is not an exact representation of the past.

Researchers have conducted various experiments on false memories (Loftus, 2005). In particular, striking results have been found concerning the factors that influence our memory system. In the experiment by Gudde, Coventry, and Engelhardt (2015), the authors provided evidence that language influences memory for object location. Subjects' answers to the location of objects was influenced by which demonstrative (*this* or *that*) and possessive (*my* or *your*) was used in the question. Participants reported objects as closer when the demonstrative *this* and the possessive *my* were used compared to *that* and *your*. Therefore, modifying a sentence, even by one word, can alter memory retrievals, evidencing the uncertainty of memory.

Similarly, Loftus and Palmer (1974) demonstrated that the way questions are asked can alter and create false memory. In their experiment, participants were asked to reconstruct details of a video displaying a car accident, such as the speed of a collision or whether they saw any broken glass. Surprisingly, the words used in the question manipulated the answers. In questions with the verb *smash* (e.g. "about how fast the cars were going when they smashed into each other?"), subjects described the accident as more intense, i.e. they reported broken glass and higher speed estimates. Opposing results were found when the same question was asked using the verb *hit*, with participants describing a gentler accident, i.e. mean speed estimates were considerably lower as well as the percentage of individuals who reported broken glass.

Moreover, EM can also be subject to false associations, i.e. when people wrongly identify a new item and combine it with a previous one. Specifically, in an experiment conducted by Roediger and McDermott (1995), subjects, after being shown a list of related items (e.g. *candy, taste, pie, sour, good...*), often made the mistake of reporting a non-represented but context-related word such as *sweet*. Such studies evidence that individuals make gist-based associations. More importantly, they also demonstrate that humans can remember incorrectly, also *remembering* episodes that did not occur.

Finally, various experiments have investigated the ageing effect on both SM and EM, demonstrating that EM is more susceptible to negative effects caused by ageing compared to SM (Piolino et al., 2002). Specifically, elderly participants reported considerably less episodic details of past events compared to the younger subjects. However, in terms of semantic information, no significant age-related discrepancies were found, thus corroborating the dichotomy proposed by Tulving between EM and SM, proving that the latter is more durable than the former.

To sum up, memories are not copies of the past, rather different factors can influence how we remember events. Our memories do not persist in time and are not a fully detailed representation of what happened. The following quote characterises memory's unreliability quite successfully,

> You don't remember what happened. What you remember becomes what happened (Green, 2008).

As time passes, memory of specific episodes dims. The way we look at events depends profoundly on our temporal perspectives. For example, try to remember a challenging exam that you had to pass in order to graduate. The feelings that arise are considerably different from how you felt the night before the exam or the moment when you handed it in. In other words, memory is the present use of past experiences.

An interesting parallel between our perspective in time and space was proposed by Ferretti and Cosentino (2013). The authors compellingly argue that just as we move in space, we see the same objects and things differently, how we see events in the past changes as we move in time. Hence, the same events have different temporal perspectives. For instance, we can easily perceive that a future episode will eventually become part of the past, so changing temporal perspective inevitably changes the representation of the event.

In more specific detail, this is due to the fact that we are different beings each time we recall past events, in the sense that what we know, feel or think is always different. The only constant is change. Consequently, past episodes or the way we look at them are constantly developing. In simpler terms, past experiences are embedded representations of the present (Droege, 2013).

> The very process of comparing the present with the past, both defines the present and changes the past, and the process is on-going (N. Clayton & Wilkins, 2017).

The inaccuracy of EM raises philosophical issues of what is actually real and what is imagined. Are individuals the same across time? This is particularly puzzling considering the role that memory plays in an individual's personality. As N. Clayton and Wilkins (2017) claim, memory is connected to identity. In the third chapter, we will consider which non-episodic forms of memory may contribute to the image of oneself. As language can influence memory, we will thoroughly examine the role that it plays in personality traits.

2.2.2 Prospective brain

With the evidence reported above, it becomes clear that memory's main function is not to preserve an accurate record of the past. However, the unreliability of memory may in part enhance its main strength, namely its adaptability. Given that EM is faulty, researchers have argued that memory serves future purposes (Ingvar, 1985). Memory has long been studied as if it only referred to the past, however, the most recent analyses have focused on its support to imagine the future.

The now well-established view on memory is that we remember facts and things that will most likely be useful in the future (Anderson & Schooler, 1991). Our memory system does not retain all details about the past since we tend to forget certain aspects of events. Such a memory system, however, considerably enhances its adaptability in different scenarios.

> This finding may help explain why we are in fact such poor witnesses. That is, the constructive element in episodic recall is adaptive in that it underlies our ability to imagine possible scenarios rather than actual ones, but it may be rather maladaptive with respect to reconstruction of the actual past (T. Suddendorf & Corballis, 1997).

As mentioned earlier, memory is a not reproductive system, in that remembering is not like playing a tape, but it reconstructs a scene. The *constructive episodic simulation hypothesis* states that the reconstructive nature of memory is due to the role it plays in the simulation of future events. Therefore, EM and SM main functions are to flexibly associate the details of the past and incorporate them in simulations of the future (Schacter & Addis, 2007).

The constructive hypothesis has received ample support from a diverse range of perspectives. For example, in the experiment conducted by Szpunar and McDermott (2008), subjects were asked to envision specific near future events. They were given one minute to imagine a scene as detailed as possible in a given context, with the settings varying between those familiar (e.g. home or pub) and unfamiliar (e.g. jungle or North Pole). The data demonstrated that when imagining future events in familiar contexts, students reported more specific images. More precisely, they reported more sensorial details, as well as a greater feeling of subjective experiences of the event. Such results prove that the content of our memory is, in part, intended to construct mental scenarios of possible futures.

Furthermore, in an experiment conducted by Levine et al. (2002), the recollection of the past and the imagination of future events were compared between that of younger subjects and adults. The data showed that adults generate less episodic details compared to younger subjects, in both imagined scenes and the recollections of the past. As evidenced earlier, EM is more vulnerable to ageing compared to SM. Hence, results were in accordance with the constructive hypothesis that the ability to construct future events is correlated with the ability to retain information of past episodes.

Continuing, the constructive episodic simulation hypothesis is also in line with studies regarding the development of EM and EFT. Different experiments have shown that episodic remembering and future thinking emerge at similar stages in childhood (Atance & O'Neill, 2001; Busby & Suddendorf, 2005). Finally, a vast number of neuroimaging studies have provided evidence that imagining the future and remembering the past rely on the same brain networks, specifically the medial temporal lobe (Szpunar, Watson, & McDermott, 2007; Botzung, Denkova, & Manning, 2008).

With this in mind, Schacter, Addis, and Buckner (2007) proposed the notion of the prospective brain. Since planning for the future is crucial for survival purposes, the authors argue that the brain is primarily prospective, therefore, it uses the stored information to make better predictions of future events. Finally, memory is adaptive as it enables *trying out* the different possible outcomes of a given situation. From this, we can conclude that memory is about the future.

2.2.3 Goal-oriented MTT

Before examining the nature of MTT in the future, we should first point out how such a process can result as defective. Being deeply rooted in EM, simulating the future can rely on false memories of the past. Imagining and remembering share various cognitive components, so are easily confused. It is obvious that foreseeing the future is a complex task as there are innumerable ways in which things can go wrong. Moreover, if individuals create expectations based on what they remember, which is prone to error, these may be amiss.

For example, various psychologists have shown that humans tend to underestimate the time to complete specific actions in the future (Kahneman & Tversky, 1977; Buehler, Griffin, & Peetz, 2010). Gilbert and Wilson (2007) evidenced the different errors that simulations of the future can face. They argue that simulations of the future are unrepresentative, the future is never identical to the past, thus basing our expectations on what happened earlier is misleading. Furthermore, when we simulate the future, we omit numerous details of scenarios, simulations are thus *essentialised* and abbreviated. Finally, simulations are decontextualised, with individuals often neglecting the influence that the present contexts can have.

A good example is buying groceries when hungry compared to shopping after a meal. In the first case, you will most likely buy food that satisfies your current hunger as opposed to the latter case, which is more driven by an anticipatory behaviour. Put differently, remembering and imagining are faulty in similar ways, given that the brain is subjective in both recollection and anticipation.

It should now be clear that there are several ways in which our predictions can fail, but MTT remains the only tool available to face the power of time. In particular, future thinking allows us to take farsighted decisions (e.g. planning for retirement) and to create mental scenarios that aim to represent an actual situation as much as possible. In other words, simulations are especially appropriate in planning and problem-solving tasks.

To illustrate, Gollwitzer showed that mentally constructing a future event can enhance prospective memory, the memory of remembering to accomplish specific tasks in the future (Gollwitzer, 1999). More precisely, he placed emphasis on the difference between *implementation intentions* and *goal intentions*. The latter being a form of commitment to one's goal, i.e. "I intend to do x", while the former is an intention linked to an anticipated opportunity; "When situation x arises, I will perform y". His results showed that goals have better chances of being accomplished when they are related to a specific future situation, i.e. implementation intentions enhance goal-oriented behaviour.

Having analysed the dynamics of future-oriented MTT, we shall now examine its true nature, i.e. what are the factors that determine the subjective feeling of one's self in the future. A great number of experiments have analysed the characteristics of EFT, for example, D'Argembeau and Mathy (2011) showed that EFT is constructed based on autobiographical knowledge. In their experiment, students were asked to generate a possible future event from a random cue word or a cue referring to a personal goal. Findings suggested that future events are generated more easily with cues about goals, particularly providing information about personal goals enhances the specificity and the level of episodic details of subjects' mental constructions. Subsequently, the relationship between future thinking and one's personal goal became very relevant to the theme of prospection.

Various results have led to the idea that the two have a tight relationship (Cole & Berntsen, 2016). D'Argembeau, for instance, firmly believes that a future simulation must include autobiographical knowledge to be perceived as EFT (D'Argembeau, 2016). This includes the knowledge of personal goals, which are frequently incorporated in simulations of the future. More precisely, he argues that the crucial function of EFT is to represent a personal desired future. Humans tend to *look into* the future to anticipate the possible outcomes, perhaps to avoid those that are negative and encourage more positive outcomes, that is, goal-related knowledge helps structure imagined scenarios and planning for the future.

Neurocognitive results have supported this concept. Specifically, EFT and goal-processing activate similar brain regions, particularly in the medial prefrontal cortex (Stawarczyk & D'Argembeau, 2015). In an experiment led by D'Argembeau and Van der Linden (2012), the factors that enhanced the subjective feeling of self in a future event were studied. Participants were asked to generate a future event in response to a cue word and the sensory-perceptual qualities of their mental images were then assessed. The results indicated that the events considered as more likely to happen in the future increased the vividness of the mental images. Furthermore, subjects who imagined future events relating to their personal goals, felt the event as closer in time and reported considerable more sensation of pre-experiencing. The authors thus concluded that goal processing is key to EFT and works as distinction between other future-oriented processes such as imagination.

With this in mind, Wilson and Ross (2001) proposed the *temporal appraisal theory*, which holds that individuals tend to disparage more their selves in the distant past than in the near one. Conversely, they are also likely to commend the present self and future ones when asked to form judgements about them. Following their experiments, the authors suggested that the participants evaluated themselves as continually improving, that is, goal-processing is critical when it comes to forming a sense of time.

In summary, EFT is not the future counterpart of EM. Future simulations are directed by personal goals and our expectations. Human cognition is thus characterised by goal-processing to the point where we can affirm that humans are goal-oriented beings. MTT involves goals and helps individuals to form sensations of the future to better prepare them to future outcomes. Just as remembering is not like playing a videotape, imagining the future consists of a sequence of fragmented memories rather than an event in its entirety unfolding over time, i.e. we perceive the future as anticipated memories. With the evidence reported above, we can revise the notion of MTT in the future. Specifically, MTT consists in a world model that includes oneself, episodic details and a future scenario. These mental scenes set the groundwork for the construction of future plans and allow individuals to form expectations. Considering how the world can evolve is crucial for planning and goal-processing, and MTT provides the fundamentals of such aspects.

More importantly, MTT is a mental mechanism that incorporates simultaneous goals. The world model we construct in MTT establishes the preconditions for a plan and allows us to deduce what can be achieved. For instance, suppose tonight your friend Peter is hosting a dinner party for his birthday. You can create a mental image of the dinner in which you imagine the cake, the presents, people celebrating and dancing. From such visual imagery, you can construct plans such as how long you intend to stay at the party, with whom you will socialise, thus forming expectations that will evaluate your future plans. In other words, a broad range of planning and goals are involved in MTT and their purpose is to equip individuals with an adequate consciousness of the future. In the following section we shall discuss such definition in relation to other cognitive systems.

2.3 MTT and other cognitive functions

In the final section of this chapter, the other mental abilities related to MTT will be presented. Interestingly, neuroimaging studies have provided evidence that MTT activates similar brain regions as Mind Wandering (MW), Theory of Mind (ToM) and spatial navigation tasks (Spreng, Mar, & Kim, 2009). It is thus interesting to investigate the common cognitive function of such processes. Researchers have proposed *scene construction*, the context-independent capacity to construct mental pictures, as the shared cognitive feature. This section studies the nature of the different human cognitive abilities that involve scene construction. Furthermore, we will also carefully keep in mind the proposed definition of MTT to facilitate the distinction with other mental processes studied.

2.3.1 Mind Wandering

MW is the cognitive ability to think *aimlessly*, when the brain receives no direct commands, it wanders. It is an analogous activity to daydreaming. Indeed, humans spend half of their waking time wandering. Importantly, a crucial element of this cognitive function is memory, providing the contents for the mental constructions (Michael C Corballis, 2013).

More specifically, MW can involve autobiographical knowledge, episodic foresight and other people's mental states. Brain imagining studies showed that the default-mode network is the brain area involved in MW, interestingly of which, the hippocampus is part (Raichle et al., 2001). The antithesis of MW is *mindfulness*, the psychological state of being focused on the present moment, it is the ultimate purpose of meditational practices.

In the case study by McCormick et al. (2018), the authors analysed MW in patients with hippocampal damage. While subjects' MTT abilities were considerably impaired, that is, they were not capable of forming mental constructions of themselves in the past or in the future, patients did not show any deficit in MW. They were able to mentally detach from the present context to form mental pictures relating to general knowledge rather than specific episodic happenings. In other words, their thoughts consisted mainly of semantical information, e.g. "I am thinking about whether I should take another grape" or "I am thinking how relationships change". Conversely, the control group reported more episodic details, e.g. "I am thinking of meeting some friends at a restaurant for lunch. I imagine the restaurant."

