



THE UNIVERSITY *of* EDINBURGH

This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e.g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

- This work is protected by copyright and other intellectual property rights, which are retained by the thesis author, unless otherwise stated.
- A copy can be downloaded for personal non-commercial research or study, without prior permission or charge.
- This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the author.
- The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the author.
- When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given.

***The Cognitive
Underpinning of Future
Thinking***

Stefania de Vito

Doctor of Philosophy

The University of Edinburgh

2012

Content

| | |
|--|-----------|
| Content..... | 2 |
| Acknowledgments..... | 6 |
| Declaration | 8 |
| 1. Abstract | 10 |
| 1.2 Riassunto | 12 |
| 2. Predicting the future (a divertissement)..... | 14 |
| 3. Introduction | 24 |
| 3.1 Mechanisms of future-oriented cognition..... | 24 |
| 3.2 Conceptual development..... | 26 |
| 3.3 Episodic memory and future thinking | 28 |
| 3.4 Similarities between past and future thought | 30 |
| 3.5 The debated role of episodic memory in episodic foresight..... | 35 |
| 3.6 Cognitive functions, aside from episodic memory, at work..... | 36 |
| 3.7 Executive functioning and episodic future thinking..... | 38 |
| 3.8 Self-projection | 40 |
| 3.9 Auto-noetic consciousness..... | 41 |
| 3.10 Exploring future prospects in healthy people and groups of patients | 43 |
| 4. The role of the cues in eliciting future thoughts..... | 46 |
| 4.1 Introduction..... | 46 |
| 4.2 Method | 49 |
| 4.2.1 <i>Participants</i> | 49 |
| 4.2.2 <i>Materials and experimental procedures</i> | 49 |
| 4.3 Results | 51 |
| 4.3.1 <i>Ratings of phenomenological characteristics</i> | 51 |
| 4.3.2 <i>Scoring of internal and external details</i> | 55 |
| 4.4 Discussion..... | 58 |

5. The role of past in the simulation of autobiographical future episodes 63

| | |
|--|----|
| 5.1 Introduction | 63 |
| 5.2 Experiment 1 | 67 |
| 5.2.1 Method | 67 |
| 5.2.1.1 <i>Participants</i> | 67 |
| 5.2.1.2 <i>Materials and procedure</i> | 67 |
| 5.2.2 Results | 70 |
| 5.2.2.1 <i>Ratings of phenomenal characteristics</i> | 70 |
| 5.2.2.2 <i>Recognition memory</i> | 74 |
| 5.2.3 Discussion | 77 |
| 5.3 Experiment 2 | 78 |
| 5.3.1 Method | 78 |
| 5.3.1.1 <i>Participants</i> | 78 |
| 5.3.1.2 <i>Materials and procedure</i> | 79 |
| 5.3.2 Results and discussion..... | 79 |
| 5.3.2.1 <i>Ratings of phenomenal characteristics</i> | 79 |
| 5.3.2.2 <i>Recognition memory</i> | 81 |
| 5.4 General discussion..... | 83 |

6. What does differentiate episodic future thinking from complex scene imagery? 88

| | |
|--|----|
| 6.1 Introduction | 88 |
| 6.2 Experiment 1 | 92 |
| 6.2.1 Method | 93 |
| 6.2.1.1 <i>Participants</i> | 93 |
| 6.2.1.2 <i>Materials</i> | 93 |
| 6.2.1.3 <i>Procedure</i> | 94 |
| 6.2.1.4 <i>Statistical analysis</i> | 96 |
| 6.2.2 Results | 96 |
| 6.2.2.1 <i>Ratings for phenomenal characteristics</i> | 96 |
| 6.2.2.2 <i>Number of internal and external details</i> | 98 |
| 6.2.3 Discussion | 99 |

| | |
|--|------------|
| 6.3 Experiment 2 | 100 |
| 6.3.1 Method | 101 |
| 6.3.1.1 <i>Participants</i> | 101 |
| 6.3.1.2 <i>Materials</i> | 101 |
| 6.3.1.3 <i>Procedure</i> | 102 |
| 6.3.1.4 <i>Statistical analysis</i> | 102 |
| 6.3.2 Results | 103 |
| 6.3.2.1 <i>Ratings for phenomenal characteristics</i> | 103 |
| 6.3.2.2 <i>Number of internal and external details</i> | 104 |
| 6.4 Discussion | 105 |
| 6.5 General discussion | 106 |
| 7. Episodic future thinking in amnesic mild cognitive impairment | 109 |
| 7.1 Introduction | 109 |
| 7.2 Method | 114 |
| 7.2.1 <i>Participants</i> | 114 |
| 7.2.2 <i>Materials and procedure</i> | 115 |
| 7.3 Results | 117 |
| 7.3.1 <i>Design of the analyses</i> | 117 |
| 7.3.2 <i>Ratings of phenomenal characteristics</i> | 117 |
| 7.3.3 <i>Number of internal and external details</i> | 119 |
| 7.3.4 <i>Correlations</i> | 122 |
| 7.4 Discussion | 123 |
| 8. Future thinking in Parkinson's Disease: an executive function? | 128 |
| 8.1 Introduction | 128 |
| 8.2 Method | 132 |
| 8.2.1 <i>Participants</i> | 132 |
| 8.2.2 <i>Materials and experimental procedure</i> | 134 |
| 8.3 Results | 136 |
| 8.4 Discussion | 142 |

| | |
|---|------------|
| 9. Executive dysfunction in Parkinson’s disease does not impair descriptions of current scenes | 148 |
| 9.1 Introduction | 148 |
| 9.2 Method | 151 |
| 9.2.1 <i>Participants</i> | 151 |
| 9.2.2 <i>Materials and experimental procedures</i> | 153 |
| 9.3 Results | 154 |
| 9.4 Discussion | 157 |
| 10. Role of the cue in detecting impairments at future thinking: two cases of amnesia | 161 |
| 10.1 Introduction | 161 |
| 10.2 Method | 166 |
| 10.2.1 <i>Participants</i> | 166 |
| 10.2.2 <i>Materials and experimental procedure</i> | 167 |
| 10.3 Results | 169 |
| 10.4 Discussion | 173 |
| 11. A case of confabulatory behaviour concerning personal future | 178 |
| 11.1 Introduction | 178 |
| 11.2 Method | 182 |
| 11.2.1 <i>Participants</i> | 182 |
| 11.2.2 <i>Materials and experimental procedure</i> | 183 |
| 11.3 Results | 185 |
| 11.4 Discussion | 187 |
| 12. Final Discussion | 193 |
| 13. References | 200 |
| Appendix A | 214 |

Acknowledgments

I would like to thank:

My mother and my father, for all the time you have spent with me, in particular this year, for being close to me when you feel that I need it, for the passion and the devotion you dedicate to my life, for the encouragements, your advice and the limitless patience. Thank you for being so *preziosi*.

Ercole, for being the best brother possible and the most important person of my life. Thank you for that hug, for being so wise and loving. I'm proud of you.

Scricciola, for being the golden nugget that lights the cave, for daily sharing your life with mine, for being so *irrinunciabile*. Thanks because only you can deeply understand this acknowledgment. "I don't have any words". TADL.

Sonia, for the passionate and thought-provoking chats (mainly on the beach ☺), for the constant support, and the long-standing, firm and growing friendship.

Eli, because a lot of special moments have elapsed since those wonderful in Krakow and the faith of friendship must be seen not in adversity, but in happiness; for being a so special *amica cara*, for sharing your time, emotions, thoughts, and dreams with me and for allowing me to do the same.

Anti, il mio amico caro, for every single moment spent together (not only) on Skype, laughing at the past, thinking of the future, and disentangling the present; for the priceless and genuine complicity, and for being an extraordinary and unique friend.

Ile, because we have been shaping ourselves together, fluctuating from flippancy to gravity. Thanks for the deep *compartecipaSione*, the empathy, the invaluable emails.

La Roxi, because we are not used to fluctuate into gravity and I adore laughing with you. Nonetheless, I seriously know that I can rely on you in the worst as in the best moments of life. Thank you, girls, for the unreal dimension that we create together.

Lore (and, of course, C.T.P.), for the beautiful moments spent together, for the support and for having not submitted yet ☺.

Zia Ersilia, Zio Ermando, il Conte Max, Pasquale, Daniele, Serena, Nonna Nunzia, for being always present in my life and for loving me. Ask Serena to translate ☺.

Prof. Della Sala, because writing a thesis is human, but supervising is divine. And you have been divine. Thank you for your advice, *l'affetto* and for sharing your immense knowledge with me.

Prof. Brandimonte, for having believed in me from the beginning and caring for me as you would for a daughter, for the support, and for being an example other than a supervisor.

Nadia, for having initiated me into this field and for being there for me.

Declaration

I have read and understood The University of Edinburgh guidelines on plagiarism and declare that this dissertation is of my own work, except where I indicate otherwise by proper use of quotes and references; that I have made a substantial contribution in the chapters written as a member of a research group; and that the work has not been submitted for any other degree or professional qualification.