Interestingly, the control group's wanderings involved visual imagery as opposed to patients who reported more verbal thoughts. Finally, discrepancies in the temporal range of wanderings were also evidenced. Patients wandered principally about the present, conversely, the control group wandered within a more extended lapse of time. These results suggest that all individuals can generate context-independent mental thoughts. In particular, it seems that if left alone, the mind wanders with the available resources. However, given the limited memory resources in individuals with hippocampal damage, their mental constructions seem significantly restricted. Moreover, such an experiment provides evidence of the critical role of the hippocampus in MW as well as the tight connection between EM and meta-representations.

Importantly, as discussed by J. W. Schooler et al. (2011), it seems that while MW is ubiquitous in all individuals, the awareness of its experience is considerably limited. In a reading task, conscious MW was tested by combining self-catching measures of MW to experience sampling method. Participants were asked to report each time they noticed their minds wandering and their results were then compared to the number of wandering provided by the experience sampling probes. Findings revealed that the number probe-caught MW was significantly greater than the self-caught, evidencing how individuals wander unconsciously (J. W. Schooler, 2004).

Despite its ubiquity, the natural function of MW is still debated, with researchers investigating whether it serves specific purposes. Earlier studies indicated that daydreaming stimulates creativity and problem-solving (Singer, 1966). In the work by Baird, Smallwood, and Schooler (2011), the hypothesis that MW enables anticipation and future planning was tested by giving subjects relatively easy tasks that did not necessitate full attention to be accomplished. In this way, subjects were let wander and were then asked to report their thoughts, i.e. the temporal focus (past, present or future) and the cognitive dimension (self-related or goal-directed). According to their results, people wandered predominantly in the future, often planning future actions, that is, without any stimulus, the human mind often thinks of the future in a goal-oriented fashion. Subsequently, the authors proposed the notion of prospective MW as a prevalent state of the human mind.

Therefore, MW, like MTT, is goal-directed, which supports the idea of the instinctive future-oriented behaviour in human beings. However, it is important to note that MW and MTT remain two distinct mental processes. As defined earlier, MTT requires a meta-representation, an awareness of oneself in time and importantly, it is temporal-oriented. MW also encompasses scene construction, but it does not necessitate oneself nor is it strictly temporal-oriented. MW involves fewer requirements on temporal coherence, in other words, MTT is a more restrictive process than MW which includes imagining fictitious worlds and aimless thoughts. Moreover, as demonstrated earlier, events more likely to happen in the future are represented through clearer images, therefore MTT consists of more vivid and accurate mental constructions than MW.

In addition, individuals are always consciously aware of their MTT, which is not the case for MW. Hence, even if MW can involve a scene construction of oneself in the future, its occurrence is more spontaneous than MTT which is triggered by either a specific sensation or a need to predict the future. For instance, MW memories are retained for a considerably shorter time and individuals are only partially aware of their wanderings. Lastly, the model proposed later will highlight this cognitive difference and demonstrate the intrinsic distinctive nature of goals in MW and MTT.

It is interesting to point out that the ubiquitous human aptitude to form mental scenarios of the future exceeds that of any other species. In particular, it allows for greater versatility and fosters flexible behaviour. Corballis goes as far as to claim that it is this capacity to mentally wander away from the present environment as well as the ability to share our wanderings, that mostly differentiates humans from animals (Michael C Corballis, 2012).

To sum up, MTT and MW are two distinct processes sharing similar properties. The former is a conscious recollection of episodes either in the future or in the past and its main function is to flexibly equip humans for the future. The latter is not necessarily temporally oriented and is stimuli-independent. Importantly, MW seems to be linked to our creative thinking capacities, however its purpose is still debated. Both processes rely on DM, but while the former has been demonstrated to be defective when the hippocampus is impaired, MW seems present in all human minds. Lastly, both mechanisms are context-independent and rely on the capability to construct mental scenes. Interestingly, goal processing is crucial to the function of both processes, strengthening the view of the goal-oriented nature of human beings.

2.3.2 Theory of Mind

Humans do not only wander in time or space, they also wander in other people's minds. ToM, or mentalising, is the ability to attribute mental states to other people, which may differ from our own. It is the belief that their intentions and desires guide their behaviour. In other words, mentalising is the ability to conceive other individuals as intentional beings.

The emergence of ToM in children has been thoroughly studied and researchers believe that it may be related to MTT. In particular, research has concentrated not only on the attribution of other people's mental states but also on the understanding of one's own past feelings and beliefs. For example, Gopnik and Astington (1988) showed that three-year-old children failed to understand that they once believed something that differed from their present mental states.

Such limited ToM capacities extensively restrict MTT skills. An impaired ability to attribute one's past mental states implies limited MTT skills. Nevertheless, failing to understand one's beliefs may also be caused by an incapacity to understand that people can have different beliefs from oneself. In other words, ToM and MTT share similar characteristics. Moreover, neuroimaging studies have shown that ToM and MTT have several brain networks in common such as the prefrontal cortex and the temporal lobes

(U. Frith & Frith, 2003).

Interestingly, the generativity and recursiveness of human language is the result of the recursiveness of thoughts. In particular, ToM involves a high level of recursion; e.g. "I believe, that she believes, that he believes...". In addition, following Grice's idea that language involves implicatures, the ability to understand other people's intentions is necessary for an efficient communication. Importantly, Grice highlighted how conversations are not entirely about detecting explicit meanings, but often involve inferences (Grice et al., 1975).

Human language, due to its richness, is characteristically imprecise as opposed to animal languages, which are generally unambiguous. Therefore, in conversations, individuals need to infer each other's beliefs (Michael C Corballis, 2012). Speakers, when narrating a story, for example, must consider what hearers already know. Likewise, for the listener, it is crucial to understand the other interlocutor's perspective. Moreover, narrating stories from other perspectives requires a functioning ToM ability. Getting beyond the obvious, it thus seems that ToM is a requirement of human language.

2.3.3 Scene Construction or Self-Projection

One last interesting process involving similar brain networks is navigation, the skill of monitoring one's orientation and direction. Although the study of the neural correlates involved in navigation have received less attention, evidence from functional neuroimaging experiments suggest that it activates the medial temporal lobes (Maguire et al., 1998). Specifically, navigation triggers the hippocampus for the representation of space and the inferior parietal cortex to enable movement. Interestingly, these brain regions are also engaged in MTT, MW and ToM.

From these findings, Buckner and Carroll (2007) have argued that the common characteristic of these processes is *self-projection*; the extremely advantageous ability to shift perspective from the present to imagine other scenarios referenced to oneself. EM, prospection, navigation and ToM are all constructive processes and in order to construct a mental picture, it is imperative to detach from the present environment.

In contrast, Hassabis and Maguire (2007) have proposed scene construction as the common process of these cognitive functions. They argue that MW, EM, EFT, ToM and navigation all necessitate the construction of mental images. Furthermore, they suggest that the vulnerability of EM is possibly due to its contribution to a wide range of complex functions. In particular, EM provides individuals with unlimited imagination, not bounded by the present environment (Hassabis & Maguire, 2009).

Their notion of scene construction stems from the fact that self-projection is too restrictive, given the broad range of mental processes involved in the same brain region. Specifically, fMRI studies showed that the hippocampal area is highly activated during the imagination of fictitious experiences. When amnesic patients were asked to imagine new experiences, such as lying on a sandy beach, compared to control patients, their descriptions were considerably fragmented and lacked spatial coherence. Patients' reports were significantly less detailed, and their imagined experiences were considered poorer than those of the control group. The authors thus concluded that the hippocampus is key for the spatial context of imagined scenes (Hassabis, Kumaran, Vann, & Maguire, 2007).

Such results are in line with the work by Hannula, Tranel, and Cohen (2006), who investigated spatial and non-spatial relational memory. Amnesic patients were shown two versions of a spatial picture, an original version and a manipulated one (where an object in the picture had been moved), then asked whether they noticed any differences between the two pictures. Similarly, for the non-spatial task, the same face images were presented with overlapping different backgrounds and patients were asked to report whether they were already shown the face images. Amnesiacs performed well below the control group in both tasks, suggesting that the hippocampus is responsible for the spatial and non-spatial representation and relation of mental images.

Finally, given that episodic remembering and imagining do not necessarily involve oneself, self-projection is not a suitable common denominator of these mental processes. Conversely, as argued earlier, MTT is a reconstructive process highly based on meta-representations. Hence, scene construction is better able to account for the shared characteristic of these mental mechanisms. One last point worth mentioning is that there are instances of ToM which do not produce a mental scene. This will be particularly relevant later when we examine cases of patients with hippocampal damage but intact ToM abilities.

2.4 Concluding Remarks

This chapter began with the distinction between SM and EM, with the former considered as an Encyclopedia, while EM is similar to a personal diary. Consequently, SM is concerned with immutable facts about the world as opposed to EM, which is subject to reinterpretations. It follows that we do not have an accurate record of the past and that memory plays a crucial role in our constructions of the future. As a result, the cognitive processes based on EM, such as MTT, are reconstructive and prone to errors; imagining, in the same way remembering, is subjective. Humans are thus characterised by temporal myopia, living in a subjective sea of time.

In particular, EM is imprecise because each time we revisit a past event, our sensations have changed, so has our perception of that event. Memory is of the future but is highly concerned with the present moment; it is the present use of past experiences. MTT is, to a large extent, guided by the present concerns and expectations, thereby a form of goal-processing mechanism. From this, we claimed that human cognition is goal-oriented.

Moreover, the aforementioned information was used to better define the process of MTT. Correctly, it was argued that MTT consists of forming a world model, thus such a mechanism requires the ability to form mental scenes. Specifically, the visual imageries must include episodic details, the representation of oneself and must be temporally oriented. Most importantly, these world models allow individuals to form expectations to value future plans and actions. Therefore, MTT enables individuals to form better predictions of the future and to reach specific goals.

The chapter concluded with the different cognitive functions related to EM. It seems that MTT is associated with the more specific cognitive ability of scene construction. Humans have a critical aptitude to form mental pictures independently from the present context, which evidences the power of the human mind and it seems that EM is key to such a process. In particular, scene construction is involved in imagination, spatial navigation and in the attribution of other people's feelings and knowledge. Hence, from the aforementioned findings, it is felicitous to deduce that the emergence of EM has changed human cognition, learning and behaviour.

3

Narrative, MTT and Tenses

After examining how the awareness of time changed human cognition, this chapter is dedicated to how its advent has revolutionised language. The claim is that narratives, a highly unique characteristic of human language, evolved as a result of the cognitive ability to travel in space and time. Specifically, MTT is at the heart of the emergence of tense systems and storytelling abilities. The relationship between MTT and language will be examined in the first section of the chapter, then the role of narrative, its cognitive requirements and its evolutionary origins will be investigated. Finally, an analysis of the understanding of narrations will be given.

3.1 MTT and Language

Having examined MTT and identified its main ingredients, this section provides an illustration of the reasons behind its close connection with language. Firstly, an analysis of how most languages situate actions in time is given. With this in mind, an investigation of the close relationship and the common properties of MTT and language will be introduced.

3.1.1 Definition: Tense and Narration

The emergence of MTT in human abilities generated numerous new conditions in communication. Episodes have been required to be situated on a time dimension for listeners to understand the temporal relationship of events. Many languages incorporate time with the use of tenses, which are grammatical expressions of locating situations in time. The conjugation of verbs is modified, with each term referring to a particular perspective in time, thus language grammar becomes critical in tense marking.

Nonetheless, some cultures deal with time differently. For example, the Chinese language does not use tense morphology, using adverbs and aspect markers to indicate time (Lin, 2006). However, as Comrie (1985) claims, different grammatical devices to express time are not indicative of different conceptions of time. Following this reasoning, it would mean that speakers of languages lacking grammatical gender categories have a different concept of sex.

Alternatively, some cultures do not conceive time as linear (i.e. past, present, future), but rather as cyclic (Janca & Bullen, 2003). Nevertheless, the consequences of the expression of time are scanty. As Comrie points out, one can find linguistic categories that situate episodes as occurring in the present moment in all cultures, that is, all human languages have techniques to locate time (Comrie, 1985).

While tenses enable to incorporate a time dimension, the way we organise our understanding of time is provided by narratives. When we refer to narratives we often think of novels or some literary works. Nevertheless, we omit to realise that everybody uses narratives in everyday life, and that it is a unique property of the human language.

Regarding narratives, the representation of sequences of events is considered to be connected by time and logic. Narratives must be involved with actions in order to be defined as such, they must include some sort of *dynamics*, i.e. they are durative. While clock time relates to some numeral length (e.g. minutes, hours or days), narrative time relates to sequences of events or occurrences (Abbott, 2008). Therefore, the sentence "It often rains in Amsterdam" is simply a description and does not contain any episode. Conversely, "Yesterday, it rained all morning in Amsterdam" is a narrative as it includes a temporal character.

In simpler terms, narratives require a temporal sequence of events unfolding over time. More importantly, in order to infer meanings, hearers must mentally represent the scene narrated. As a matter of fact, narratives enable the communication about non-present or even non-existent objects, thus are adaptations of reality. Consequently, the truthfulness of narratives is based on their *verisimilitude* (Bruner, 1991). In other words, a common characteristic between MTT and narrations is that they both generate mental constructions. In contrast, every non-narrative communication is bounded to the present. Lastly, it is worth mentioning that narratives do not necessarily require language, as there are other forms of narration such as mimes or mute films that do not involve language.

3.1.2 Language and Time

Language and memory have an intricate connection. Language is based, and could not exist, without a memory system. As language is sequential, it requires short-term memory. Nevertheless, if each sentence of a discourse is taken singularly, it becomes troublesome to infer the sense of the whole speech, hence, language also requires long-term memory.

Language relies on DM, more particularly on both SM and EM. SM allows the use of thousands of words we employ daily and works as a mental dictionary, also providing conversational material we can discuss, e.g. political situations or weather conditions. By contrast, EM allows for a significant number of unique properties such as including a time dimension for the narration of past experiences (Michael C Corballis, 2019).

MTT is presumably the main factor that forced language to incorporate a time dimension. Consequently, researchers have argued that the rules of language must depend on the way one reconstructs mental episodes (Michael C Corballis, 2009). For example, to portray simultaneous events, languages must have temporal devices to express simultaneity. This idea puts Chomsky's notion of the innateness of language under great pressure (Chomsky, 1975b), as language is considered a product of culture dependent on brain structure (T. Suddendorf, Addis, & Corballis, 2009). Nevertheless, language is also an added value to MTT, allowing individuals to make clearer inferences.

> Language itself adds to the capacity for MTT, since it provides a means by which people can create the equivalent of episodic memories in others, and therefore contributes to their episodic thinking. By telling you what happened to me, I can effectively create an imagined episode in your mind, and this added information might help you adapt more effectively to future conditions. And by telling you what I am about to do, you may form an image in your own mind, and work out a plan to thwart me (Michael C Corballis, 2009).

Finally, what would we talk about if we lived entirely in the present, without the sense of time provided by MTT?

3.1.3 Common properties

Despite being very close, language and MTT cannot be said to go hand in hand. There are utterances that do not require any mental constructions. For example, sentences such as "go get me a coffee", do not generate any mental constructions and such action can be undertaken without any MTT. Besides, the cases of animals and amnesiacs evidence that MTT and language do not fully depend on each other. Specifically, animals have shown signs of MTT while their linguistic skills remain remarkably restricted (N. S. Clayton & Dickinson, 1998), and amnesic patients have reported impaired MTT abilities while their linguistic capacities remained intact (Tulving, 1985b). It thus seems possible to have MTT abilities without linguistic capacities and vice-versa, in other words, it would be inaccurate to claim that the two processes rely on each other. Nevertheless, it is interesting to note the common properties they share.

Combinatorial structure

Episodic thought and language have very similar structures. The same elements, people and actions can reoccur in different episodes. Similarly, in language, the same words and subjects are repeated differently in each sentence, forming new ones every time; every episode is thus a potential sentence (Corballis & Suddendorf, 2007).

Generativity

Chomsky argued that generativity is the component that most differentiates human language from that of other species (Chomsky, 1975a). His idea is that the human species is the only one capable of forming an infinite number of sentences from a finite set of elements. Interestingly, the same property also holds for episodic thought. We can generate an infinite number of images from the combination of a finite number of people, actions and places. Likewise, for language, it can thus be argued that the generativity of MTT in humans may be the condition which stands out from other species' MTT activities.

Michael C Corballis (2019) claims that the generative nature of language derives from that of imaginative thought. MTT reflects our ability to think of *whatever, whenever, wherever.* Furthermore, Chomsky later proposed that generativity is also the cause of another critical property of language, namely recursion: the ability to include sentences within sentences (Hauser, Chomsky, & Fitch, 2002). Interestingly, MTT provides the same result, as we can mentally construct events within events.

In other words, recursion and generativity seem to operate analogously in both language and MTT. It is very probable that these properties are related. Corballis, for instance, asserts that the generativity of language derives from that of imaginative thought, rather than on the structure of language itself (Michael C Corballis, 2019).

Role of time

MTT and language are both related to time, with the former allowing us to perceive it and plan accordingly, whereas the latter enables us to share the content of our thoughts. For instance, the more complex forms of MTT, such as the pluperfect or the perfect tense, require one to set a reference point in the past or the future and locate the situation before it, that is, to perceive a moment in the future which occurs before another episode further in the future. Sentences such as "She will have graduated", show the complexity of our mental constructions and the close relationship between MTT and language (Stocker, 2013). With this in mind, language grammar seems to be dependent on how we structure our thoughts in time.

The study on the Pirahã tribe culture led by the American linguist Everett is a good illustration of the connection between language grammar and mental time constructions. The Pirahã language is the only known language that lacks numerals, colour terms and perfect tenses. Furthermore, they have straightforward systems to incorporate time in their language (Everett et al., 2005).

In light of this evidence, Everett suggested that Pirahã culture communicates only about immediate experiences and is said to live entirely in the present. As a matter of fact, Everett showed that Pirahã culture does not have any mythical figure or historical tales, suggesting that their narrations are almost exclusively about their immediate experience (Everett, 2009). These findings provide empirical data regarding the relationship between time in language and imaginative thought.

Core Subjectivity

The final interesting common property is the core subjectivity of MTT and language. In the second chapter, how remembering and imagining are subjective processes was discussed, also demonstrating how retrieving an old episode or a future one depends on present concerns and goals. In other words, the perspective of the self in time plays a crucial role in remembering and imagining.

Similarly, the same property also holds for language. The way we see things in time is vital to the way we talk about them. As Klein (2013) argues, it is how the speaker experiences or imagines an event that is essential in language, rather than the reality per se. Moreover, time is the ultimate arbiter of the truth condition of a sentence, i.e. the truthfulness of any statement depends on the moment of the utterance. Therefore, any sentence describes the state of only one moment, precisely the current one (Lipman, 2018).

For instance, the sentence "Napoleon died in exile in Saint Helena's island" describes the current state, i.e. there has been a state, previous to the present one, during which Napoleon died while in exile in Saint Helena. The same holds for sentences in the future such as "Next year will be a leap year". This statement only describes the current state that it is now the case that next year will be a leap year. Put differently, that something has happened or will happen are both two facts of the current state.

Therefore, if memories are the present representation of the past, the same holds for language, i.e. every sentence is a representation of the present state. Our perspective in time is thus key to our memory and communication, as both MTT and language depend on the present view. With the aforementioned evidence regarding MTT and language, it seems that the close connection between the two is overt. In the next section a closer inspection of the cognitive functions involved in narrations will be given, as well an evolutionary approach.

3.2 Narrative and Cognition

A unique property of human language is storytelling. The cognitive requirements that have enabled the development of such capacity will be analysed, more precisely, the relationship between scene construction abilities and narratives will be investigated. Interestingly, it will be demonstrated how the two share a bidirectional dependence. Finally, an introspective examination on the evolutionary origins of narrative will be given.

3.2.1 Narration and Scene Construction

If MTT allows us to extend our temporal consciousness beyond the *here and now*, the same can be said about narratives, as they allow us to represent and communicate our past episodes. Specifically, as memory is what remains from the past, when we recall and share a past episode, it is our memory that dictates the story we narrate. In other words, our experiences are stories (Kahneman, 2011).

In 1972, when Tulving coined the term EM, he defined it as follows:

> A person's episodic memories are located in and refer to his own personal past. Most, if not all, episodic memory claims a person makes can be translated into the form: "I did such and such, at such and such a place, at such and such a time." (Tulving et al., 1972)

From the very first definition of EM, the close connection between narrations and EM is perceivable. Narratives are the instrument permitting the communication about our retrospective and future thinking. In particular, given how far we can *look into* time, storytelling allows us to describe our wide temporal horizon (Nehaniv, 1999). For instance, Corballis asserts that our capacity to construct the past and the future empowered us with the ability to tell stories (Michael C Corballis, 2014).

Most importantly, in conversations, in order to ensure the global convergence between hearers and speakers, the mental pictures formed through narrations must coincide.

The human scene construction abilities thus become crucial for both the production and understanding of narrations. We will analyse the role of abilities such as understanding hearers' intentions, navigating in time and in space in narrative comprehension.

As argued by Francesco Ferretti (2014), the same systems that help us monitor the right direction in space enable us to maintain a global coherence in discourses, that is to say, coherence is highly reliant on our ability to navigate in space and time. Hence, it is argued that our communicative skills rely on our scene construction abilities. A good illustration is the novel "Invisible Cities" (*Le Città Invisibili*) by the Italian writer Italo Calvino (Calvino, 1978).

In the book, Calvino quests hidden combinations of spatial pictures through language, using narration to create complex and fictional mental pictures. The main character, Marco Polo, describes surreal and imaginary cities, such as one that is sustained in the air, or a city that is reflected on a lake, where everything that happens in the city occurs in the reflection as well. The structure of the narrative invites the reader to form spatial conceptions to represent the different cities. The story is reliant on the ability to navigate in space to understand its complex and imaginary descriptions. The interesting point is that, although the cities are imagined, it is our ability to construct scenes, more particularly to navigate in space that enables us to understand and form a common coherent imagined picture.

By contrast, as mentioned earlier, ToM is also among the vital ingredients of story comprehension. It is now well-established that human language understanding goes beyond what is literally said. Conceiving other people's viewpoints is essential to infer the meaning of a conversation. Language is highly dependent on the ability to perceive other people as intentional beings. In particular, understanding a character's behaviour and intentions are crucial to grasp the link between events and actions that form a storyline.

This is especially evident in the novel "In the Café of Lost Youth" (*Dans le café de la jeunesse perdue*) by the French writer Patrick Modiano (Modiano, 2007). Each chapter of the book is narrated by a different person in the story, therefore it is imperative for the reader to consider what each character knows, believes and feels. In other words, understanding the perspective of multiple individuals is key for the global coherence of the story. Therefore, deducing a narrator's perspective is a cognitive process that requires ToM abilities.

Finally, temporal understanding of events relies on our ability to construct the future and the past. To understand narrative time, i.e. the correct order of sequences of events, it is imperative to be able to navigate in time. For instance, in the novel "Mrs Dalloway" by Virginia Wolf, the main character, while preparing a dinner party, recalls different episodes from her past (Woolf, 1992). The storyline is composed of the reminiscences about past events and the present moments. The reader is thus asked to navigate back and forth in time in order to comprehend the narrative structure. Such narrative styles are highly reliant on the capacity to mentally represent events in time, that is to say that an analogous process to MTT is what allows us to produce and understand stories that do not have a chronological order.

Following this evidence, Ferretti and Cosentino (2013) proposed a model in which language appropriateness depends upon the ability to conceive other individuals' viewpoints, as well as navigating in space and time. Specifically, language is regarded as part of a higher cognitive function, namely behavioural appropriateness, which allows humans to flexibly operate in different environments. Interestingly, as argued earlier, scene construction is a common feature of MTT, mental mind travel (navigation in other people's mind) and mental space travel (navigation in space).

As a consequence, it is plausible to speculate that the cognitive skills of scene construction are at the heart of human narrative communication; without such cognitive capacities, the construction of narratives is significantly altered as well as their understanding. For instance, the generation of fictional narratives and the recollection of well-known fairy tales were tested in the amnesic patient K.C. (Rosenbaum et al., 2009). His performance on the fictional test was greatly insufficient, performing better in the generation of popular fairy tales (e.g. Little Red Riding Hood), but still below the control group. In particular, his narratives were substantially disorganised, lacked details and global coherence. The authors thus concluded that his inability to recollect past experiences and to bind details into a coherent narrative reflected his defective EM and unimpaired SM.

These results are in line with the aforementioned impairments found in relational memory of individuals with hippocampal damage (Hannula et al., 2006). Given their inability in spatial and non-spatial relations, it is unsurprising that their narratives lack global coherence. Their intact SM allows them to incorporate the main aspects of stories, however, their deficit in EM prevents them to include specific details that guarantee an overall structure and coherence. In other words, their imprecise narratives may be due to their faulty scene construction abilities and limited sense of change in time. The hippocampus is thus crucial for the creation of mental scenes, providing the contents and contributing to the spatial environment.

In conclusion, narratives, similar to MTT, depend on meta-representations and are temporal oriented. It seems that damage to the hippocampus significantly alters the ability of scene construction and with that, MTT and narrative production are greatly impaired. In particular, the lack to form coherent mental representations is associated with a deficit in understanding causalities. Finally, EM and SM serve as content to both MTT and narrative, evidencing once more how the past is shared through narrative stories.

3.2.2 Stories creating selves

Having considered how memory and narrative are cognitively related, their similar function will now be discussed. As mentioned earlier, the way we look at past events is crucial for the way we talk about them, in other words, our memories work as referent for our stories. While in the second chapter an analysis of how language can influence memory retrieval was given, here, the focus is on the corresponding functions of narratives and memories, with particular attention to personal past episodes. While it is commonly acknowledged that one's view of the self through time is key to the development of a personal identity, psychologists have been investigating the role of narratives in such context.

The memory system that represents the knowledge of one's past is known as Autobiographical Memory (AM), which emerges from the combination of different memory systems. It is composed of general knowledge about oneself, such as the name of the school one attended (which belongs to our SM), as well as specific episodes of one's past, e.g. a particular moment from school, such as the feelings of the first day (which belongs to our EM). As argued by Nelson (1993), sharing memories gives a social aspect to AM. Storytelling's function is to express one's view of personal past and the development of AM in children is associated with their ability to share past stories. Thus, AM serves a personal as well as a social purpose.

Researchers have investigated the influence of narratives on memory retrieval. For instance, in the experiment led by Pasupathi, Stallworth, and Murdoch (1998), participants were divided into three groups and asked to recount a story. During the retelling of the story, one group was given a very attentive listener, the second group had a distracted one and finally the last group did not retell the story at all. The idea was that an attentive listener would encourage participants to include more details in their stories. Three weeks later, participants were asked to recount what they remembered about the story. Results corroborated the initial belief, participants who told their stories to attentive listeners reported a more accurate long-term memory. Conversely, there were no significant differences between subjects who told the story to distracted listeners and those who did not retell the story at all.

Such results suggest that rehearsing information about past events benefits the long-term memory system. Therefore, narrating past experiences aids preservation of our memories. In addition, the more details are included in our narrations, the more specific our memories will become. It is important to note that storytelling is not always an accurate representation of the past, thus rehearsal can also strengthen false memories.

Following these findings, the relationship between the emergence of AM and narratives has been thoroughly examined, as well as its implications on the perception of oneself. Conversations with parents are among the first processes helping children to develop a personal self. For instance, children's memory and maternal narrative styles of reminiscing were evaluated in the study by Harley and Reese (1999). For three weeks, mothers narrated stories to their children about past episodes. The information retained by children was then assessed verbally as well as their self-recognition abilities, demonstrating that children whose parents shared more detailed narrative stories reported more information about their past experiences. Similarly, children's self-recognition was positively correlated with the ability to talk about the past. The authors thus concluded that narratives play a crucial role for the development of children's self-perspective.

Furthermore, Bohanek et al. (2006) presented evidence that families' narrative style can affect the sense of oneself. In their experiment, families' narrations of positive and negative events were recorded and evaluated. Following their conversations, children's self-esteem was then assessed, indicating that a narrative style that includes children's perspectives of the experience makes them feel valued and part of a cohesive family. Moreover, findings suggested that such narrative style enhances children's self-esteem. Conversely, single perspective stories fail to develop a sense of integration and a shared meaning about the past, resulting in considerably lower children's self-esteem.

In witnessing parents' storytelling about the past, children can establish a conception of what is relevant in narratives. They can also grasp new meanings and form new feelings towards a past event. In other words, parent-child conversations play a crucial role in the emergence of a subjective perspective as well as the development of the self. Specifically, storytelling about the past can provide children with a new view of a past experience. Correctly, narrations can reshape memories and consequently, the view of oneself.