Stefania de Vito

A Nonno Ercole

1. Abstract

Thinking about the future can take numerous forms, varying from planning actions to foreseeing possible scenarios by means of knowledge and informed guesses, or speculations and intuitions, or imagination and creativity. Different cognitive processes are needed for each of these different types of future thinking. This thesis encompasses a series of experiments both on healthy volunteers and on brain damaged patients, revolving around the issue of “Future Thinking” (FT) that is the cognitive ability, specifically human, of envisaging one’s own future. The concept of FT and the relevant literature are presented and discussed in Chapters 2 and 3.

The ability to foresee has been normally assumed to rely on the reconstructive nature of episodic memory. This hypothesis is investigated in Chapters 4, 5 and 6. In these chapters data on young adults, who mentally pre-experienced autobiographical episodes, are presented to investigate which type of cue would elicit richer visualizations and to explore possible differences between temporal and a-temporal scene construction. The findings from these experiments on healthy volunteers call for a deeper understanding of the relationship between past experience and FT. Chapter 7 discusses results revealing that aMCI patients produced fewer episodic but more semantic details for both past and future events, as compared to controls, suggesting that reminiscence and FT are the expression of the same neurocognitive system. However, contrary to what was generally thought, data on patients with Parkinson Disease with spared memory performance reported in Chapter 8 and 9 show that FT is not entirely dependent on memory (and the hippocampus), rather the results suggest that poor performance in FT is associated with poor executive control. In Chapter 10 two patients affected by dense amnesia are investigated. Chapter 11 presents a single case exhibiting florid confabulation. The results confirm that although amnesia is associated with poor performance on FT, memory deficits cannot account for the entire picture of FT deficits. Indeed, dysexecutive symptoms play an important role in eliciting FT deficits.

In its conclusions (Chapter 12) therefore, the thesis postulates that FT is supported by a wide range of cognitive abilities. In particular, executive skills, rather than episodic memory, hold the lion share in our ability to envisage our own future.

1.2 Riassunto

Esistono diversi modi di pensare al futuro, che comprendono la pianificazione di azioni, la previsione di possibili scenari utilizzando conoscenze pregresse, speculazioni, intuizioni, o anche immaginazione e creatività. Per ognuna di queste differenti modalità sono necessari molteplici processi cognitivi. Questa tesi comprende una serie di esperimenti, svolti sia con persone sane che con pazienti con danni cerebrali, volti ad indagare l'abilità cognitiva, peculiare dell'uomo, di immaginare il proprio futuro. Il concetto di costruire un futuro immaginato e la letteratura rilevante sono presentati e discussi nei Capitoli 2 e 3.

Si assume normalmente che la capacità di immaginare il proprio futuro dipenda dalla natura ricostruttiva della memoria episodica. Tale ipotesi è analizzata nei Capitoli 4, 5 e 6, che presentano dati su giovani adulti che pre-esperiscono mentalmente episodi autobiografici, valutano quale tipo di cue elicitati visualizzazioni più dettagliate ed esplorano la differenza che intercorre tra costruzioni di scene temporali e atemporali. I risultati di questi esperimenti su partecipanti sani indicano una meno ovvia relazione tra esperienze passate e costruzioni del futuro. Il Capitolo 7 discute i risultati che rivelano che i pazienti con aMCI producono meno dettagli episodici ma più dettagli semantici sia quando ricordano esperienze passate che quando costruiscono esperienze future, rispetto ai controlli, suggerendo che ricordare il passato e immaginare il futuro sono espressioni dello stesso sistema neurocognitivo. Tuttavia, contrariamente a quello che si pensava, i dati raccolti su pazienti affetti dal morbo di Parkinson, con memoria intatta, riportati nei Capitoli 8 e 9 mostrano che la capacità di immaginare scenari futuri non dipende interamente dalla memoria (e dall'ippocampo). I risultati suggeriscono piuttosto che difficoltà nel costruire episodi futuri riflettono disfunzioni esecutive. Il Capitolo 10 riporta i casi di due pazienti affetti da una severa amnesia e il Capitolo 11 presenta un caso singolo che genera floride confabulazioni. I risultati confermano che, se è vero che la perdita di memoria si associa a difficoltà nella simulazione di scenari futuri, è vero anche che i deficit di memoria non possono spiegare interamente il quadro di un'eventuale compromissione

dell'immaginazione del futuro. Infatti, sintomi disesecutivi comportano marcate difficoltà nell'immaginare episodi futuri.

Nelle conclusioni (Capitolo 12), infine, si suggerisce che l'immaginazione di episodi futuri sia supportata da una serie di abilità cognitive più vasta di quella che era stata originariamente postulata. In particolare, le funzioni esecutive, più che la memoria episodica, giocano un ruolo di primo piano nella nostra abilità di pensare al futuro.

2. Predicting the future¹ (a divertissement)

“There is no such thing as predicting the future!”, says Sally in Woody Allen’s *You will meet a tall dark stranger*. But people have a go at it nevertheless. Sally’s mother, her husband and even herself fantasize about meeting the stranger of their dreams. “If you can see into the future, how come you didn’t know I was gonna jump out a building and land on top of you?”, asks Boris to Helena (Whatever works, Woody Allen). “Humans have the ubiquitous capacity to imagine, plan for, and shape the future (even if we do frequently get it wrong)” (Suddendorf, 2006, p. 1006). And they do so for various reasons. Many dilemmas, more or less ordinary, can be approached by projecting oneself forward in time and envisaging how different variations of the event will turn out. Max uses a future picturesque homely setting to persuade his friend to leave the vessel, where he has always lived:

You’ll introduce me to the mother of your children and invite me for a Sunday dinner. I’ll bring the dessert and a bottle of wine and you’ll tell me that I shouldn’t have and you’ll show me around your house shaped like a ship. Your wife will be cooking a turkey and, while we’ll sit at the table, I’ll tell her that she is an excellent cook. She’ll say that you talk about me all the time. (The legend of the 1900, Giuseppe Tornatore)

Quentin Tarantino’s *Pulp Fiction* begins with Pumpkin and Honey Bunny providing a “reasonably good script of going to a restaurant” (Atance and O’Neill, 2001, p. 536) and scrutinising it, in the attempt to foresee probable hazards:

[Restaurants] are not expecting to get robbed. [...] Same as banks, these places are insured. Manager [...] he’s just trying to get you out the door before you start plugging the diners. Waitresses? [...] no way they’re taking a bullet for the register. Busboys, some wetback

¹ de Vito S, and Della Sala S. Predicting the future. *Cortex*, 47(8), 1018-1022, 2011.

getting paid \$1.50 an hour, really give a fuck you're stealing from the owner? Customers sitting with food in their mouths. They don't know what's going on. One minute they're having a Denver omelette, next minute, someone's sticking a gun in their face.

Most people can mentally cast themselves in hypothetical scenarios and imagine related complex details. "Imagine there's no countries/It isn't hard to do" ("Imagine", John Lennon). This ability, variously labelled as episodic future thinking (Atance and O'Neill, 2001), prospection (Buckner and Carroll, 2007), proscopic chronesthesia (Tulving, 2002) or mental time travel (Suddendorf and Corballis, 2007), allows humans to examine the possible reactions likely to be elicited by the subcortical systems in certain contexts (Gilbert and Wilson, 2007). Towards the end of Clint Eastwood's *Hereafter*, George, who used to work as a psychic, has an appointment with Marie. He is sitting at a café, sees her arriving and looking for him, but he hesitates for a while to stand up from the table and reach her. He imagines Marie and himself very close, holding and kissing each other. This scene makes George smile and persuades him to meet her. Recent neuroimaging studies have revealed the neural regions that are engaged during the construction of possible future events (for a review see Schacter et al., 2008). At odds with what common sense would suggest ("past is fact and future is fiction", Suddendorf and Corballis, 2007, p. 302), most of the areas associated with future episodic thoughts have also been reported to be active when remembering past events. The most frequently observed among these regions are the medial prefrontal cortex, the lateral temporal cortex, the posterior regions of the medial and lateral parietal cortex encompassing the posterior cingulate and retrosplenial regions, and the medial temporal lobe including the hippocampus. The same regions belong to the "default network", a brain system that participates in internally focused functions, involving also autobiographical retrieval and imagining the future (Buckner et al., 2008). In light of such observations, it seems reasonable to propose that recalling past events is closely related to the ability of envisaging future ones. Nothing new, if we think that Immanuel Kant had the same insight in 1798:

Recalling the past (remembering) occurs only with the intention of making it possible to foresee the future; we look about us from the standpoint of the present in order to determine something, or to be prepared for something. Empirical foreseeing is the anticipation of similar cases (*expectatio casuum similium*) and requires no knowledge of causes and effects, but only the remembering of observed events, as they usually follow upon each other. Repeated experiences help to develop skill in empirical anticipation. (Anthropology from a Pragmatic Point of View, Immanuel Kant, p. 77)

Edmund Burke maintained that one “can never plan the future by the past” (Letter to a Member of the National Assembly, *The Works of the Right Honourable Edmund Burke*, Vol. 4, p. 55). Confucius disagreed: “study the past if you would divine the future”. Do we really need the past to imagine the future? The literature provides controversial findings. Should this be the case, amnesic patients ought to exhibit severe impairments in simulating their future. Indeed, people with memory impairments, observed, among others, by Lidz (1942), Tulving (1985), and Klein et al. (2002), seemed almost mentally marooned in a permanent present, since the preceding events were “not available to meet the new” ones (Lidz, 1942, p. 595). H.M. became amnesic in 1953, after the bilateral resection of medial temporal lobe structures (Corkin, 2002). When Sue Corkin asked him in 1992, “What do you think you’ll do tomorrow?”, he answered, “Whatever is beneficial”. He had “no database to consult when asked what he would do the next day, week, or in years to come” (S. Corkin, personal communication, 01/26/11). Hassabis et al. (2007) reported the lack of particulars and of spatial coherence shown by focal amnesiacs when constructing novel scenarios. It would actually seem that “we have no grasp of the future without an equal and corresponding outlook over the past” (Bergson, 1913, p. 69-70). The surrounding past and present cast a light on the future that otherwise might be hardly glimpsed, remaining hazy, vague and confused (Lidz, 1942).

“What did the previous day mean for him? And could he think about the next day? I could not understand how much he suffered for a similar difficulty” (The Professor’s Beloved Equation, Yoko Ogawa; own transl., Il Saggiatore, p. 31).

Ilya Kabakov and his wife, Emilia, have wonderfully expressed the conceptual relationship between memories from the past, the present and the future in one of their oeuvres, titled “Where is our place?” (2003) (see Fig. 2.1). The installation is articulated in three temporal spaces: present times are black and white pictures decorating a gallery at head height; enormous legs represent visitors from a remote past admiring portions of impressive and oversized 19th century paintings with giant gold-leaf frames hovering over the contemporary pictures, which, in comparison, almost become insignificant. The gigantic paintings disappearing into the ceiling suggest an historical period different from the present. They are gargantuan because they tower upon the *hic et nunc*. The viewer becomes solely a link in a chain of the three dimensions. He can have a glance at his future, through trapdoors into the floor. But the future content is markedly small and indistinct, far too narrow to be fully appreciated, and can only be guessed or imagined. Similarly, the people dancing in the middle of Edvard Munch’s painting *The Dance of Life* (1899-1900), are encircled by what they have been and what they will be.

“Life’s more interesting phenomena - he replied - probably always have this Janus face towards the past and the future” (Doktor Faustus, Thomas Mann).

It has been speculated, for instance by Endel Tulving, that “the ability to contemplate future scenarios was a driving force in the evolution of episodic memory. This proposed selection-for-imagination might even be blamed for the inherent fallibility of our recollective faculty” (Dudai and Carruthers, 2005).



Fig. 2.1 - “Where is our place?” by Ilya and Emilia Kabakov. Venezia, Querini Stampalia Foundation, 2003. Photo by Francesco Allegretto. Reproduced by permission.

The failures of episodic memory are apparently due to a flexible and, consequently, fallacious mechanism that enables people to retrieve and recombine bits of information in order to reconstruct autobiographical past events. In the attempt to put together these pieces, people are likely to make mistakes. This is probably the reason why memory cannot be considered a faithful recreation of past episodes. In “Swann’s way”, Proust defined the act of remembering a “labour in vain”: “How paradoxical it is to seek in reality for the pictures that are stored in one’s memory”.

“Then you say she’s lying, boy?”

Atticus was on his feet, but Tom Robinson didn’t need him.

“I don’t say she’s lyin’, Mr Gilmer, I say she’s mistaken in her mind”

(To Kill a Mocking-bird, Harper Lee, Londo: Mandarin Paperback, p. 218)

Miss Prism: Memory is the diary that we all carry about with us.
Cecily: Yes, but it usually chronicles the things that have never happened, and couldn't possibly have happened. I believe that memory is responsible for nearly all the three volume novels that Mudie sends us.

(The importance of being Ernest, Oscar Wilde)

There are lots of people who mistake their imagination for their memory.

(Quote attributed to Henry Wheeler Shaw aka Josh Billings)

Human memory is a marvellous but fallacious instrument. The memories which lie within us are not carved in stone; not only do they tend to become erased as the years go by, but often they change.

(The Drowned and the Saved, Primo Levi, transl. by Raymond Rosenthal)

The process, which causes such imperfections might be the same that lies behind the creation of novel episodes. It allows us to reshuffle details that unfolded in the past, although in different combinations and in different situations (Schacter and Addis, 2007a). “The past is the melting salt which spices up the future”, croons an Italian singer, Claudio Baglioni, (“*il passato è sale e si scioglie per dar sapore al futuro*”), but can also be updated to shape one's behaviour in the present and to construct alternative plausible behavioural modes ready to be used (Ingvar, 1979; Dudai, 2009).

Human behaviour is active in character, that is determined not only by past experiences, but also by plans and designs formulating the future, and [...] human brain is a remarkable apparatus which cannot only create these models of the future, but also subordinate its behaviour to them. (Luria, 1973, p. 13)

“I want memory to have a prospective dimension, to inhabit the future tense, to bring new worlds into being” (“Remembering the

future”, Malcom Bowie, in *Memory: An anthology*, edited by HH Wood and AS Byatt, 2008, p. 14).

A revealing example of human behaviour that is modelled on previous experiences and driven by future goals is shown by Rob Reiner in his comedy film, *When Harry met Sally* (1989). Harry decides not to take anyone to the airport at the beginning of a relationship, “because eventually things move on and you don’t take someone to the airport and I never want anyone to say to me: ‘How come you never take me to the airport anymore?’”. However, the part played by episodic memory in the simulations of future scenarios is still debated. The amnesic patients mentioned above exhibited widespread lesions encroaching upon brain areas other than the hippocampus (Nyberg et al., 2010; for a discussion, see Squire et al., 2010), including regions engaged in executive functions (e.g., see Samarasekera et al., 2007). People with a well-characterized hippocampal lesion and a subsequent deficit in recollecting recent personal memories, have reported to perform similarly to controls in future thinking tasks (Squire et al., 2010). Not all the areas activated by future simulations are involved in remembering past events (Addis et al., 2009). The activation of the hippocampus itself is not invariably required during all the steps of the simulating future process (Summerfield et al., 2010). Moreover, specific areas, as, for instance, the right frontal pole, are specifically involved in the construction of future events (Okuda et al., 2003; Addis et al., 2007; Summerfield et al., 2010), suggesting the fundamental role played by frontally based executive functions in the production and recombination of event-related details, even when episodic memory is spared. Furthermore, neuropsychological studies of patients with an impairment of the prefrontal cortex have shown a deficit in their subjective time, i.e., the ability of thinking about their “continued existence” (Szpunar, 2011, p. 410) that might substantially contribute to the capacity of mentally time travelling. Such observations provide us with clues as to the possible alternative roles played in the scene construction by cognitive functions other than memory. “It is accurate prediction of the future, more so than accurate memory of the past per se, that conveys adaptive advantages” (Suddendorf, 2006, p. 1007). However, predictions are likely to be wrong. We cannot be accurate in imagining our future.

If the sky that we look upon
should tumble and fall
and the mountains should crumble to the sea
I won't cry, I won't cry, no I won't shed a tear
just as long as you stand, stand by me
("Stand by me", Ben E. King)

How can he be so sure? "Trying to predict the future is like trying to drive down a country road at night with no lights while looking out the back window" (Peter F. Drucker). Also Dom Cobb, in Christopher Nolan's *Inception*, warns Arianna against using her memories to construct new scenarios:

Dom: Never re-create places from your memory. Always imagine new places.

Arianna: You draw from stuff you know, right?

Forecastings "tend to over-represent the moments that evoke the most intense pleasure or pain" (Gilbert and Wilson, 2007, p. 1353) and do not take into account many real features, as the capacity of adaptation. At the end of *Frida*, a movie that recounts the harsh life of Frida Kahlo, compelled to undergo countless medical operations after a car accident, the Mexican painter realizes that "at the end of the day, we can endure much more than we think we can" (*Frida*, Julie Taymor). It is possible that in the future we will see "things you people wouldn't believe" (*Blade runner*, Ridley Scott).

Indeed, it has been noticed that [...] in any case, the record of forecasters in the past thirty or forty years, whatever their professional qualification as prophets, has been so spectacularly bad that only governments and economic research institutes still have, or

pretend to have, much confidence in it. It is even possible that it has got worse since the Second World War. (Age of Extremes: The Short Twentieth Century 1914-1991, Eric J. Hobsbawm, London: Michael Joseph p. 5-6)

People cannot use the “pensieve”, with the help of which one “siphons the excess thoughts from one’s mind, pours them into the basin, and examines them at one’s leisure” (Harry Potter and the Goblet of Fire, JK Rowling).

“At the end of the day, all these things were still to happen! It was the future - Kees Poppinga’s future, which, in an evening of a December Wednesday, at 8 o’clock, could not yet be guessed” (The Man Who Watched Trains Go By, Georges Simenon, our transl., Adelphi, p. 12).

Aiming at predicting the future, we use cognitive functions, not crystal balls. Mental simulations might be “the means by which the brain discovers what it already knows” (Gilbert and Wilson, 2007, p. 1354). The sphere that we hold in our hand reflects us, like the Escher lithograph, “Hand with reflecting sphere” (1935). Therefore, our forecasts cannot be more precise than a sibylline statement with no commas (*Ibis redibis non morieris in bello*²). So, people can “mentally time travel” from past to future passing through the present (Tulving, 1985). Even the mother of all the muses, Mnemosyne in the Ancient Greek mythology, “has a Janus face, looking to both time past and time future” (Dudai and Carruthers, 2005).