In comparison, if storytelling has an influence on the view of oneself, the converse also holds, that different self-concepts form different narrations. That is to say, narratives reflect personality traits. For instance, in the work conducted by McAdams et al. (2004), participants were asked to complete a self-report assessment measuring five personality traits. Following the assessment, they were asked to produce narratives based on life scenes, confirming the predictions on the relationship between narrative theme and character traits. To illustrate, openness was greatly associated with complex narrative structures, mixed emotions and different points of view, whereas individuals with low openness tended to include personal continuity rather than change in their narrations. Similarly, individuals who scored high in the personality trait of agreeableness were associated with narratives about friendship and unity. Finally, neurotic subjects recounted more life-narrative scenes classified as emotionally negative.

In a more recent study, participants' constructions of collaborative narration were analysed in relation to their extraversion personal trait (McLean & Pasupathi, 2006). Subjects were first assessed on their extraversion trait, then asked to report their self-defining memories, showing that extraverted individuals engaged more frequently in collaborative narrations. In particular, they produced more audience-oriented stories, thus reflecting their openness to social bonding. In other words, they constructed narratives involving higher degrees of social influence, indicating that narratives mirror individuals' personality.

With this in mind, it seems clear how self-concept and life stories are intrinsically related. Narratives help us understand our past experiences and form a narrative identity, i.e. storytelling plays a crucial function in the relationship between the self-concept and life stories.

> First, situated stories affect self-concept when storytelling serves to express the event as being highly self-relevant, as having changed the self in some way, or as reinforcing existing self-views. Second, creating a situated story can affect a participant's subsequent stories; that is, when one constructs a particular situated story in a specific context, that story influences the degree of elaboration and the nature of the evaluations one has about that event subsequently, similar to the work on parent-child reminiscence (McLean, Pasupathi, & Pals, 2007).

Individuals can make sense of their past through narratives. The types of narrative children are exposed to can have considerable influence in the shaping of their character, also aiding children to form an identity and play a social function. This is especially evident when children develop the awareness that a past experience works as referent for the narration of past events. Once they acquire this conception, they are able to form shared representations. The narrative aspect of events in the past adds a social value to their memory system, helping them understand and deal with the past and may even create new insights with respect to an old event. The development of the self is mediated through shared awareness with other individuals (Welch-Ross, 2001).

When constructing a story about a past event, one is forced to revive the episode and structure each element to ensure the verisimilitude of the story. Narrations can thus give a new perspective and help organise past events, adding a new level to our memories and contributing to the process enabling individuals to become selves. In particular, narratives increase self-awareness in time (Cosentino, 2011).

To sum up, just as each time we revisit a past experience we form new feelings about it, each time we narrate a past event, we get a different view of it. Therefore, narratives and memory share a similar function towards one's self-perspective. Memories serve as content for our storytelling and narratives elicit past memories reinforcing them in the long term. Every type of narrative includes a collaborative, communicative and social aspect, thus affecting how individuals form narrative identities and help connect episodes of the past to the present and the future. Finally, with such evidence in mind, it seems clear that meta-representations and narratives are interrelated; narratives generate mental constructions and it is from these that we produce our storytelling.

3.2.3 Evolutionary considerations

The evolution of language is a very subtle topic and has been a prominent debate in philosophy of language. In this section, the emergence of narratives in relation to their cognitive features is discussed.

As mentioned earlier, narratives are independent of language, telling a story can be accomplished through other means such as manual gestures, drawing and still pictures. Hence, narrations arguably preceded language, in particular through pantomimes. Nevertheless, the core property of narration is global coherence, the understanding of the overall meaning of a discourse (Ferretti et al., 2017).

Previously, we analysed how navigating in time is crucial to grasp meaning in narratives. Indeed, Corballis argued that language evolved primarily to allow the sharing of past experiences and expectations of the future (Michael C Corballis, 2009). In particular, given the large amount of time we spend narrating episodes of our past and the future, it becomes very arduous to imagine narratives without MTT. The notion is thus that MTT paved the way for the emergence of narration. Moreover, MTT and narratives arose as a need to encode information such as "who did what to whom, when and where", in hostile environments (Pinker, 2003).

Although MTT and memory today may play crucial roles in the shaping of people's identity or in the perception of time, their original functions have considerably changed. More particularly, MTT and memory evolved to equip human beings with a future advantage that enhanced survival chances. Future planning was probably a critical juncture in human history, significantly altering their living conditions and being a major driver of cognitive and behavioural flexibility. Suddendorf and Corballis strongly believe that MTT was key to the survival strategies of human beings (T. Suddendorf, 2006; T. Suddendorf et al., 2009).

In order to support humans with greater survival chances, MTT evolved to foresee the future rather than remember the past. In comparison, memory emerged to serve purposes for accurate predictions of the future, rather than provide a record of past events. Notice that, recalling past episodes per se does not give any selective advantage if it does not concern the present moment. Conversely, remembering for future purposes (such as remembering to carry the keys when you go out) is the gist of memory and MTT, and was probably their initial purpose.

Narratives, however, allowed for better forms of cooperation. Considering that narration allows us to talk about non-present objects or scenes, it is presumed that it provided a survival advantage, in particular, narratives enabled us to transmit knowledge to other generations. The human ability to learn is, to some extent, unique and narratives may have facilitated its progression. Therefore, both MTT and narratives have been crucial components of the human race.

Researchers have demonstrated that most human knowledge is acquired through communication with other individuals (Hewlett & Cavalli-Sforza, 1986). In terms of evolutionary means, narratives can be perceived as the process by which one exchanges beliefs to fit in local habitats (Sugiyama, 2001). Narratives are particularly apt to serve such a function as they are forms of representation of experiences. Most importantly, they are significantly efficient as they permit the sharing of an episode, that may involve a considerable amount of time, into a relatively brief story.

In other words, narratives have enabled humans to strengthen their memory system as well as their general knowledge. Furthermore, storytelling favoured cooperation and was probably a crucial factor for the development of the social aspects of humans. Nevertheless, given the function of narratives as representation of experiences, constructing mental scenarios is their fundamental component. Therefore, MTT very probably functioned as a precursor for the evolution of storytelling.

In conclusion, narratives allow us to share our wide temporal perspectives, increasing our knowledge of experiences, as well as promoting social cooperation and communication (M. C. Corballis, 2016). It is undeniable that human progress has been considerably facilitated through narratives, to the point where we can argue that human species can be renamed *Homo narrans* (Niles, 1999).

3.3 Goal-oriented Narratives

The final section of this chapter is dedicated to how humans understand narratives and their structure. Various models of narratives have been provided and the widely acknowledged belief is that navigating in time through causal relationships between occurrences of a story is key to the global coherence. In the first part, an examination of the Trabasso model of narration is given, with the second part being concerned with the development in children of the knowledge associated with the understanding of narrative stories.

3.3.1 Trabasso model of narration

Narratives have been widely examined in the study of reading comprehension as well as storytelling production. The striking finding concerns how humans understand the connection between the different events of a narrative story. Interestingly, the statements crucial to a story are those which share more causal relationships with other statements. Furthermore, as shown by Trabasso and Van Den Broek (1985), these statements are also easier to retain and recall. Consequently, Trabasso and Van den Broek provided a Causal Network model to represent the storyline of a narration through relationships from cause to consequence.

Figure 3.1 illustrates the causal relationships between the events of the story *Frog, Where Are You?* (Trabasso & Stein, 1994). The story presents an initial setting (S) of a boy who owns a dog and a frog. While he is asleep however, the frog goes missing (event, E). The next morning, the boy is obviously upset about the frog missing (internal response, IR) and wants it back (goal, G1). From here, he starts a quest to find his frog (G2) in different locations, which leads to different goals (G3), attempts (A) and outcomes (O). The final attempt results in the positive outcome of the boy finding his frog. The figure represents the relationships between the different events connected with the character's goals and plan of action.

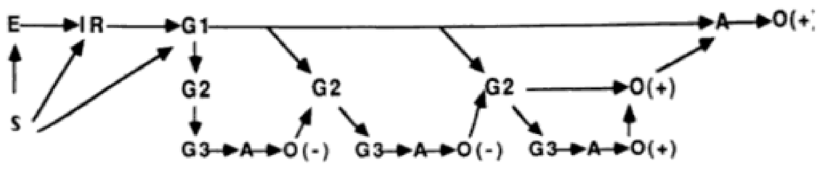

Figure 3.1: Causal relation representation for *Frog, Where Are You?* story.

Such representation followed previous studies on how individuals understand the global coherence of narratives. In their study, Stein and Trabasso (1982) investigated how children make moral judgements and comprehend characters' behaviour. In the first experiment, subjects were first narrated a story and they later heard additional information that would reinterpret characters' behaviour. In the second experiment, children heard two versions of the same story presenting different endings, in one version the main character achieves her goal, as opposed to the second version which results in a negative outcome. The aim was to understand children's sensitivity towards goals and whether they make moral judgement based on characters' intentions.

The results revealed that children understand stories through the goal-plans of actions. Characters' intentions, plans, actions and beliefs are what children refer to when making judgements about them. The additional information gave a different judgement towards a character, evidencing the fact that children have an awareness of goals and intentions. The authors concluded that in order to understand a story, children need to have a definite knowledge of humans' intentionality.

Following these findings, Trabasso later provided evidence on the coherent understanding of goal-plans (Trabasso & Wiley, 2005). He claimed that to interpret a character behaviour in narrations, individuals need to keep in mind the attainment, maintenance, abandonment, substitution and revision of goals. Put differently, goals motivate actions and planning provides ways to predict future outcomes. In his first experiment, Trabasso studied the accessibility of goal information by studying participants' recognition time for different test words relating to a subordinate or a superordinate goal. In the second experiment, subjects were given a narrative presenting either a local inconsistency (relating to a subordinate goal) or a global one (relating to a superordinate goal).

The results demonstrated that readers make inferences from local to global levels to understand how events and actions unfold in a story. The local subordinate goals, as well as the local inconsistencies, were more accessible to participants, in particular, comprehending a story involves a hierarchical goal-plan description, i.e. a consistent view of how characters can reach certain goals undertaking specific actions. The knowledge of goals, plans, actions and outcomes allows readers to make inferences and develop a coherent understanding of the story, in other words, a clear idea of the consequences of characters' actions is needed to grasp meaning in narratives.

In another study, Trabasso provided two versions of the same story, a hierarchical and sequential one. He then illustrated the advantages and disadvantages between the two structures. In accordance with his previous findings, he argued that hierarchical narratives allow us to make better inferences about goals and intentions, while in the sequential version, goals are not clearly stated. The hierarchical version thus enables us to generate more interepisodic inferences and it represents more accurately how individuals understand stories (Trabasso, 1991), in other words, the Causal Network model proposed by Trabasso and Van Den Broek (1985) seems to accurately capture how individuals represent and understand narratives.

Furthermore, this hierarchical representation of narrative is in line with the different forms of thinking and goal structure put forward by Robert Kowalski. Specifically, the English computer scientist studied how humans construct higher and lower-level representations to think more effectively. In his cognitive model, he distinguished two types of goals, Maintenance and Achievement Goal (MG and AG respectively). The latter is a desired future state with respect to changes in the environment that triggers a MG, whereas MG is the ultimate goal that determines the construction of sub-goals and the action of characters (Kowalski, 2005, 2011).

To illustrate, in Aesop's Fable *The Fox and the Crow* (Hague et al., 1999), the fox's MG is to find food and eat. In order to achieve its ultimate goal, the fox must steal the piece of cheese the crow is holding. Consequently, the fox needs to get the crow to sing so that the cheese would fall, and it could finally get it. The fox thus reaches the desired state after having reduced its ultimate goal into sub-goals, get the cheese and make the crow sing. This is a precise example of MG (which is the fox's goal to eat) and AG (the fox's sub-goal to eat the crow's piece of cheese and get it to sing), and the kind of reasoning they come with.

Interestingly, this type of narrative structure is highly relevant to MTT, demonstrating that goals are about some future states, while actions concern the present. Furthermore, the model of narration put forward by Trabasso considerably suits the goal-oriented aspect of future thinking, providing further evidence of the involvement of MTT in narratives, showing that the two share similar characteristics. In particular, such a model takes into account the causality between events, which is crucial for the global understanding of the story. Lastly, these findings corroborate the notion of goal-driven cognition in humans.

3.3.2 Development of goal-plan understanding

In this section, the development of the understanding of goals in narrations will be discussed. Different studies have investigated children's knowledge of goals and plans of action, suggesting that during the preschool years such ability is in a developmental phase.

In the study by Trabasso et al. (1992), children's ability to produce a coherent narrative was investigated. Children were asked to construct a coherent story looking at a pictorial event-sequence. The results suggested that three-year-old children did not encode any goals or intentions of the characters, their narrations were mainly descriptive and lacked a sense of sequence and motivation of actions. Four-year-olds instead showed some signs of knowledge of goal-oriented behaviour. However, their knowledge was considerably inferior to that of older children, indicating that goal-processing is not yet fully functional.

Similarly, Berman conducted an experiment to examine the understanding of hierarchical structure in children (Berman, 1988). Participants had to narrate a story from a picture booklet. Interestingly, only five-year-old children were able to provide a coherent sequential story of events, younger participants lacked a hierarchical organisation of episodes. More specifically, they only evaluated pictures in isolation from the rest of the story. Berman thus concluded that in order to understand a story, children must have some knowledge of a narrative structure, that is, they must be able to comprehend how events are connected and have an awareness of time.

In accordance with such results, Trabasso and Nickels (1992) investigated the construction of coherent narratives in children. Participants were asked to describe the events of a picture storybook. Interestingly, they found that children who showed more awareness of goals and plans of actions were also more capable of maintaining a coherent structure in their narrations. Moreover, three-year-olds were considerably more descriptive in their narrations compared to older participants. In other words, the understanding of narrative at such a young age relies on the ability to identify and describe characters.

With this in mind, it seems that between the fourth and fifth year of age children develop an understanding of planning. The knowledge of plan allows us to interpret characters' actions deriving from their beliefs. Following these results, Trabasso and Stein (1994) have suggested that future-oriented behaviour relies on the ability to understand human intentionality. Planning is future-oriented, children failing to understand characters' goal-plans demonstrate a meagre awareness of time. Furthermore, plans unite the past (a desired state) to the present (an attempt) and the future (the attainment of that state).

From the evidence reported above, it is plausible to speculate that the understanding of narrative structure increases with age. Children's knowledge of goals emerges in preschool years, this will be particularly relevant for the next chapter, where the MTT abilities in preschool children will be investigated. These results confirm the importance of goal-oriented behaviour in the understanding of narratives.