I’ll sing my songs in the streets
and I’ll live my life hard-nosed
like a homeless warrior without sword
with my foot in the past

² The sibylline statement might translate as follows: *He will go, will come back, will not die in war*. In Latin the “*non*” could be yoked to “*redibis*” (i.e., He will go, will not come back, will die in war), or with “*morieris*” (i.e., He will go, will come back, will not die in war). Therefore, the Latin statement is ambiguous unless one puts a comma before or after the “*non*”.

and my gaze to the future

(“A muso duro”, Pierangelo Bertoli, own transl.)

My own future lies in my past and in my present

(“Prendi in mano i tuoi anni”, Litfiba, own transl.)

Thinking about the future can take numerous forms, varying from planning actions to foreseeing possible scenarios by means of knowledge and informed guesses, or speculations and intuitions, or imagination and creativity. Different cognitive processes are needed for each of these different types of future thinking. In this divertissement we mentioned episodic memory, on which our previsions are built; executive functions, which allow flexible searching inside memory storages; working memory that provides a workspace in which to manipulate and reassemble planning details; semantic memory, from which we draw scripts for postulating alternative scenarios; and temporal orientation that is vital to order the sequence of foreseen events. It has been maintained that “The best way to predict the future is to invent it” (Alan Kay, 1971). Perhaps, instead, the best way of thinking about the future is to use our imagination to remodel and re-create the past. In order to plan the future, which is what memory is about, we need a system of representations rather than mere recordings of events. The price that we pay is a memory system, which is fallacious and prone to errors (Schacter and Addis, 2007b), but it is worthwhile.

3. Introduction

3.1 Mechanisms of future-oriented cognition

Pietro Paladini, who has just been widowed, is suddenly to make a vital decision. One of his dearest friends, Jean-Claude, has been fired and Pietro is asked to take over his job of chairman. Pietro is to choose whether or not to become rich and powerful, betraying Jean-Claude. In such a situation, he finds advantageous to consider a future scenario, based upon what he knows, a personal past experience, and an event that he read.

I'm now living an event similar to one that I had already experienced in the past, and that's the reason why I'm quiet, with lowered eyes, looking at his shoes' "screen", where it has started being projected a movie full of opulence and pomposity that I would have never thought to desire: fabulous salary, power, permanent contract, stock options, private plane, works of art, vintage cars, exclusive apartments, chauffeur, any kind of benefits. [...]

It's obvious that I'll end up refusing the offer [...], and nonetheless, in the meantime, I'm here, looking at a twenty-two metres boat slowly flashing before my eyes, with myself at the helm and Claudia sunbathing on deck. (*Caos Calmo*, novel by Sandro Veronesi, UTET: Torino, 2005, own transl., p. 179)

Thierry, who is requiring the resolution, suggests him not to answer in that moment. "You're facing a difficult situation", he says, "that might hamper your future thinking".

These citations encapsulate the idea of episodic future thinking, encompassing all the involved cognitive processes mentioned in the previous chapter:

- Episodic memory. Thierry's offer reminds Pietro of an autobiographical past situation, which could have similarly changed the course of his life;
- Semantic memory. Pietro remembers a Schnitzler's³ character who in a few minutes has the opportunity to lose everything or to gain much money;
- Executive functions. He explores different memories, looking for the details he is interested in, to evaluate pros and cons. Thus, he is to deal with planning, checking, and binding together the converging inputs to come to a decision;
- Working memory. Pietro mentally works to combine these details to the point of extending an unprecedented meaning to them;
- Temporal orientation. He has to recognize the events that come up into his mind and to attribute a temporal order. This process avoids confusing past episodic with semantic memories, and with the hypothetical future development he is depicting at the moment.

Moreover, Thierry supplies the intuition temporarily ignored by Pietro, i.e., the essential role likely to be played by the present situation on his resolution.

Each step of episodic future thinking is likely to be affected by a distinct cortical brain damage. Given the complexity of the constructed experience task, Berryhill et al. (2010) raised the possibility of possible cognitive consequences (concerning future thought) of a lesion in *any* brain region.

The present thesis aims at investigating the cognitive underpinnings of foresight, “because humans may need to get better at it if we are to continue to survive” (Suddendorf, 2006, p. 1007). Accordingly, we will first provide a critical review of the current knowledge regarding this fundamental mental ability.

³ Arthur Schnitzler is a writer. In particular, he is the author of “Traumnovelle” and “Night Games”.

3.2 Conceptual development

The aptitude to imagine personal future episodes has always received a considerable amount of attention, not only from neuroscientists, but also from philosophers, singers, poets, painters, writers, sculptors, and movie directors, as formerly elucidated. However, only recently, researchers have begun to experimentally investigate the cognitive processes underlying this ability.

A long standing debate in the literature concerns whether this ability should be considered separately from or in conjunction with memory. Moreover, when considered straight in conjunction with memory, different kinds of relation may be taken into account.

Haith (1997) distinguished four relations:

- a) “continuation of a repeating past”, which is the simplest future-oriented cognitive performance based upon the expectation that cycling events will replay, like repeating and continuing phone rings;
- b) “projection of past trends”, anticipated by Wolff in the eighteenth century as the *expectatio casuum similium*, also quoted in Kant’s “Anthropology from a pragmatic point of view” (1798) (see previous chapter). In this case, people do not expect the same event to reply *verbatim*. But, on the basis of observed past events, they foresight similar facts, extrapolate a trend without distinctly knowing the link of causes and effects;
- c) “induction from observation”, which allows to construct future from analogy not only with own direct past experience, but also with indirect experience, i.e. experience of others or experience drawn

- from a general knowledge of the world. “We have never died, but we know we will” (p. 33), consequently we can envisage that moment;
- d) “imagination and invention”. This fourth relation raises the possibility of release from events occurred before to us or others and from reiterating past trends, imagining novel episodes that have never happened, like a hypothetical trip on Mars.

The preceding taxonomy entails the potential involvement of two memory systems: episodic and semantic memory. Tulving proposed the first formulation of a distinction between these two memory systems in 1972. This early differentiation was hinged on the diverse typologies and sources of to-be-remembered information. That is, individual experiences in the former case and general knowledge of the world in the latter. These concepts have evolved and, eventually, Tulving (2002) argued that episodic memory bears a unique relationship with time, a relationship of which semantic memory system is devoid. Episodic memory “allows people to consciously re-experience past experiences” (Tulving, 2002, p. 6). Perhaps, the lack of such a special connection with time is the reason why the semantic memory system has mostly been ignored in the studies concerning future thought. The literature has mainly focused on exploring the relation between thinking about the future and episodic memory.

And in fact, Szpunar (2010) has noticed that even the heterogeneous nomenclature adopted to identify forethought depends on whether or not it was thought to be in relation with episodic memory.

Some studies have highlighted a close linkage, although for different roots, between remembering personal past and envisaging personal future. To those we shall turn next. Cursive script will be adopted to underline the definitions coined within each work.

3.3 Episodic memory and future thinking

Atance and O'Neill (2001) have built their definition of *episodic future thinking* upon Tulving's most recent conceptualisation of episodic memory. Indeed, the two researchers have formulated a distinction between semantic and episodic future thinking, which mirrors Tulving's categorization for past memories. Whereas semantic future thinking concerns the projection into the future of a general knowledge of the world and, consequently, of reasonably good scripts, episodic future thinking "refers to an ability to project the self forward in time to pre-experience an event" (p. 537). In line with Tulving's theory, they maintained that it is the episodic memory system to underlie the capacity to cast personal events into the future.

Likewise, Suddendorf and Corballis (1997) have developed, from Tulving's theory, the idea of a close linkage between the skills of mentally travelling back to the past and of casting own minds forward. More precisely, they have provided a key account for this linkage, referring to the ability to travel mentally in time as "a prime mover in human cognitive evolution" (p. 165). A further explanation of this evolutionary perspective suggests that natural selection works on what episodic memory does for our survival. And one of the ways it may work in this direction is to inform about potential future scenarios (Suddendorf, 2010). The particularity of what Suddendorf (2010) labels *episodic foresight* implies the production of novel representations through combinations of pieces of information.

Schacter and Addis (2007a) have broadened this suggestion. Their *constructive simulation hypothesis* has suggested that the mechanism lying behind the episodic memory evolved as constructive rather than reproductive to allow individual simulations of future episodes. This selection permits people to collect elements from different memories, and to combine them in an unpredicted manner to shape a unique scenario. Thus, the researchers have speculated on the functions of episodic memory thought to prepare us for the future. What they have in mind when talking about *episodic simulation of future events* is the ability of "drawing on elements of past

experiences in order to envisage and mentally “try out” one or more versions of what might happen” (Schacter et al., 2008, p. 40). According to this view, Dudai and Carruthers (2005) have reminded that Mnemosyne, the personification of memory in ancient Greek mythology, had two heads facing the opposite directions of past and future. Morewedge and colleagues (2005) have argued that when people simulate their reactions to future episodes, they spontaneously rely on memories of similar events which were already experienced in the past. In addition, Gilbert and Wilson (2007) have noticed that “we naturally imagine our next dental appointment by remembering our last one” (p. 352). And also in a recent review Schacter, Addis and Buckner (2008) have observed that a crucial function of the brain is to use past experiences to anticipate future events.

D’Argembeau and Van der Linden (2004; 2006) have supported the idea of an intimate relation between remembering the past and *pre-experiencing* the future. In two different studies, they have demonstrated that phenomenal characteristics associated with both past and future representations might be similarly influenced by the same factors (the findings of these studies will be further analysed in the following session). Thus, they have suggested that the abilities of travelling backward and forward rely on similar mechanisms.

Bar (2007) has posited that episodic memories may be translated into novel *predictions* through associative activations. Thus, memories are “the building blocks of predictions” (p. 280). That is, the linked stored elements activate associations which are relevant in a specific situation. Predictions are generated by these associations, which is why they so often go awry. According to the idea that simulations are based upon memories, inaccurate to represent the past, Gilbert and Wilson (2007) have suggested that simulations cannot be accurate in representing the future. Furthermore, such inaccuracy is exacerbated by the fact that, when constructing future simulations, people often use a sample of the most memorable, as well as unrepresentative, memories (Gilbert and Wilson, 2007). This concept can be clearly illustrated using the example of the devastation of the Twin Towers in New York on September 11, 2001, the worst terrorist attack Americans ever endured: a

highly atypical event that, for this reason, might come very easily to mind. People who made their predictions and plans accordingly to such a memorable happening, were likely to be in danger of making mispredictions. And indeed, in the last months of 2001, the decrease of commercial airline passengers determined an increase in automobile traffic, which killed more people than the attack itself (Morewedge et al., 2005).

3.4 Similarities between past and future thought

The surge of evidence, which has shed a light on the commonalities linking episodic memory and episodic foresight, encompasses neuropsychological and phenomenological studies, and brain imaging research.

Parallel impairments in episodic past and future thoughts have been uncovered in many patients studies.

The earliest observation of an amnesic patient, who was also unable to imagine the future, was provided by Lidz (1942). Lidz reported on the case of O.S., a 30 years old man, who was admitted to the hospital seventeen days after a suicidal attempt by inhalation of carbon monoxide and suffered from a pure amnesic disorder. O.S. was tied to others for simulations and he had no sense of continuity of events. In fact, since he could not completely rely on his past, his future remained “hazier, more vague and more confused” (p. 596).

However, the pioneer of the above-mentioned surge is considered Endel Tulving (1985), who has reported on the case of K.C. (a.k.a. N.N.), aged 36, who suffered dense anterograde and retrograde amnesia following a closed-head injury that damaged several areas in the brain, including the frontal and medial lobes. His awareness of subjective time was also highly impaired. He seemed mentally trapped in a permanent present. When asked what he was going to do the day after, K.C. smiled faintly, and then answered, “I don’t know”. When encouraged to describe how was his state of mind like while trying to think about his future, he just said,

“Blank, I guess”; “It’s like being in a room with nothing there and having a guy who tells you to go to find a chair, and there’s nothing there”; and “It’s like swimming in the middle of a lake. There’s nothing there to hold up or do anything with” (Tulving, 1985, p. 4).

The famous amnesic patient, H.M., interviewed about his future plans by Sue Corkin in 1992, provided an as brief as eloquent answer that reflected his incapability to cast himself even in the most immediate future (S. Corkin, personal communication, 01/26/11; see previous chapter).

Dalla Barba and his colleagues (1997) have described the case of GA, a 52-years-old housewife, with no history of psychiatric diseases, who developed an amnesic-confabulatory syndrome consequent to a subarachnoid haemorrhage and ischemia. GA is the first case of an experimentally documented confabulation, which embraced the whole personal temporality (past, present and future). The impairments concerned her performances in episodic memory, orientation in time and place and personal future planning tasks. Her case was deeply investigated, with two tasks. At the first task, GA scored equally poorly to the episodic memory questions concerning her personal past and future, reporting the same percentage (60% for past and 60% for future) of confabulatory answers. At the second task, a future version of the Crovitz test, requiring a detailed account of autobiographical episodes related to a specific cue-word, GA confabulated when reporting a personal past event and even more when providing a future episode.

Amnesic patient D.B., a 78 years old man, was also found to be impaired in his ability to think about his personal future (Klein et al., 2002). The authors administered a questionnaire about past and future events (i.e., What did you do yesterday? What are you going to do tomorrow?), in which D.B. was severely impaired (with respect to both past and future questions). Interestingly, his deficit for future thinking was constrained to his personal future and he was able to imagine future public events, such as political events, as well as control subjects. However, Rosenbaum et al. (2009) noticed that the questions posed to allow the construction of

public events did not seem to promote the production of detailed narrative responses. For example, the question “Can you tell me what you think might be some of the most important issues facing the environment over the next ten years?” elicited the response “Threat that weather and rainfall patterns are going to change because of industrial pollution” (Klein et al., 2002, p. 367).

On the contrary, five patients with bilateral hippocampal damage, who were examined by Hassabis et al. (2007), were encouraged to generate “as many sensory and introspective details as they could” about a fictitious event, imagined from short verbal cues (i.e., “Imagine you are lying on a white sandy beach in a beautiful tropical bay”). The authors have reported an example of an event they produced: “As for seeing I can’t really, apart from just sky. I can hear the sound of seagulls and of the sea... um... I can feel the grains of sand between my fingers... um... I can hear one of those ship’s hooters... um... that’s about it. *Are you actually seeing this in your mind’s eyes?* No, the only thing I can see is blue. *So if you look around what can you see?* Really all I can see is the colour of the blue sky and the white sand, the rest of it, the sounds and things, obviously I’m just hearing... *Can you see anything else?* No, it’s like I’m kind of floating...”. As we can read, the scenarios they depicted were poor in detail and lacked in spatial coherence. Consequently, their scores fell definitely below the range of controls.

Klein’s ‘Lived Future’ Questionnaire (2002) was also administered to M.C., a young woman suffering from a severe impairment of episodic memory and topographical orientation deficits, as results of status epilepticus that could have caused an ischemia in both hippocampi (Andelman et al., 2010). The other cognitive functions were within normal limits. ‘My memory did not return to me... I take each day one at a time... I don’t see past today and tomorrow... and can’t picture myself in anything beyond the immediate present... that’s why I don’t have any aspirations or wishes’, she said (p.432). This case underscores once again the critical role of the hippocampus in envisaging future events other than the patient’s “affective de-compensation” (p.431), which came along with her full awareness of the severe problems in remembering and foresight.

Lastly, patients suffering from mild Alzheimer's disease presented with clear difficulties at generating autobiographical elements related to past and future episodes (Addis et al., 2009).

The association between episodic memory and future thinking has been highlighted also in clinical studies, which did not involve patients with impaired memory.

Twenty-four people with depression, hospitalized after self-poisoning, provided less specific autobiographical past and future events, in response to cues. In addition, a correlational analysis has showed an association between past and future specificity in both suicidal and control groups (Williams et al., 1996). Furthermore, D'Argembeau et al. (2008) have showed schizophrenic patients' failure in casting themselves into the future, suggesting a relation between this deficit and the failure in retrieving past memories. The patients presented pronounced difficulties in producing specific past and future events, if compared to controls, as well as a disorder of the sense of subjective time.

Moreover, the activation of particular brain areas has been showed to considerably overlap in backward and forward mental time travel. Okuda et al. (2003) have measured brain activity with Positron Emission Tomography (PET) in healthy participants thinking and orally reporting past experiences and future prospects in a naturalistic setting. Future and past thoughts share a common cerebral network, which encompasses the superior frontal, medial temporal and medial occipito-parietal areas. Their findings have also showed that specific areas in the frontal pole, including Brodmann Area 10 (BA 10), and the medial temporal lobes were more activated during future thinking task. The authors have hypothesised that a greater amount of activation of past episodes might be necessary to gain insights into the future and that additional cognitive processes are required to select the information needed to construct future prospects.

Addis et al. (2007) have used functional Magnetic Resonance Imaging (fMRI) to further investigate participants' brain activity during past recollections and future reports. With this aim, they have distinguished a "construction phase" (i.e., generation of the event) and an "elaboration phase (i.e., production of as much detail as possible to describe the event). In the former phase, the findings have revealed a common activation of left hippocampal, and of posterior visuospatial regions, for both past and future events, while the right hippocampus was engaged uniquely by future thoughts, along with the right fronto-polar cortex (BA 10). On the contrary, a considerable overlap between past and future events, encroaching upon left medial prefrontal, bilateral parahippocampal, and retrosplenial cortices, the posterior cingulate and the precuneus, characterized the latter phase. This overlap has been attributed to the common cognitive processes that might be primarily prominent during the elaboration, e.g., self-reflection, contextual and episodic imagery.

Likewise, Szpunar et al. (2007), using fMRI, have found that episodic memory and episodic foresight commonly engaged various brain regions, including the medial prefrontal cortex, the posterior cingulate cortex, the medial temporal cortex and the occipital cortex. At odds with the semantic comparison tasks adopted in the two previous studies, the researchers compared the experimental performances with a task requiring the imagination of Bill Clinton participating in an every-day life event (like a barbecue), thus, with neither temporal reference nor self-projection.