3.4 Concluding Remarks

This chapter analysed the relationship between EM and language. The evidence presented suggests that with EM came an awareness of the fourth dimension that radically changed human communication. The striking similarities between MTT and language were reported, and it was argued that MTT functioned as a precursor to the emergence of narratives, in other words, the development of means must have preceded the one of content.

More specifically, the ability of storytelling is unique to human beings and has most likely evolved thanks to the capacity to form mental representations. The cognitive skill of scene construction enabled our ancestors to refer to non-present things, probably conferring a considerable advantage to human survival strategies as it allowed the sharing of past events. Narratives have been particularly fruitful means of representing previous experiences, allowing humans to foster their learning abilities and equipping them with a new method to transmit knowledge. Humans are the only known species with a conscious awareness of time and means to express it, which are believed to be intrinsically related.

Finally, an analysis of the relationship between memory and narrative was provided. Evidence suggested that the two are interrelated as memories serve as content for future stories and narratives strengthen and give new meaning to past experiences. This suggests that the two share a bidirectional dependence mediated by meta-representations, which helps individuals to form a narrative identity. Lastly, narrative understanding was discussed. In narratives, humans comprehend texts as a sequence of related events, forming judgements and beliefs about characters through their goals and plans of action, in other words, the properties of MTT are reflected in narrations which evidence their close connection.

4

MTT and Psychiatric Disorders

Having evaluated the components of MTT and its main properties, this chapter will thoroughly examine its development in children, helping to revisit its definition and the cognitive relationships with the other mental processes alike. Thereafter, empirical data will be provided, specifically, focusing on the conditions of autistic and schizophrenic patients. Interestingly, such diseases come with impaired capacities to represent mental scenarios. Given such deficits, their impact in the narrative abilities of such individuals will be investigated.

4.1 Development of MTT and other cognitive abilities

In this section, the development of MTT and the various cognitive processes related to it will be discussed. In the first part, an analysis of the emergence of MTT and EM will be given. We will later examine how sociability of individuals is transformed with the advent of EM. Lastly, we will evaluate the case of ToM and to what extent it is related to EM and scene construction abilities.

4.1.1 MTT and EM development

Memory is among the most critical components of human consciousness. Its development in children has been thoroughly examined from the very first months of existence. Researchers have illustrated that the first signs of a functioning memory system appear in the earliest stages of infancy. For instance, Pascalis et al. (1995) showed that newborn babies have already some knowledge of their mother's face. In their experiment, neonates demonstrated looking at a familiar face for much longer than an unknown one, suggesting that infants possess a mental portrayal of their mother's aspect.

Furthermore, similar results were reported concerning neonates' auditory perception. In an experiment led by DeCasper and Spence (1986), pregnant women recited the same text aloud every day for the last six weeks of pregnancy. After birth, each neonate heard two recordings: a novel story and the one their mother narrated, with infants preferring the more familiar story to the new one. More specifically, the recited text was more reinforcing than the novel passage. Such findings demonstrate that neonates possess a certain kind of memory system.

It is now well established that by six months children can retain information in tasks involving repetition or imitation, even several weeks or months after the demonstration (Barr & Hayne, 2000; Hayne, 2004). These results are taken as evidence of the early development of DM. Nevertheless, such findings are mainly of semantical nature, the first signs of EM in children are evidenced at a later stage. Tulving (2002b), T. Suddendorf and Corballis (1997) argued that the first seeds of EM emerge between the third and fifth year of age.

Nevertheless, studies on the development of AC in children identified different results. In an experiment by Hayne et al. (2011), children aged three and five were asked to posit pictures of themselves at different ages on a timeline. They were also engaged in conversations about past and possible future events. Results showed that even three-year-olds had some awareness of themselves in the past and in the future, whereas five-year-olds demonstrated much stronger self-awareness in time, reporting more verbs in past and future tenses, as well as more first-person references. Given these results, the authors concluded that by the age of three, children already possess some episodic knowledge.

A similar study examined children's recall of recent events and predictions about the future (Busby & Suddendorf, 2005). Participants were asked to report a personal event of the previous day and a possible event of the following day. Results evidenced that the ability to retrieve the past and to imagine a coherent future develops around the age of four and five. Five-year-olds were considerably more accurate in their recollections of the past and predictions of the future showing a more concrete autobiographical knowledge and self-awareness in time.

Conversely, three-year-olds were unable to remember what they did the previous day or what they will do the next one. Hence, it seems that MTT only emerges at around the fourth or fifth year of age along with EM. Furthermore, no substantial difference was found between the accuracy of MTT in the past and into the future, children were equally able to retrieve the past and predict the future. This corroborates the idea that EM and episodic foresight rely on the same neural components.

In line with such results, Atance and Meltzoff (2005) studied children's understanding of a future psychological state. Participants, aged three, four and five, were asked to imagine themselves in different scenarios and were then asked to choose one item from a set of three. However, only one of the items could have been used in the imagined future state, the other two were relatively useless and did not coincide with the scenario. The children's decision thus reflected their ability to foresee the future event. Most three-year-olds choose the correct item, showing some awareness of future states, but their performances were well below that of older children. In particular, five-year-olds were considerably more accurate when explaining their choice of selection. The authors concluded that MTT emerges in preschool years, more specifically, between the age of three and five.

Nevertheless, given that linguistic skills are also in a developmental phase during those years, such results can be misleading. Children's failure in such tests may be due to insufficient linguistic capacities rather than an unawareness of time. For instance, T. Suddendorf and Busby (2005) proposed an experiment analysing MTT abilities independent of language. Children were left in a room with a puzzle board without its puzzle pieces. Later, they were moved to a second room where there were different games, among which the pieces of the puzzle. When asked to go back to the first room, children had the opportunity to choose one game to bring with them. If children remembered correctly the first room, they would decide to bring the pieces of the puzzle (children's preference was compared to a control group that did not have the empty puzzle board in the first room). The three-year-old children selected the game independently from what they experienced in the first room, thus demonstrating a lack of MTT abilities. Conversely, considerably more older children selected the pieces of the puzzle, suggesting that they correctly navigated in time and imagined themselves in the other room. Again, such findings validate the idea that MTT emerges around the fourth year of age.

Finally, Atance and Jackson (2009) studied the different characteristics of future thinking, claiming that future thinking is the product of different cognitive processes. Their study investigated the development of capacities such as MTT, prospective memory or delay of gratification, demonstrating how such capacities are all in a developmental phase, as five-year-olds performed considerably better than three-year-olds in most tasks. Moreover, children's scores were highly correlated, suggesting that these future-oriented processes are interdependent. They concluded that as first proposed by T. Suddendorf and Corballis (2007), future thinking depends on distinct components and that MTT relies on different cognitive systems.

To sum up, it seems that EM and the awareness of oneself in time emerges in the early stages of childhood. However, it is only around the fourth year that children begin to efficiently represent a mental scenario of a future or past event. Interestingly, children are equally capable of retrieving the past as imagining the future, suggesting that the two develop in parallel and supporting the idea that they rely on the same neural components. Lastly, MTT is possibly dependent on different cognitive systems, thus the development of such systems in children is considered and the possibility of their parallel emergence investigated.

4.1.2 The social impact of Memory

As previously suggested, MTT may be cognitively related to other mental abilities. Here, we shall discuss the development in children of capacities such as scene construction, prosocial behaviour, planning and retrieval of AM, demonstrating how such skills emerge in parallel in children, at around the same age as MTT, evidencing their cognitive connection. In particular, we will evidence how such cognitive abilities assume a social aspect and aid individuals to cope with their environments.

For instance, Thompson, Barresi, and Moore (1997) studied the development of future-oriented prudence and altruism in a future-oriented scenario. Future-oriented behaviour was tested in a delay of gratification test, with children given the possibility to choose between two rewards, they could either receive one sticker now or two later. Altruistic behaviour was assessed in a shared gratification test, in which children could either choose between receiving one sticker now or one for themselves and one for someone else later.

The aim was to study children's capacity to deal with future desires for themselves and for others. Notice that both tasks require children to imagine the future situation and inhibit their current desires. Results demonstrated a considerable increase in delay of gratification between three and five-year-olds. Similarly, older participants choose the delay for shared reward more frequently than the younger ones. In other words, by the end of preschool years, children can deal with the future for both themselves and other individuals.

Conversely, the incapacity of three-year-old children to deal with future desires may be due to insufficient scene construction abilities, i.e. they are unable to represent a future situation externalising their present concerns. Similar results were observed in an experiment studying the planning capacities of children. Subjects were examined on several trials of the Tower of London test, a neuropsychological assessment for planning abilities, in which the number of moves to reach the desired goal changed (Kaller et al., 2008). Four-year-old children were unable to solve tasks involving three or more moves, i.e. tasks that required intermediary moves, in other words, they were not capable of reducing their goal into sub-goals while keeping in mind a mental representation of their ultimate goal. Their failure to look ahead substantially restricted their planning abilities and their problem-solving skills. Conversely, five-year-olds performed considerably better in tasks requiring intermediary moves. Hence, it seems that scene construction abilities and an awareness of the future emerge in children between the fourth and fifth year, equipping them with more advanced forms of planning and problem-solving skills.

Such limited future-oriented behaviours in younger children suggest that their understanding of time is still very limited. For instance, Povinelli (2001) studied the conceptual development of time in preschool children. Previous research had demonstrated that around two, children begin to recognise themselves in mirrors (Amsterdam, 1972). Povinelli however, provided a different experiment studying the reactions of children to videos displaying themselves.

In his work, the experimenter placed a sticker in children's forehead without them noticing it. Children were then videotaped and were either shown the video immediately after or a couple of days later. The aim was to study whether children understood the connection between the delayed video and their present state. Results showed that when shown the video immediately after, very few three-year-olds reached up for the sticker while most of four-year-olds did. Similar results were found in an analogous experiment with photographs instead of videos.

Nevertheless, even when shown the same video a few days later, many four-year-olds still tried to reach up for the sticker, thus they failed to understand the temporal relation between the video and their current state. Conversely, most five-year-olds reached up for the sticker only when shown the video a few moments after and not days later. The author concluded that only after the fourth year children understand temporal connections.

With this in mind, Fivush (2011) illustrated the importance of AM in the social context. He firstly argued, as we analysed earlier, that the development of AM can be influenced by external factors such as the reminiscing style of mothers, that is, the emergence of AM can be affected by cultural environments. Moreover, our relationships with other individuals and the feelings we have towards them are to a large extent dictated by AM. In particular, AM gives individuals a feeling of self-consciousness through time, providing a sense of experiencer, i.e. that one is the same person as the one in the past.

In other words, the emergence of AM, prospective thinking and scene construction abilities are all key to the sociability of individuals and seem to develop around the same time as MTT abilities. Further research on their connection is needed, currently the possibility that they are cognitively related is not ruled out. Moreover, such processes play significant roles in a vast range of tasks such as problem-solving or planning, demonstrating how the cognitive processes involved in MTT affect individual's behaviour and cooperation.

4.1.3 The case of ToM

As previously discussed, ToM is the human capacity to understand and infer other individuals' beliefs and knowledge, i.e. perceiving them as intentional beings. Like MTT and the cognitive processes alike, mentalising requires being able to externalise one's feelings and bearing in mind a non-representated state. Nevertheless, interpreting other people's beliefs may involve limited scene construction competences. To this aim, we will investigate the development of such ability to evidence its singularity and how its connection to scene construction is still unclear.

Research studies have investigated ToM abilities at different stages of childhood, identifying mentalising occurrences even in six-month-old infants (Kovács, Téglás, & Endress, 2010). In the experiment provided, subjects were evaluated in a visual object detection task. Infants were shown an animated movie consisting of an agent hiding a ball behind an occluder. In one condition of the experiment, the agent left the scene and unbeknownst to him, the ball was moved. The aim was to study infants' looking times when the agent returned to the scene to look for the ball behind the occluder. When both the observer and the participant knew the ball had been moved, the looking times were shorter than in the false-belief condition, in other words, infants looked at the scene for a longer time when the agent falsely believed the ball to be behind the occluder. The authors suggested that infants computed agents' belief, raising the hypothesis that some ToM skills are acquired at very early stages of infancy or may even be innate.

Further research indicated that twelve-month-old infants can interpret other individuals' goals and intentions (Gergely et al., 1995). The authors assessed infants' capacity to infer agent's intention to approach a spatial goal. A sequence of pictures representing an agent intended to reach a specific spatial location were presented to participants. Different conditions were provided in which either an obstacle changed the agent's route to reach the goal or in which the agent took an unexpected longer direction (the non-rational condition). Participants' looking times were taken as means of comparison, showing that infants looked longer in the non-rational approach condition than the rational one. This suggested that by the twelfth month of age, babies have a concept of intentionality and expect individuals to take the most economic approach to spatial goals.

Further results evidenced that around eighteen months, infants are capable of understanding different representation of an object. For instance, Leslie (1987) claims that comprehending pretence is a sign of mentalising. Her known example consisted of a mother holding up a banana pretending to speak on the phone. Children aged eighteen months laugh at such scene as they do not confuse the use of a banana with the one of a telephone. Leslie termed such cognitive mechanism as *decoupling*, arguing that it is evidence of an early emergence of meta-representation.

Furthermore, studies have proven that at age three, children know the difference between thoughts and physical states, understanding that a banana can be eaten while the thought of one cannot. They also have a knowledge of the meaning of verbs such as know, believe and guess (Wellman, 1988). Flavell et al. (1981) showed that three-year-olds but not younger children understand that a person sitting opposite to them sees the same object differently.

Nevertheless, different experiments have demonstrated how only four-year-olds and older can solve a false-belief paradigm (Baron-Cohen, Leslie, & Frith, 1985; Perner, Leekam, & Wimmer, 1987). The well-known test presented the following scenario: Maxi has a chocolate bar which he places under a blue cupboard, then leaves the scene. While he is away, his mother moves the chocolate under a green cupboard. Maxi later returns and looks for his chocolate. Children are asked to answer the question "where will Maxi look for his chocolate?". The correct answer of the test is "in the blue cupboard", as this is where Maxi falsely believes the chocolate to be. The results showed that only at around the age of four children begin to pass such a test. Further research illustrated that children aged five or older understand second order degree tasks, i.e. "Mary believes that John believes" (Sullivan, Zaitchik, & Tager-Flusberg, 1994). Such results suggested that more complex forms of mentalising, such as "putting yourself in someone else's shoes" and anticipate their actions develop at a later stage. Interestingly, such tasks involve higher forms of meta-representation, such as observing a scene from someone else's eyes and assimilate their knowledge. The poor result of younger infants may thus be caused by the complexity of the mental representation required by the false-belief task.