Studies on clinically normal people suggest further commonalities. Such similarities have been documented, in particular, by the phenomenological richness reported in past and future events. D'Argembeau and Van Der Linden (2004) asked participants to describe some positive and negative events (past and future), which occurred in one of two time frames, a recent and a remote one. Their results revealed that the sense of experiencing both past and future events was more strongly associated with positive, than with negative episodes. Furthermore, the most recent events were imagined or remembered with more contextual details and a stronger feeling of experiencing than the distant ones. Another research was carried out by the same authors (D'Argembeau & Van der Linden, 2006) and it has found that, both for past

and future reports, one's ability of visual imagery correlated with the amount of visual and sensorial details experienced, and that the aptitude to regulate emotions via suppression was associated with fewer sensorial, contextual and emotional details.

Finally, Addis et al. (2008) have observed that younger adults produced a greater amount of details mainly related to the core of the event ("internal") than older adults for both past and future events, implying that aging might affect future thinking similarly to how it affects memory. These results supported once again the constructive simulation hypothesis.

3.5 The debated role of episodic memory in episodic foresight

Suddendorf (2010) has pointed out that basically two interpretations concerning the above-mentioned links have been addressed in the literature.

One argues that episodic memory is a fundamental part of future thinking, as it provides the "raw material" (p. 100) to envisage situations likely to occur in the future. These are essentially the kinds of relation that Haith (1997) has identified as "continuation of a repeating past" and "projection of past trends" (see above): one is inclined to predict a reoccurrence in the future of what happened in the past (*verbatim* or through a details recombination). The second type of relation is close to Tolman's "theory of expectancy", that illustrated how rats can flexibly recombine their prior experience to deal with *ex novo* situations. The use of memory may be instrumental in the development of adaptive responses that extend beyond the stereotyped recurrence of reinforced sequences (Tolman et al., 1946). However, there is another possibility, that Haith (1997) called "imagination and invention", which contemplates the hypothetical trip of Mars never experienced. In this case, "episodic memory (together with other memory systems) may hence provide the vocabulary for episodic foresight. Humans can recursively combine and recombine basic

elements into novel scenarios and evaluate these in terms of their likelihood, desirability and so forth” (Suddendorf, 2010, p.101).

On the other hand, episodic memory is not to be necessarily considered as a “building blocks of predictions” (Bar, 2007, p. 280) or a “vocabulary” of elements which to draw on to foresee. The other theory, which Suddendorf (2010) has referred to, accounts for these links in a different manner. It argues that both episodic memory and future thinking share the same neurocognitive resources. They can draw on a widespread range of specific abilities, like a particular type of consciousness (autonoetic consciousness; Tulving, 1985), the ability of binding details, executive functions, self-projection (Buckner and Carroll, 2007) and related capacities, like conceiving others’ viewpoint (theory of mind) and navigation (Buckner and Carroll, 2007). That is, a number of cognitive functions other than episodic memory might play an integral role when constructing scenes. This latter theory accounts for a consistent body of research, already mentioned in Chapter 2, that we shall further explore next.

3.6 Cognitive functions, aside from episodic memory, at work

The role played by episodic memory in the construction of future prospects is still controversial. Recently, it has been suggested that it may not be a *condicio sine qua non* in simulations of future scenarios. Such an intuition has been corroborated by several criticisms to the studies mentioned above and consequent research, aimed at further disentangle this issue. Some of the studies mentioned earlier, do not detail the lesion location of the amnesiacs (O.S. and D.B.). In other cases (K.C. and Hassabis’ patients) the information that has been provided indicates an extensive damage, including impairments encroaching upon areas beyond the hippocampus (Squire et al., 2010). These observations downsize the importance of episodic memory and the hippocampus in future imaging, rendering the hypothesis of a crucial part played by episodic memory in future thinking arguable. In addition, some of the latest studies, using fMRI, have provided no evidence of a hippocampal involvement in subjective

time travel. Nyberg et al. (2010) required well-trained participants to imagine walking in a familiar environment in past, present and future. Thus, they were not to create an episode content, but were solely to self-project in a standard situation recurring in different temporal frames. The task, which held constant the informational content, did not recruit the hippocampal region. The authors interpreted their findings suggesting a closer relation between the hippocampus and the content, rather than between the hippocampus and the “conscious temporality of the experience” (p. 22357). Likewise, Squire et al. (2010) reported on future thinking performances in five patients with a well-characterised bilateral hippocampal lesion and one patient with extensive medial temporal damage, presenting with a subsequent, respectively, moderate and marked impairment in recent personal memories. The study aimed at casting a light on two of the key components of the past-future core network, embracing the medial prefrontal cortex, posterior regions in the medial and lateral parietal cortex, the lateral temporal cortex, and the medial temporal lobe including the hippocampus (Schacter et al., 2007). The intact ability of these patients in future thinking sharply contrasted with their striking impairment in recalling recent past episodes. Consequently, the authors have suggested that a selective hippocampal damage, which spares the rest of the core network proposed, is not sufficient to affect future imaging. Maguire and Hassabis (2011) have assumed that the patients could have supplied reports more semantic in nature, prompted by the single-word cue, likely to cause a semantic bias. However, Squire et al. (2011) have noticed that also one of the patients (P01) described by Hassabis et al. (2007), albeit the marked amnesia, was successful at constructing scenes, elicited by full sentence descriptors. This demonstrates that amnesia *per se* does not necessarily affect the ability of simulating scenes.

Consistently with this idea, it has been proposed a broader theoretical interpretation for the data concerning the age-related reduction in specificity for episodic memories (Levine et al., 2002), for those showing a parallel pattern in future thinking (Addis et al., 2008) and for the strong correlation between hippocampal activity and the amount of details produced in past and future events (Addis et al., 2009). At odds with what Levine et al. (2002) and Addis et al. (2008) maintained (i.e., that this kind

of age deficit entirely reflects an impairment of the constructive episodic memory system underling both past and future thoughts), Gaesser et al. (2011) have documented that age-related decline in reporting details extended also to a condition, that does not require episodic memory, e.g. a picture description task. These findings uncovered a non-episodic source of age differences in past and future thinking tasks, a source which is unrelated with memory itself.

3.7 Executive functioning and episodic future thinking

Obviously, the ability of future thinking is related to the capacity to produce specific personal details, mediated by executive control. Such observations were instrumental in the development of other studies that have been designed to explore the possible causal link between executive functioning and future prospects, in the attempt of gaining greater control over the simulation of scenes. This new branch of research takes into account that the extensive damages exhibited by the amnesic patients described above include also areas that play a crucial role in executive functions (e.g., see Samarasekera et al., 2007). The generation of detail-rich descriptions requires reconstructive mechanisms for the binding of information. Deficits or decline of these mechanisms might hamper the generation of details and, consequently, may account for impairments in a wide range of conditions, from episodic future thinking to the picture description task (Gaesser et al., 2011). Rosenbaum et al. (2009), for instance, view a more general construction deficit as a plausible, alternative root of K.C.'s impairment in future simulations. Aiming at testing this possibility, K.C. was required to produce fictional episodes and to retrieve or identify elements of semantic narratives (famous fairy tales and bible stories). Also in these conditions, the patient's scores fell well below the control range. These results stand in stark contrast with the episodic constructive simulation hypothesis. If future simulations must rely on the reformulation of past personal memories, then K.C. should have presented with a normal recollection of semantic narratives, albeit his severe impaired autobiographical episodic memory. However, this was not the case. Indeed, even when the information that he necessitated was available, he failed to construct detailed and integrate narratives.

Similar results have been obtained by Addis et al. (2010), who documented an age-related reduction in specificity also under a recombination paradigm, simply requiring healthy older adults to reformulate various elements into a cohesive episode. In line with this evidence, Addis et al. (2008) noticed a close linkage between tasks involving executive performances and tasks requiring episodic elements generation. In the study they carried out the amount of episodic details provided in past and future reports correlated with the Backward Digit Span task, which measures the executive control and engages the dorsolateral prefrontal cortex (Hoshi et al., 2000).

Accordingly, a number of neuroimaging studies have shown a greater frontopolar activation, including BA 10, during future thoughts, than during past recollections (Okuda et al., 2003; Addis et al., 2007; Summerfield et al., 2010). Interestingly, the greater was the activation of BA 10, the larger was the amount of elements provided in future constructions (Addis & Schacter, 2008).

Consistently with these observations, Summerfield and colleagues (2010) have showed, using fMRI, which components of the core network (Schacter et al., 2007) are variably engaged and disengaged during the various steps of a scene construction task. The participants were instructed to combine the single scene elements they were provided with in a cohesive scenario. The details were presented one at a time with no context. fMRI documented a significant activation of the hippocampus and the dorsolateral prefrontal cortex during the presentation of the first element. However, the introduction of the second element did not recruit the hippocampus, but required an increasing activation of the dorsolateral prefrontal cortex, perhaps to maintain two elements in working memory. The addition of the third element up-regulated several regions (i.e., the medial parietal cortex), down-regulated in both the previous phases, and increased the activation of the hippocampus. Thus, the hippocampus might not be invariably required in a construction scene process. On the contrary, frontally based executive functions are likely to be an integral part of the episodic elements reformulation mechanism.