However, considering the early signs of ToM in babies, it is possible that the development of scene construction and ToM abilities are disconnected. This is further supported by the case study of a patient (known as G.T.) with a significant planning and memory impairment, but a relatively untouched ToM (Bird et al., 2004). The patient's performance in memory tests revealed a severe deterioration of his EM. G.T. scored well below control level in the Autobiographical Memory Interview, conversely, his SM remained unaltered.

Nonetheless, in the ToM test, G.T.'s performance matched those of control participants. The patient was capable of understanding characters' mental states and demonstrated no difficulty even in the more advanced ToM test. Specifically, he was able to infer meanings even in non-literal utterances involving mental or physical states. Following such results, the authors suggested that the damaged area of the brain, namely the medial frontal cortex, is not involved in ToM processes.

To sum up, children show the first signs of AC around three-years-old. The ability to mentally travel in time emerges at around four years in parallel with EM. Similarly, the capacities for meta-representation are manifested in the early stages of childhood. However, the ability to form accurate mental scenarios evolves around the fourth year, along with MTT skills. From the evidence reported above, it appears that such capacities enhance problem-solving skills and prosocial behaviour. Interestingly, around the same age, children also begin to understand and produce coherent narratives.

Lastly, studies have reported some evidence of ToM abilities even in infants. Specifically, it seems that babies make assumptions of other individuals' behaviour and show signs of confusion when their expectations are not confirmed. Nevertheless, a major change occurs in ToM development around the age of four (U. Frith & Frith, 2003). It is believed that the more concrete scene construction skills shown around that age have a considerable influence on ToM abilities. Taken together, such findings support the results illustrated in the development of narrative comprehension and production, corroborating the hypothesis that scene construction and MTT are at the heart of human communication.

4.2 Cases of impaired MTT

In this section, we shall discuss empirical evidence regarding the cognitive relation between MTT and narration, specifically focusing on scene construction capacities of individuals affected by autism and schizophrenia. Interestingly, both disorders come with an impairment in social interactions and the ability to form mental representations, thus their narrative abilities will be examined to help formulate better estimations in our model.

4.2.1 Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is a neurodevelopmental disease mainly characterised by deficits in communication, interaction and behavioural flexibility (also known as the triad of impairments). Today, between 1 and 2% of children are affected by autism. Interestingly, it seems that men are more susceptible than women, with approximately five times more boys affected by the disorder than girls (APA, 2000). The complexity of such disease is principally due to the wide range of symptoms involved.

Recently, ASD has been a leading theme of extensive research efforts. The deficit of ToM abilities in autistic children was among the first notable finding concerning the disease (Baron-Cohen et al., 1985). In the false-belief task experiment, 80% of autistic subjects failed the test. Subsequently, Baron-Cohen proposed the mind-blindness theory, which holds that the social impairments of individuals with autism is caused by a lack of cognitive skills.

Nevertheless, autistics have also shown remarkable abilities, particularly in tasks requiring attention to local details. For example, they outperform in the Embedded Figure Test, a task that consists of finding a smaller figure hidden in a more complex figure (Jolliffe & Baron-Cohen, 1997). In light of such uncommon capacities, Frith proposed the Weak Central Coherence (WCC) theory that accounts for the uneven distribution of cognitive skills in autism. Specifically, the WCC perceives ASD as a cognitive style, rather than a cognitive deficit, that processes information differently. Individuals with autism are more focused on specific details rather than seeing objects as a whole (U. Frith, 2003).

Interestingly, a shared symptom between the two theories is the inability to perceive precise meta-representations. The mind-blindness theory holds that autistic individuals lack the cognitive skills to view the scene from someone else's eyes, that is to say, they fail to form complex mental representations. Conversely, as stated by the WCC theory, autistics have difficulties to process global information, i.e. to see the whole picture. Accordingly, their mental imageries are likely to be fragmented.

Complement results were found in an experiment assessing EM and EFT abilities in ASD (Lind et al., 2014). In the experiment, participants were asked to describe a personal past episode, a possible future one and imagine a temporal fictitious scene. They were also assessed on their descriptive abilities by narrating a story from a picture book. No narrative impairment was found but autistics' reports were considerably less detailed and lacked vividness and spatial coherence, suggesting a deficit in MTT abilities independent of their narrative skills. In addition, autism was also associated with an impairment in scene construction abilities. Specifically, as hypothesised by the WCC theory, autistics are unable to connect elements into a whole scene.

Moreover, such results are in accordance with neuroimaging studies conducted on the brain of autistic individuals (Stanfield et al., 2008). As reported by structural imaging studies, a brain affected by ASD is characterised by an abnormal hippocampal volume. Given the abnormal hippocampus and considering the deficient MTT abilities due to inconsistent meta-representations, recent studies have investigated the narrative skills of autistics.

In the experiment by Marini et al. (2019), EFT and narrative generation skills were evaluated. EFT was assessed using the same procedure as Atance and Meltzoff (2005), consisting of understanding a future state by selecting the appropriate item for an imagined scenario. Participants were also given a sequence of three cartoon-stories, one was a blank sheet, and were asked to generate a narrative that would form a coherent story with the two drawings. Subjects had to generate either the beginning, the middle or the final scene of the story. EFT and narrative skills are associated and equally impaired in autism, with autistic subjects with low EFT skills also having lower narrative abilities. Specifically, the clinical group had major difficulties with the temporal organisation of events, demonstrating an inability to form adequate scenes for ongoing stories. In particular, the authors suggested that autism is associated with an impairment in narration when individuals are asked to self-generate the scenes. For instance, in the aforementioned work, autistics had to generate a narrative looking at a picture book which is a cognitively less demanding task. As a result, their performances were on a par with the control group.

Such deficits in self-generated narrations reflect the results found regarding the lack of global coherence in their narratives. More precisely, Diehl, Bennetto, and Young (2006) studied narratives' consistency following the model of narrative comprehension proposed by Trabasso and Van Den Broek (1985). In the experiment, participants were required to retell the story "'Frog, Where are you?". The global coherence was assessed computing the overall connectedness of the narrated story (the total number of causal connections between statements). The clinical group produced less causally connected and more fragmented stories, particularly, the number of statements with no causal connections with any other sentence was significantly higher for the autistic subjects. Their narratives were more descriptive and similar to a listing and although they had an adequate understanding of the story, they seemed unable to infer causal inferences. The authors proposed that such difficulties may be caused by how they represent information.

A similar study found analogous results in an experiment where participants had to arrange sentences to form a coherent story, then answer questions assessing their understanding of global inferences (Jolliffe & Baron-Cohen, 2000). As predicted, individuals with autism performed below the control group in the global coherence task, appearing less able to extract and integrate information. In particular, they poorly answered inference questions such as "why did X do Y?". Interestingly, their incapacity to understand global contexts was less marked when the degree of elaboration of the story was less demanding.

Such studies confirm the possible connection between causal inferences and mental representations. In particular, autistics have a limited understanding of causalities that can have substantial effects on their interpretation of the world. As proposed by Boucher (2001), autistics feel lost in a sea of time, failing to understand that things evolve in time and lack a hierarchical temporal analysis. Such distorted perception of time may in fact cause their inability to process causalities and explain their repetitive behaviours.

Finally, their deficits in scene construction and in understanding the passing of time can partially explain their lack of flexible conduct. In particular, autism is characterised by repetitive behaviour, individuals affected by ASD undertake their activities following a predetermined schedule and are extremely rigid about it. If something forbids them to follow their schedule, they manifest signs of uneasiness, in other words, it seems that autistics are unable to flexibly adapt their plans or form new ones. If constructing meta-representations set the groundwork to form plans for the future, autistics' deficit in scene construction abilities may thus be responsible for their limited planning capacities.

In addition, different studies have demonstrated autistics' inability to perform in planning tasks such as the Tower of London or the Stockings of Cambridge tests. Moreover, they were also remarkably less successful in tasks measuring mental flexibility (Dubbelink & Geurts, 2017). In other words, their scarce ability to construct meta-representations is reflected in their capacity to form plans and adapt to new schemes. These finding emphasise the importance of scene construction in humans' flexible behaviour.

To sum up, autism is associated with a different system for processing information, not necessarily worse, but primarily focused on the local level. As a result, they manifest an important deficit in understanding full contexts, i.e. to take into account details of an image as a whole. Such impairments restrain them from forming coherent mental imageries and process the causal relation between events. With the evidence reported, we can thus argue that scene construction abilities are significantly deteriorated in ASD, leading to a difficulty to comprehend and interact with the social world.

4.2.2 Schizophrenia

Schizophrenia is a multifaceted mental disorder that can affect speech capacities, memory and the ability to understand reality. The term schizophrenia was first coined by Eugen Bleuler in the early twentieth century (Bleuler, 1911), today around 0.7% of the population is diagnosed with such disease (Jim van Os, 2009). Among the different symptoms observed, the nature of the memory system in schizophrenic patients has received most attention.

Specifically, in an experiment by Feinstein et al. (1998), patients' retrieval of AM was tested. Subjects were asked to recall personal experiences from their childhood, adulthood and from their recent past, then participants' reports were evaluated according to two measures: personal facts and personal events. The former assessed the quality of the semantical knowledge of the memory, whereas the latter evaluated the episodic nature of the memory. While patients' scores on personal facts was slightly below that of control participants, schizophrenics performed considerably worse in personal events. Results evidenced an inferior memory for all three age spans recorded, particularly for the adulthood years. Taken together, such results provide evidence of the significant AM impairment in schizophrenia.

Furthermore, complementary results have been observed in several neuroimaging studies on the hippocampal area. Structural imaging revealed a reduced hippocampal formation in schizophrenia, while functional neuroimaging detected hippocampal hyperactivity. Such anomalies have been correlated with the damaged memory system in schizophrenia (Heckers, 2001). Following these findings, research has focused on schizophrenic patients' self-consciousness, with various authors associating their faulty memory system to their disturbed sense of unity and identity (Sass & Parnas, 2003).

In more recent years, researchers have examined MTT abilities in individuals diagnosed with schizophrenia (D'Argembeau, Raffard, & Van der Linden, 2008). The experiment consisted of testing schizophrenic patients' ability to generate personal past and future episodes, showing that patients' performances were significantly below that of control subjects. These results evidenced schizophrenics' pronounced inability to construct specific events. The authors argued, that their MTT deficit is partly due to their deficit in memory and their inability to retrieve contextual details.

Consequently, later studies focused on their scene construction abilities (Raffard et al., 2010). In the experiment, the authors used the same procedure used by Hassabis et al. (2007) in their work on scene construction abilities in amnesiacs. Schizophrenic patients reported fewer sensory details and spatial references, lacking a sense of subjective feeling. In particular, patients' descriptions were deficient in spatial coherence and were more fragmented than those of the control group, demonstrating that scene construction abilities are significantly limited in schizophrenia.

Moreover, schizophrenics have also reported difficulties in planning and ToM abilities. In an experiment testing planning capacities on a Tower of London task, the clinical group was substantially less able to solve such puzzle, with patients taking considerably more moves and time to tackle such problems (Morris, Rushe, Woodruffe, & Murray, 1995). Furthermore, different experiments assessing ToM abilities have reported significant discrepancies between schizophrenics and the control group. Specifically, schizophrenics have difficulties in attributing intentions to other individuals and inferring their knowledge (Sprong et al., 2007).

In addition to these impairments, schizophrenia is also associated with a damaged language structure. It appears that their language is defective and can be manifested through different symptoms. McGrath (1991) hypothesised that the lack of planning and execution is the common denominator of these linguistic symptoms given the frontal lobe dysfunction in schizophrenia. Specifically, schizophrenics are unable to keep track of conversations and their discourses are characterised by *derailment*. As argued by Ferretti and Cosentino (2013), their language impairment reflects their inability to travel in space and time.

Although specific experiments on the quality of narration in schizophrenia have not been provided yet, the evidence that has been reported suggests that schizophrenics may possess a narrative impairment. Here, we propose a possible experiment aiming at analysing schizophrenics' production of narratives and their ability to organise a story coherently. Given the lack of details in their meta-representations and their defective ToM, it is interesting to study whether schizophrenics have a diminished capacity to produce coherent and detailed narratives.

We propose a research study to assess such mental capacities in two experiments: a story retelling task and an assessment on their ability to construct a comprehensible narrative. In the first experiment, similar to Diehl et al. (2006), participants are first given a picture book of the children's story "Frog, Where Are You?", while listening to an audiotape version. Following this, they are asked to retell the story without the book. The aim is to evaluate their language pragmatics, as the task requires participants to retell the story in a comprehensible way to another individual.

The overall aspect of the narrated story is assessed according to the following criteria: length, complexity, gist recall and coherence. The story length is evaluated by the number of statements and the complexity by analysing the grammar. We expect no substantial discrepancies between the control and the clinical group in these two criteria. Schizophrenics' cognitive deficit should not prevent them from performing on a par with the control group.

Conversely, gist recall and story coherence are assessed using Trabasso's model of narrative understanding. Trabasso and Van Den Broek (1985) showed that the most important statements of a story are also the ones that share most causal connections with other statements. In other words, we examine whether the produced story contains the most crucial sentences, e.g. "The frog was gone" or "Tom looked everywhere for the frog", in order to assess how subjects weigh the different events of the story. Furthermore, gist recall is determined by dividing the number of causal connections of the narrated story by the total number of causal connections of the original version. Most importantly, likewise in Trabasso's works, we consider that there is a causal connection between statement A and B if event A cannot have happened without event B, or vice-versa.

Similarly, the coherence criteria analyses whether the produced story maintained a causal chain between events. That is to say, coherence is computed by dividing the total number of causal connections by the total number of sentences. In addition, we also consider the number of unrelated sentences, i.e. statements with no causal connection to other statements in the story. Gist recall and coherence of the story are expected to be more challenging tasks for schizophrenics. Given their impaired ability to attribute intentions, it would be unsurprising if the patient group failed to form a coherent chain of events of the story. In other words, we predict that their narratives will be more fragmented and disconnected compared to the control group.

In the second experiment, participants are given 5 statements of a story in a random order. Subjects are asked to arrange the statements so that they form a coherent story. The objective of this task is to study schizophrenics' capacities to understand context and causalities. The time to execute the task as well as the final score of the test are used as measures to compare the two groups. Considering their inability to form detailed meta-representations, we expect schizophrenics to underperform in such a test. Their impaired scene construction ability prevents them from forming a correct picture of the story and consequently their understanding of the story as a whole is compromised.

We believe that such further studies are needed in order to assess schizophrenics' understanding of narratives and causalities. The experiments we suggested are aimed to shed light on this topic of research. Moreover, results would also provide new interpretations to the role of scene construction in narration. Lastly, our predictions of impaired narrative abilities are in line with the derailment aspect of schizophrenics' language and their incapacity to form intelligible narratives about their own lives (Roe & Davidson, 2005).

4.3 Concluding Remarks

This chapter began with investigating the development of the different cognitive processes in children. The evidence indicated that between age four and five, children witness a major leap in various abilities. Specifically, it seems that EM, MTT and scene construction skills develop in parallel and such cognitive capacities enhance individuals' problem-solving and planning abilities. Furthermore, around the same age, children also begin to comprehend and form coherent narratives. Finally, the case of ToM was analysed. While it appears that making assumptions on other individuals' behaviour may be innate, more complex forms of ToM evolve around the age of four.

Thereafter, an introspective analysis of patients affected by autism and schizophrenia was given. Research evidenced their similar symptoms, particularly concerning memory and meta-representations. In addition, the experiments on narrative abilities in ASD confirmed our hypothesis of the close link between scene construction and narrative communication. To our knowledge, such experiments have not been provided on schizophrenic patients, we proposed an experiment for future research. Nevertheless, with the evidence reported, we can claim that autism, amnesia and schizophrenia are associated with an impairment in EM and scene construction abilities that affects their production and understanding of narratives.

5
MTT Model

With this evidence reported in mind, this chapter is dedicated to our model of MTT. As mentioned earlier, MTT is subject to different interpretations, i.e. researchers have contrasting beliefs on its structure. Most importantly, a coherent explanation of the relationship between MTT and the other cognitive processes has not yet been formulated. To this end, a model underling its social function in individuals will be proposed. The intention is to specify what MTT really consists of, how it is related to other cognitive skills and what added value it furnishes individuals with.

In the first part, we will revisit the given definition of MTT, investigating what it really consists of and how it differentiates from other processes. With this in mind, we will determine the cognitive relationships between its different components and the processes alike. Finally, the model will present our hypothesis of the cognitive value of MTT in individuals.

5.1 The Thought Process

MTT is the cognitive process that enables us to retrieve episodes from the past as well as foreseeing possible future ones. The advent of MTT considerably favoured humans' future-oriented behaviour and enhanced the adaptability to different environments. As discussed earlier, meta-representations are a key component of such process. Specifically, MTT's main characteristic is to create a reality, that is, to form a world model in which individuals and events can occur.

The aim of these constructed realities is to be as similar as possible to the actual world to better prepare individuals for the future. However, given that our memory system is fallible, MTT can also be prone to errors. Formally, there is no difference between MTT in the past and in the future, we will thus discuss the latter, as the original function of MTT has most likely been to equip human beings with a future advantage.

First, the world models individuals form require the incorporation of oneself. These mental constructions represent the beliefs individuals have towards the future, i.e. how they expect the future world to be, in other words, MTT represents their perception of the future and from these mental scenes, individuals can prepare for their prospective plans. Hence, MTT's purpose is to pre-experience a possible future event.

With this in mind, it becomes evident that MTT creates a personal reality, i.e. it is a highly subjective mental process. For instance, including oneself in a world model is crucial to contribute to the feelings of pre-experiencing. Moreover, the sensations that arise from these mental constructions are to a large extent provided by EM. Correctly, following the previous example of Peter's dinner party, if in your world model you expect to meet and socialise with some specific individuals, it is because from your previous experiences with Peter, you remember he likes such people very much, while your expectations such as seeing Peter blowing out candles on a birthday cake are provided by your SM, i.e. your general knowledge of what happens at birthday parties. Hence, mental constructions are formed through both episodic and semantic details.

It is worth observing that by setting these preconditions to MTT, an impaired memory system would already substantially reduce the MTT abilities. Specifically, MTT would be greatly restricted to individuals with a defective EM. Considering that EM allows the recollection of past events as well as the conception of future ones, the content for meta-representations is significantly limited if EM is damaged. In other words, with such a definition, MTT heavily relies on the memory system, which is in line with the aforementioned research.

Another point worthy of consideration is that future thinking without the incorporation of oneself is not MTT but simple SFT. For example, a reunion between the heads of the government debating the actions to tackle climate change is not MTT, as no mental construction, nor the retrieval of any information from a personal past experience is required to discuss this issue. Such discussions involve uniquely semantical knowledge, thus they cannot be recognised as MTT.

So far, we have defined MTT as a mental representation of one's picture of the future allowing individuals to reach specific goals. Such a definition is particularly effective to distinguish it from other cognitive processes, particularly MW. Importantly, including a goal to a mental construction does not necessarily make it MTT. Although MTT may have evolved to enhance the adaptability to various events the future may hold for us, there are mental constructions of the future involving goals that should not be taken as MTT. More precisely, there are certain kinds of daydreaming that involve a meta-representation with the incorporation of oneself and a specific goal, which should be carefully differentiated from MTT. Specifically, MTT involves more vivid pictures than MW and comes with higher forms of reasoning.

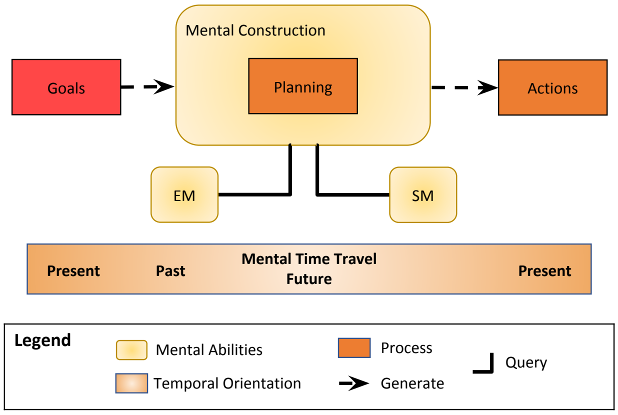

Figure 5.1: MTT Process

To illustrate, consider the earlier example of the dinner party. In your world model, you imagine the host blowing out candles on the cake and opening the various presents he received. Such mental representation can make you reflect on some aspects of the future. For instance, as you picture people giving presents you may consider what you should get to the host, in other words, from your mental construction you start questioning the present and how to reach specific situations. MTT thus involves different forms of thinking such as backward and forward reasoning. You create a future episode that includes a MG, and from there you reason backwards to form sub-goals (or AG) that will help you reach the ultimate goal. Put differently, goals generate meta-representations, which set the groundwork for goal-plans of action (Figure 5.1). It is also interesting to note that generating a possible future scenario relies on our imaginative abilities.

Conversely, in MW, such forms of thinking are extremely rare as the mental pictures involve a limited subjective sense of self. For example, suppose you start daydreaming about how it would be if humans could fly. Although you can picture yourself with such ability, and you construct a precise plan of what you would do if you could fly, from such mental constructions you do not engage in any form of backwards reasoning that involve yourself in the present. Particularly, MW is a recreational mind travel. As Klinger (2013) suggested, anticipating possible negative outcomes of plans increases goal commitments and attainment considerably more than mere fantasising about goals. Therefore, unlike MTT, MW does not foster the achievement of goals. In particular, the forms of planning involved in MTT and MW constitute their main difference.

To sum up, MTT functions as a predictor of the future, supporting humans' adaptability with a flexible behaviour and aids individuals to reach specific goals. Therefore, it involves higher forms of planning and different kinds of reasoning that require to travel back and forth in time. Conversely, MW is simply a form of recreational time travel. In particular, no specific purpose of the process has been proposed yet.

5.2 Cognitive Connections

Having provided the main features of MTT, we shall now evidence the cognitive relationships between its different constituent to help determine the missing components of individuals who have restricted MTT abilities. Most importantly, such analysis will help us specify which components of the process are key to the nature of human beings. To this end, Figure 5.2 is proposed as a representation of the cognitive connections between the different processes related to MTT.

Firstly, as observed from the diagram, all cognitive processes fall under the ability of scene construction. One needs to be able to inhibit the feelings of the present moment and create a mental scene to undertake such cognitive processes. Without such ability, these cognitive mechanisms are substantially restricted, therefore, scene construction capacities, as argued by Hassabis and Maguire (2007), are key to MTT. Meta-representations provide the means to mentally travel in time. Furthermore, it seems that EM works as a mediator for the construction of mental scenes in the different cognitive processes.

As previously stated, MTT relies on the memory system and is a cognitively analogous process to imagination, in other words, memories and the knowledge of the world determine the content of the mental constructions. SM particularly provides knowledge of the future world. In order to imagine a new or old scene, SM helps us conceptualise the settings of the mental pictures, whereas the expectations and predictions about the future are to a large extent dependent on our previous experiences, that is, to pre-experience an event we rely on the recollection of similar past episodes. Therefore, SM and EM contribute to the construction of mental scenes; seeing oneself in time gives rise to the ability known as AC.

Importantly, MTT is associated with planning for the future and goals. Specifically, as observed previously, individuals engage in higher forms of thinking in MTT processes. In particular, a coherent picture of the future allows individuals to form plans. In order to form consistent mental scenarios, one needs to realise how the outcome of an action satisfies the preconditions for the next one. Understanding causalities becomes crucial to accurately predict the future. Put differently, MTT works as a mental construction of the future world in which individuals forge their plans to achieve specific goals, that is, humans conceive the future in terms of their plans, i.e. MTT processes reflect individuals'

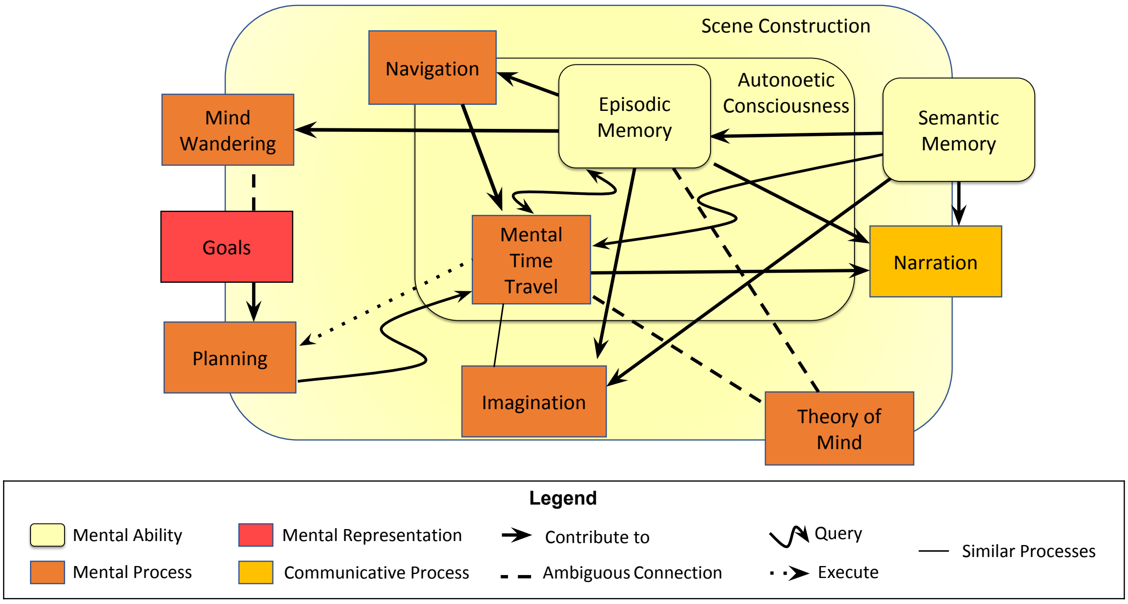

Figure 5.2: Cognitive Relations

intentions of how they would like the future world to be.

Conversely, MW is a recreational and reflective process that does not always generate a mental representation, nor is temporally oriented. For instance, wondering about what being a friend really means involves a limited sense of change in time and scene construction skills. Hence, an awareness of time, planning abilities and goals are not necessarily related to MW.

In addition, navigation in space is also an added value of MTT. Forming a scene of the spatial environment relies on the ability of scene construction, such meta-representations are, to a large extent, dictated by our memory system. Interestingly, neuroimaging studies have evidenced the association of the hippocampal area during spatial navigation tasks (Maguire et al., 1998). Having a coherent spatial concept is particularly relevant to form correct mental scenes. Specifically, spatial perception is essential for the representation of sequences of mental scenarios. For instance, to continue on the example of the dinner party, imagining how you will get there involves spatial movement and the portrayal of different scenes. Thus, navigation in space is highly relevant for future planning.

Finally, the relation between ToM, EM and MTT is still ambiguous, particularly given that ToM does not always involve scene construction abilities. However, in order to better predict the future, considering what other individuals think is particularly important. For instance, consider a different scenario of tonight's dinner, where the aim is to organise a surprise party for your friend. In such a case, in order to guarantee a positive result, it is crucial to consider what the guest of honour knows and believes, in other words, while ToM may not be a crucial component of MTT, it is undoubtedly a valuable one.

A last cognitive relationship worth mentioning is that between MTT and narratives. A distinction must be made between producing a narrative and listening to one. In the former case, the story we form is based on our mental construction of the episode dictated by our memories, in other words, the meta-representation of the narrative and the MTT process is the same, i.e. in narratives we share our mental constructions, whereas the logical order of such process is reversed when we listen to a story. As a consequence of what we hear and understand, we form a mental scene, hence, a bidirectional dependence characterises the relationship between the two.

5.3 Implications

Having analysed the relationships of MTT and the different cognitive processes presented in Figure 5.2, we can speculate that a deficit in MTT is characterised by an impairment in the cognitive skill of scene construction and a compromised AC, thus we will explore the implications of such deficits. While scene construction abilities work as means to form mental pictures, EM and SM serve as content to fill our mental imageries with a subjective character. As evidenced in the diagram, scene construction is a cognitive ability related to a broad range of processes. Such skill is essential in order to keep two pictures in mind: a picture of our surroundings and a mental construction. Being able to hold a non-represented image in mind has had far reaching consequences for human beings.

Earlier we discussed how remarkable the ability of humans to plan for the future is. We believe that such capacity is closely linked to the ability to form meta-representations, in particular, goals generate mental constructions which allow individuals to form plans for the future. In other words, planning involves a sequence of mental scenes focusing on a desired final goal. For instance, scene construction is particularly important to assess planning abilities in tasks such as the Tower of London test. Bearing in mind a representation of an ultimate objective is highly advantageous in order to reach it, that is to say, scene construction facilitates reaching goals and future-oriented behaviour.

Nevertheless, it would be infelicitous to claim that without scene construction abilities individuals would not be able to maintain or attain specific goals. In other words, planning and goals do not always involve meta-representations. For example, suppose your objective is to graduate, there is no need to form a mental picture of the end of your studies to reach such goal. However, when a goal is particularly detailed and involves a series of intermediary steps, a mental representation of it is very likely beneficial. Hence, limited MTT entails a limited capacity to plan for the future.