3.8 Self-projection

When addressing the idea of prospection, some authors stressed the importance of a specific frontally-based function, of which future thinking is considered a “prototypical example” (Buckner and Carroll, 2007, p. 50): self-projection. Self-projection is a striking feature of our cognitive system that allows us to shift personal perspectives from the immediate environment to alternative situations. Thus, this ability is considered crucial when we conceive another individual’s viewpoints (theory of mind) and imagine ourselves in episodes before they occur. The brain network engaged in self-projection embraces frontal lobes and medial temporal-parietal lobes, which are also up-regulated in envisaging the future, episodic remembering, theory of mind and navigation (Buckner and Carroll, 2007). Therefore, Buckner and Carroll (2007) considered these abilities as single components of a “larger class of functions” (p. 55). By this view, their hypothesis is that self-projection relies upon memory system, since past personal details serve as the foundation to guide possible future simulations. Accordingly, self-projection itself is to be viewed as a crucial part of episodic remembering and imagining. They suspected, in line with the constructive episodic simulation hypothesis, that “the adaptive value of episodic memory is not solely in its ability to afford mental reconstruction of the past but rather in its contribution to build mental models – simulations – of what might happen next or other perspectives on the immediate environment, such as what others are thinking” (p. 55). However, some answers provided by K.C. stand in stark contrast with what they maintained. When asked, in more than one occasion, to describe what he felt when trying to imagine a future scenario, the patient, as previously mentioned, claimed, “It’s like being in a room with nothing there and having a guy tell you go to find a chair, and there’s nothing there” or “it’s like swimming in the middle of a lake. There’s nothing there to hold up or do anything with” (Tulving, 1985, p. 4). These sentences uncovered his ability to project himself in different situations. He managed to imagine swimming in the middle of a lake, while being interviewed by the experimenter. Although he did not

provide much detail, he was able to “shift perspective from the immediate present to alternative perspectives” (Buckner & Carroll, 2007, p. 49). And, indeed, many years later, Rosenbaum and his colleagues (2007) documented that K.C. preserved his ability to infer other people’s thought, presenting with no difficulties in tasks assessing theory of mind (strictly related to self-projection). Therefore, it may be argued that theory of mind’s abilities, which are related to self-projection, can be uncoupled from severe impairment of episodic memory and auto-noetic consciousness (Rosenbaum et al., 2007).

3.9 Auto-noetic consciousness

Auto-noetic (derived from the ancient Greek words αὐτός, which means “own self”, and νοέω, which means “I think”) consciousness gives a crucial contribution in the discussion of episodic future thinking and might be closely related to the capacity of projecting themselves into the future. This self-awareness allows us to recognise an event, which comes into our mind, as a memory, for instance, avoiding to confuse it with a dream or a simple thought. We make use of this ability whenever remembering past experiences or envisaging novel scenarios. When a person remembers an event from his own past, this kind of consciousness confers the awareness that the event is actually a veridical part of his personal past experience (Tulving, 1985). Thanks to auto-noetic consciousness, individuals can be aware of their subjective experience throughout time, by perceiving the present situation not solely as a continuation of their past but also as a prelude to their future. As the narrative mode of the “stream of consciousness” that was used by Joyce, the awareness of subjective time confers us the cognizance of a unique sense of time, which extends from the past to the future, passing through the present moment (Wheeler et al., 1997). “If we could somehow shed all that we had learned about the temporal structure of the world, what would our experience be like? Perhaps we would inhabit a dreamlike region, devoid of causal connections, of a past, present, and future, of a sense of place in time” (Friedman, 1990, p. 85). K.C.’s awareness of

subjective time was highly impaired and also GA's temporal consciousness was still working but not in the proper way (Dalla Barba et al., 1997).

The concept of auto-noetic consciousness is closely related to that of chronesthesia. The distinction between the two notions lies in their emphasis. The concept of "auto-noetic consciousness" stresses awareness of one's self existence in subjective time. The concept of "chronesthesia" stresses awareness of the subjective time in which one's self existence unfolds (Szpunar, 2011). A similar concept has been formulated by Dalla Barba et al. (1997) and has been labelled as "temporal consciousness". Temporal consciousness usually interacts with less stable, and thus more vulnerable, modifications in the long-term storage system. This work allows quick and steady updates in present orientation and in future planning. For instance, GA's temporal awareness was able to use only more stable modifications of the long-term storage system. The result was that the patient remembered "another" past and planned "another" future. She mistakenly involved her habits and personal semantic information in a personal temporal workspace. Her verbal statements were unintentionally incongruous to her history, her background and present situation. She was living one and half hours from the hospital and since her disease she never cooked. Nonetheless, when asked, "What are you going to do in a few minutes?", she did not hesitate to answer, "I will go home to cook the supper".

Damage to the prefrontal cortex may crucially compromise the capacity of travelling backward or forward in time, as consistently demonstrated in neuropsychological studies.

3.10 Exploring future prospects in healthy people and groups of patients

The present work stems from the interest to analyse in depth the intriguing ability of future thinking in healthy participants and people with different kinds of brain damage.

It begins with three chapters investigating normal people.

In Chapter 4 future prospects are elicited with different cues in the attempt of evaluating the characteristics of the prompts that we will then adopt in further experiments, especially with patients. In particular, in this study we are interested in understanding which type of cue makes the future task more challenging, which one encourages the production of more detailed descriptions and which cue might enhance the dependence on semantic memory.

In Chapter 5 we aim at ascertaining whether or not the simulations of the future might be based on reproductions of events that have already occurred. Participants in our future tasks are always instructed not to use their autobiographical memories or any part of them to envisage their future. Nonetheless, we suspect that, on some occasion, it is inevitable that participants might evoke events already experienced rather than constructing truly novel events. Two experiments are reported in Chapter 5, which probe this possibility empirically. In both of them, young adults are required to mentally re-experience and pre-experience temporally close and distant autobiographical episodes and to perform a delayed task, scored as remember-know judgments on new, old-remember, and old-imagine words.

Two further experiments, reported in Chapter 6, aim at investigating the contributions of familiarity of setting, self-relevance and self-projection in time to future thinking. The role of familiarity of setting is explored in the first experiment, by contrasting future thoughts with autobiographical future episodes supposed to occur in unfamiliar settings. The role of self-relevance is assessed in the second experiment, by comparing future thoughts to future events involving familiar others.

The role of self-projection in time is evaluated, in both experiments, by comparing episodic future thoughts with autobiographical events that are timeless in nature.

The second part of the dissertation focuses on the assessment of different populations of patients performing future thinking tasks.

The goal in Chapter 7 is to investigate whether amnesic Mild Cognitive Impairment (aMCI) affects episodic future thinking. Amnesic MCI is a high-risk factor for Alzheimer's disease and is characterized by a selective impairment of episodic memory, likely reflecting hippocampal malfunctioning. These patients present with a reduction of episodic specificity for past events. We are interested in observing whether such reduction extends also to future prospects. To this end, we assess fourteen aMCI patients and their respective controls.

In Chapter 8 we investigate whether the performance of people with Parkinson's disease (PD) on future simulation tasks is dependent also on executive control rather than solely on memory. Thus, we study patients without memory problems, to ascertain whether they might still present with difficulties future thinking. Should this be the case, we will explore the characteristics of those who failed in this task. Thirty-one PD patients and their matched controls are asked to imagine plausible future scenarios.

In Chapter 9 we discuss the hypothesis that patients presenting with impairments out with the domain of memory, such as executive dysfunctions, might perform poorly not only on a future task, but also when describing current settings while physically present in them. We investigate this hypothesis by assessing fourteen PD patients and matched controls. The patients were recruited from the sample reported in Chapter 8.

Chapter 10 stems from a debate concerning the use of two particular types of cue in testing amnesic patients (see Maguire & Hassabis, 2011; Squire et al., 2011). Here we further investigate the amount of details prompted by two types of cue (namely a

short sentence descriptor, Hassabis-like vs. a single word cue, Squire-like) in future descriptions in two cases of patients with amnesia, G.C. and M.D. The main question addressed in this study is which cue encourages a richer visualization avoiding semantic biases.

Chapter 11 reports on a single case, patient T.H., who confabulates when remembering past personal episodes. We aim at assessing whether or not confabulations regarding the past might extend also to the future and to a scene construction condition.

We finally discuss the findings reported in this dissertation taken together in Chapter 12.

4. The role of the cues in eliciting future thoughts

4.1 Introduction

The present study sprang from the attempt of understanding the properties of the different cues prompting future constructions. Heterogeneous cues have been used in the various studies of future thinking. Several authors have acknowledged that the type of cue used is a crucial factor to be taken into account when interpreting the results (Race et al., 2011; Hurley et al., 2011; Maguire & Hassabis, 2011). Indeed, the difference in cues has been considered the reason for having obtained different outcomes, hence leading to different conclusions (e.g., Maguire & Hassabis, 2011; Hurley et al., 2011). Nonetheless, the issue of the importance of cue has never been addressed directly in studies exploring the ability of foreseeing. Knowing the properties of particular kinds of cue might allow to eschew biases or to recognize and interpret them in the appropriate way should they occur. Some authors have used single cue-words (i.e., “*coffee*”, Kwan et al., 2010; Squire et al., 2010), some others preferred short verbal sentences (i.e., “*Imagine you are lying on a white sandy beach in a beautiful tropical bay*”, Hassabis et al., 2007; or “*Imagine catching your grandchild getting into trouble twenty years from now*”, Race et al., 2011). In the former case, the cue is generic and usually participants are told that the cue is just a prompt to imagine a particular scenario, which, therefore, is not framed by the cue. In the latter cases the cues are more specific and provide a setting (as in Hassabis et al.) or a template (as in Race et al.’s). When Hassabis et al. (2007) investigated the ability of constructing fictitious scenarios in hippocampal amnesiacs, they stated that they adopted the specific short sentence descriptor (i.e., “*Imagine you are lying on a white sandy beach in a beautiful tropical bay*”) to increase the probability that their patients relied on generic memory representations thus reducing the effect of retrieving from episodic memory. However, whether or not a specific cue allows one

to access to more “semanticized” memories remains matter of debate (see Maguire & Hassabis, 2011 and Squire et al., 2011).