At the same time, MW processes without scene constructions are also substantially restrained. Specifically, as shown in the experiment by McCormick et al. (2018), individuals with limited MTT abilities reported more verbal thoughts than visual images. Subjects were still processing information and mind wandering as much as the control group, but given their impairment in scene construction, their thoughts were considerably more restricted.

Similarly, complex forms of ToM that involve higher degree of meta-representations are also expected to be deficient in individuals with limited MTT skills. Nevertheless, understanding other people's intentions does not necessarily require meta-representations. Thus, the relationship between scene construction and ToM is still unclear as we evidenced earlier analysing their development in children.

Additionally, the ability to imagine new experiences independently of context is also highly reliant on the capacity to form a mental scene. As evidenced in the work by Hassabis et al. (2007), amnesiacs, unable to mentally travel in time, were also severely impaired to form any new mental scene. Compared to the control group, amnesiacs reported considerably less detailed and coherent visual images, raising the hypothesis that imagination and EM are cognitively related and deficient due to an impairment in scene construction skills. Consequently, such inability may significantly restrict the production of imagined stories.

More specifically, the ability to tell personal stories is significantly reduced without a precise record of the past nor the capacity to form meta-representations. For example, recounting a story such as the first day in school is inaccessible to individuals with a compromised EM. If one cannot form a mental representation of such experience, sharing it with other people becomes improbable. As a result, individuals' social interactions are greatly restricted as well as their social relations, which are to a large extent dependent on EM. Their sense of identity is also largely affected given their lack of awareness through time.

Mentally representing a story helps us conceptualise the narrated episode, inferring the settings and most importantly, it facilitates storing new information. The mental imagery of an event allows us to tell a story independently of context, in other words, when we share a story we base our narrative on the mental construction we have formed. It is thus unsurprising that individuals with limited scene construction abilities produce incoherent and inaccurate narratives, i.e. their narrations reflect their imprecise mental representations (Rosenbaum et al., 2009).

With this in mind, scene construction is at the heart of the flexibility of the human mind. The extent to which humans can create mental scenes, while maintaining a conscious interaction with the actual world, is key to their adaptability. Therefore, defective scene construction skills heavily restrict mental thoughts, behavioural flexibility and the understanding as well as the interaction with the social world. At the same time, EM is key to narratives as it is the kind of memory that generates mental images. A defective EM implies that long-term knowledge is significantly altered, therefore, while narrative understanding may not be comprised, although the story will not be entirely remembered, narrative production is substantially restricted. Furthermore, one's identity is also greatly affected given their scarce self-image.

Interestingly, such predictions match the results found in autistic and schizophrenic patients. Both disorders are characterised by a defective EM and limited scene construction abilities. In particular, as studied earlier, individuals affected by such disorders are significantly deficient in planning for the future, imagining new scenarios and have a restricted self-image. In addition, ASD has been associated with the inability to form coherent stories, which corroborates the hypothesis of the connection between EM and scene construction with the sociability of individuals.

Finally, we previously discussed Trabasso's model of narration, in which he proposed that humans reflect upon stories through the causal connections between events and the goals and plans of characters. This model conforms with our model of MTT given that individuals construct mental scenes of the future as a groundwork for their prospective plans, in other words, individuals conceive the future as a sequence of causally connected images to reach a desired state. Trabasso's model captures such a mechanism adequately in narrative understanding, which coincides with our notion of future thinking. Travelling back and forth in a narrative and understanding the causality between events are key processes to the overall comprehension of a story. In a similar way, such a process is also vital to form correct mental scenes to accurately predict the future.

More specifically, it is argued that memory and scene construction abilities are crucial to such a mechanism of understanding. Forming a mental episode of a story facilitates its interpretation and allows individuals to infer meanings. From these mental pictures, individuals can grasp the context of the scene which allows to better represent the connection between the different events of the story. We believe that memory, in particular

EM, is essential to scene construction abilities. Hence, both are at the heart of narrative communication.

To illustrate, consider the following narrative, from the experiment by Jolliffe and Baron-Cohen (2000).

> Mrs Jones wanted to decorate her very bare wall. In the local paper, she saw a shop was advertising paintings in a sale. So she went to buy a painting to decorate her wall. When she arrived at the shop she hurried in to look around. She came across a painting that she liked very much, but was disappointed to discover it had just been sold. All she could find in the sale was work by modern artists. Mrs Jones didn't like modern paintings, so she went and bought a beautiful clock instead.

Our claim is that mental constructions allow individuals to interpret the scene and determine the causal connections between events. The idea is that a mental picture enables to infer the connection between her initial desire to decorate the bare wall, her quest for a painting and the reasons for which she ends up buying a clock. In simple terms, meta-representations help represent the story as a sequence of connected events rather than some fragmented unrelated episodes. Consequently, it also provides a clearer understanding of goals and plans of action of characters.

Nevertheless, whether EM and scene construction are cognitively interdependent is still debated. In particular, researchers have found cases of amnesiac patients with unimpaired scene construction abilities (Mullally, Vargha-Khadem, & Maguire, 2014), hypothesising that a non-hippocampal area may be involved in scene construction tasks. Hence, the involvement of the hippocampus in scene construction needs further clarification. However, our findings reflect the importance of MTT in individuals. A limited MTT ability comes with an impaired EM and scene construction abilities, thus it is hypothesised that MTT is key to the flexibility and sociability of humans and plays a fundamental role in narrative communication.

5.4 Concluding Remarks

To conclude, a detailed description of MTT was provided in our model. We defined such cognitive process and identified its components. It seems that scene construction abilities and EM are both the vital components of such mechanisms, the former helps us understand narratives, the latter is the record of experiences and dictates the stories we narrate. Moreover, it also plays a crucial function in our sense of identity. Based on the findings of autistic and schizophrenic patients, we hypothesised that EM and scene construction are at the heart of human communication and interaction, enabling individuals to understand social contexts.

6 Conclusion and Future Directions

This chapter will briefly recapitulate the main arguments and contributions of this thesis, as well as providing an outline of possible future research directions.

6.1 Conclusion

This thesis has been concerned with the cognitive implications of the evolution of a memory system that allowed the representation of events in time. Following the research on amnesic patients unable to remember personal past events, EM has been established as a time-dependent memory system, whereas SM consists of factual knowledge of the world independent of temporal context. The unique feature of EM is that of meta-representation, i.e. it is a kind of memory that generates mental constructions. From this, it was theorised that EM is key to the reconstruction of past events.

Interestingly, the dichotomy between EM and SM was also shown to hold for future thinking, with the distinction between EFT and SFT. The former creates a mental construction to pre-experience an event, while the latter does not necessarily require meta-representations, being more concerned with common knowledge of the future world. Hence, EM and EFT constitute the reconstructive cognitive process known as MTT.

Neuroimaging studies have shown that the hippocampus is activated in both the retrieval of the past and the construction of the future. Consequently, it was argued that EM is also involved in the imagination of the future and that it evolved to make more accurate predictions. We deduced that human cognition is future-oriented and MTT contributes to the construction of plans and goals.

In addition, researchers have evidenced the involvement of the hippocampal area in other cognitive processes such as MW, navigation in space, imagination and ToM. It seems that scene construction is the common denominator of such processes, i.e. the cognitive ability consisting in forming a mental representation independently of context. We further argued that scene construction is at the heart of human flexible and adaptive behaviour. Moreover, the involvement of EM in such different cognitive processes may, in part, explain its unreliability, in other words, rather than holding a record of the past, it seems that EM's key function is to form meta-representations.

Thereafter, we shifted our attention to language and the role played by EM and scene construction abilities. In particular, the role of narratives, the kind of communication that allows to refer to non-present objects and events was investigated. As a result, the mental constructions formed by hearers and speakers must combine in order to guarantee an effective communication. Specifically, we analysed the connection between memory and narratives in relation to one's view of the past, showing how the two are correlated and interdependent. We claimed that narratives give a social aspect to memories and concluded that being a person entails having a story (Fivush, 2011).

Moreover, it was suggested that the relation between memory and narrative is mediated by scene construction. The ability to narrate stories is connected to our ability to imagine and reconstruct events. In more specific terms, mentally representing an event reinforces its memory in the long run and enhances the comprehension and production of coherent stories. This is particularly appropriate when the story is not presented in chronological order or when it is narrated by different characters, in other words, scene construction abilities and narratives share a bidirectional dependence.

Interestingly, Trabasso proposed a model stating that to understand the global coherence of a narrative, individuals must infer the causal relations between events of the story (Trabasso & Van Den Broek, 1985), that is, to understand a story, it is crucial to comprehend the goals and plans of actions of characters. With this in mind, we argued that MTT and scene construction are key to narrative understanding, with the former helping us comprehend the temporal order of events, while the latter allows us to consider the different elements of the story and infer their causal relations. Hence, as proposed in the introductory chapter, the seemingly innate human aptitude for narratives is the result of our impulse to form mental pictures. When we look at the static picture of the ship, we form different mental scenes representing the ship wrecking, which altogether form a narrative.

We then analysed the development of the cognitive processes involved in MTT in children, showing how MTT, EM, scene construction abilities, narratives understanding and production all emerge during childhood, around the age of four. We interpreted these findings as evidence of their cognitive relation. We then analysed the cases of autism and schizophrenia, evidencing how their impairment in MTT, more specifically in scene construction abilities, restricts their understanding of causalities in narratives and substantially limits their social capacities.

Finally, we proposed a MTT model, reconsidering its definition and cognitive requirements. Tulving correctly proposed that a conscious awareness of oneself in time is key to such process. Moreover, we claimed that meta-representations are also a necessary component of MTT as suggested by T. Suddendorf and Corballis (1997). Lastly, incorporating oneself in these constructions is essential to generate a sense of pre-experiencing. We argued that such components allow individuals to mentally project themselves in the future to form plans and predictions. Impairments in MTT skills result in a limited sense of change in time, while deficient scene construction abilities entail a poor understanding of causalities and contexts.

To conclude, the ancient Greeks suggested correctly that forethought has been a watershed in human evolution. The capacity to mentally represent and share knowledge independently of context has been a turning point in human cognition, thus we strongly believe that such capacity needs to be taken under consideration when discussing the evolution of other cognitive related abilities.

6.2 Future Directions

This section presents our suggestions for future research. We strongly believe that further clarifications should be made regarding the relationship between EM and scene construction, particularly, considering cases of individuals with unimpaired capacities for meta-representation and damaged EM. The scene construction ability of such patients should be carefully examined, specifically, it would be interesting to analyse whether all kinds of complex meta-representations are still accessible to them. As it stands, it may be possible that a non-hippocampal area is also responsible for meta-representations.

Furthermore, with regards to scene construction and narration, it is crucial that future research takes into account the difference between self-generated tasks and narratives already providing figures of scenes. The former is a considerably more cognitive demanding task than the latter. In the study of individuals with limited narrative comprehension and production, it would be beneficial to follow a given model of understanding such as Trabasso's, to help clarify the level of impairment in narrations. Specifically, the same experiment performed on autistic subjects regarding the understanding of causalities would be particularly relevant for schizophrenic patients.

In addition, the role of scene construction in non-narrative communication also requires further attention, particularly, the case of metaphors. Sentences such as "the sky is crying" do not require complex forms of scene constructions, but it would be interesting to study how individuals infer its meaning, i.e. that it is raining outside. Specifically, the understanding of such metaphors of individuals with impaired scene construction abilities could provide insight on the role between metaphors and meta-representations.

Similarly, the relationship between planning and scene construction also requires further explanation. Researchers should distinguish between plans for goals that necessitate meta-representations and those which do not involve such cognitive skill. We argued that more detailed goals require mental constructions, for example, games such as chess necessitate to foresee different number of moves and scene construction capacity is extremely beneficial. It would thus be particularly interesting to study amnesiacs' ability in such games and to what extent their skills are improvable.

Finally, future work should also be dedicated to scene construction and narrative abilities in artificial intelligence (AI). Interestingly, as argued by Hassabis et al. (2017), neuroscientific research will become increasingly valuable to bridge the gap between humans and machines. Studying the biological brain can give crucial insights for the construction of artificial agents, while trying to reproduce the human brain is an efficient way to learn about its mechanisms.

To illustrate, EM has inspired the "experience replay" feature of deep Q-networks, a reinforcement learning algorithm. While the network is offline, it remembers and replays experiences from the past, in this way, uncommon experiences instead of being processed once, can be stored and reused. Such a system reduces considerably the experience needed to learn. Consequently, deep Q-networks have recently reached human performance levels on different arcade games (Silver et al., 2015).

Nevertheless, scene construction independent of context in artificial agents is still very far from achievement. Currently, machine learning research has been able to convert sensory data into precise descriptions, an essential prerequisite for intelligent agents (Eslami et al., 2018). The neural network receives as input the agent's view of a scene and outputs a representation of the same scene from a different arbitrary viewpoint, in other words, the network is able to understand the world around itself without any human labelling. However, scene representation at the moment is restricted to spatial aspects, further work should consider representing scenes across both space and time.

Such findings pave the way towards imagination in machines. Experts claim that machines being able to imagine scenes can be a breakthrough in AI research. Imaginative artificial agents that can plan for the future represent a milestone towards creative machines (Hassabis et al., 2017). Today, most AI learning is based on analyses of statistical data, however it is questionable if such learning system is sufficient to reach human levels. Moreover, imaginative thinking in machines can lead to ideas and solutions that go beyond those of the human mind.

Today, machines can play complex games such as chess or go and beat human world champions. However, their knowledge is restricted to these games and they are not capable of thinking outside the boundaries. Imagination will bring machines closer to human flexible behaviour. An intelligent agent needs to represent objects in terms of the actions they allow to do and not simply in descriptive terms. For instance, a five-year-old child can understand that a chair can also serve other purposes than "sitting on it", such as hiding things or reaching objects placed on high tables (Mahadevan, 2018). Such thinking processes are still very far away in AI, nevertheless, we believe that they may be key to the development of intelligent artificial agents.

Lastly, as proposed by Sengers (2003), a missing component in AI is the coherence of actions over time. The author suggests that agents need to be able to understand narratives, more specifically, intentionality. Presently, machines perform different tasks unrelated between themselves and lack an understanding of behaviour across time. That is to say, instead of seeing objects in terms of cause and effect rules, they ought to see them in terms of the components that constitute them. The author argues that narrative is key to mark such difference in AI, that will lead to the development of intentionally comprehensible agents.

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