Kwan et al. (2010) have reported that the mother of H.C., a patient with developmental amnesia, resulting from a bilateral hippocampal atrophy, considered many of her daughter’s past memories (elicited in their study by means of the single cue word) as “stories that had been retold over the years and may have been ‘semanticized’ to some extent” (p. 3184). To avoid this bias, i.e., to minimize the description of stories frequently retrieved or retold, Race et al. (2011) adopted a more specific short descriptor cue. Maguire and Hassabis (2011) have ascribed to Squire et al.’s (2010) study a semantic bias related to the use of the single-word cues. Maguire and Hassabis (2011) have noted that the single-word cues could have elicited descriptions based on semantics. This objection seems to contrast with what they themselves had stated in their previous study, where they said to have used short sentences descriptor with the aim of enhancing the dependence on semantics (Hassabis et al., 2007).

The debate acquired particular relevance since the same patient, H.C., was found to be impaired at imagining future thinking when the descriptions were prompted with a single-word cue (Kwan et al., 2010) and unimpaired when prompted with short descriptions (Hurley et al., 2011). A possible argument that was suggested to explain this difference was that a specific cue (short-descriptor) might somehow help patients in generating specific scenarios (Hurley et al., 2011). However, this was not true for Hassabis et al.’s (2007) patients, who were found to be impaired although they were tested with short sentences as cues. In addition, Squire et al. (2010) reported on hippocampal patients who exhibited a preserved ability of constructing future experiences in response to single-word cues.

Digging into the debate regarding the different cues uncovers a number of inconsistencies leaving open the question as to which type of cue might facilitate the construction of plausible future scenarios.

We aimed at partially disentangling this issue, by comparing two different kinds of cue, i.e., a generic cue, i.e. common objects (e.g., *table*, *apple*), and a cue that characterized a specific setting (e.g., *market*, *kitchen*). Both cues were presented as single words, to minimize the differences between the procedures. The prompts did not differ in length, but in the level of specificity. According to Hassabis et al. (2007) and Hurley et al. (2011), patients with brain injuries should find it less challenging to perform a future task in response to a setting-cue (“commonplace, everyday scenarios were specifically selected to increase the dependence of constructions on generalized semantic memory representations formed from numerous prior experiences, and thus minimize any possible contribution of recent or even remote episodic memories” Hassabis et al., 2007, p. 1729), given that, in this way, they are prone to generate more semantic descriptions (i.e., with a greater amount of external details) On the contrary, Maguire and Hassabis (2011) and Race et al. (2011) maintained that an object-cue is more likely to elicit a semantic bias, than a setting-cue. Indeed, Race et al. (2011) stated that they have used a cue representing a context to discourage participants from reporting frequently recalled and retold event information and Maguire and Hassabis (2011) argued that “participants did not have vivid and coherent scenarios in mind but may, instead, have supplied descriptions that were more semantic in nature, and recall from semantic memory is spared in patients with damage to the hippocampus. This semantic bias is likely caused by the single word cues used by Squire et al. compared with the full sentence descriptors used in other studies, which specifically encourage rich visualization”. We aim at contrasting these two hypotheses.

In particular, our goal is to compare the future events elicited using two different types of single word cue: a cue defining an object (i.e., object-cue) versus a cue defining a setting (i.e., setting-cue). We will compare the future events on the basis of a priori parameters: the richness of internal details, the richness of external details, the perceived phenomenological characteristics, and the time of response needed to construct the events. In line with Conway (2001), our hypothesis is that participants will produce more internal and less external details in response to the setting-cues

than in response to the object-cues, and that they will take longer to generate an event elicited by an object-cue than with a setting-cue.

4.2 Method

4.2.1 Participants

Forty young adults (20 males and 20 females) participated in this experiment as volunteers. The average age and education was 29.7 (± 8.7) and 15.8 (± 3.25) years, respectively. None of the participants had any history of neurological or psychiatric disorders.

4.2.2 Materials and experimental procedures

The experiment was carried out in one session. Participants were required to remember and imagine autobiographical episodes in response to eight cue-words. Four of these cue-words were objects (e.g., table, apple) and four of them were settings (e.g., church, market). Participants were instructed to retrieve or imagine specific events (which had to take place at a specific time and in a specific place), that had happened to them in the past or that might happen to them in the future, related to a specific cue-word. When asked to imagine future events, they were instructed to avoid retrieving memories of past events or parts of them, but rather to imagine events that could happen to them in the future given their current plans and goals. They were given the following example: “For instance, if I ask you to imagine any event that might happen to you during the next two years, which involves the word *table*, you should try to imagine a particular conversation, a particular meal or a particular moment occurring while sitting at a table, that could last from a few minutes up to an hour”.

Each trial started with a slide presented on a computer screen, and with the task instructions concerning the temporal direction (remember or imagine) and the cue word. An example of the instruction given to the participants in the object-cue condition was “*Imagine an episode that might happen to you in the next years which might involve an apple*” (for the future task) and “*Remember an episode that happened to you in the past which have involved an apple*” (for the past task). In the setting-cue condition participants were prompted as following “*Imagine an episode that might happen to you in the next years at a market*” (for the future task) and “*Remember an episode that happened to you in past at a market*” (for the past task). There was no time limit for imagining or retrieving the event. Participants were solely required to say “STOP” when they had retrieved or imagined the event. A stopwatch was used to register each participant’s time of response.

Once they stated that they had remembered/imagined the event, they were asked to describe it in as much detail as possible, and asked to experience it as vividly as possible, including aspects such as setting, objects or people present, what had happened, as well as any emotions, colours, smells, tastes, or sounds which was elicited.

Recollections and simulations were digitally recorded to enable later transcriptions and subsequent scoring of the participants’ responses. After the transcription, a trained rater systematically parsed the details generated in the past and future events using the standardized scoring procedure developed by Levine et al. (2002). Thus, first she segmented the main event (i.e., the most talked about, with a brief timeframe) into details and then distinguished between (a) internal details (i.e., episodic information pertaining to the main event, specific to time and place) and (b) external details (general knowledge related to the event). Internal details were further categorized into: (a) event (happenings, individuals present, physical/emotional actions and reactions, weather), (b) place (information about the environment where the event occurred), (c) time (date, season, month, day of the week, time of day), (d) perceptual (sensory information, body position) and (e) emotion (emotional state, thoughts). External details were further categorized into: (a) external event (specific

details from other incidents, from all of the above categories, external to the main event), (b) semantic (general knowledge or facts, ongoing events, extended states of being), (c) repetition (unsolicited repetition of details), and (d) other, such as metacognitive statements, or editorializing. Furthermore, a second rater, trained for this purpose, was asked to score 20 protocols.

Following the description of each event, the participants were asked to rate the phenomenological characteristics of the mental representation they had just formed on a 7-point scale, using a modified version of the MCQ questionnaire (see D'Argembeau & van der Linden, 2004). The modified version of the MCQ questionnaire that we used has been reported in Appendix A.

4.3 Results

4.3.1 Ratings of phenomenological characteristics

The ratings of visual details, sounds, smells, tastes were averaged, for each participant, to form a general “sensorial details index”. Likewise, the ratings of clarity of location, clarity of spatial arrangement of objects and people were averaged into a “clarity of location index” (D'Argembeau & van der Linden, 2004). Furthermore, the scoring included a “temporal index” (indicating the temporal details included in each representation), a “structural index” (indicating how clear participants considered their representations), and an “index of intensity” (which indicated how strong was the feeling of re-experiencing or pre-experiencing the event). The main ratings, with the respective standard errors, are showed in Table 4.1.

| Index | Past | | Future | |
|-------------------|-------------------|------------------|-------------------|------------------|
| | Object-cue | Setting-cue | Object-cue | Setting-cue |
| Sensorial | 4.27 (\pm 1.1) | 4.50(\pm 1.2) | 4.34(\pm 1.2) | 4.26(\pm 1.3) |
| Location | 5.48(\pm 0.9) | 5.34(\pm 1.1) | 4.86(\pm 1.4)* | 4.35(\pm 1.4) |
| Temporal | 5.39(\pm 1.3) | 5.24(\pm 1.5) | 4.19(\pm 1.7) | 4.50(\pm 1.9) |
| Structural | 5.46(\pm 1.1) | 5.85(\pm 0.8) | 5.05(\pm 1.5) | 5.09(\pm 1.4) |
| Intensity | 5.06(\pm 1.3) | 5.35(\pm 1.1) | 5.25(\pm 1.2) | 5.06(\pm 1.3) |

Table 4.1 - Mean ratings (\pm standard errors) as a function of temporal direction of the event (past vs. future) and of typology of cue (object vs. setting).

*** Future episodes were related to a higher *clarity of location index* when the prompt was an object, rather than a setting, $t(39) = 2.36, p = 0.02$.**

Separate 2 (temporal direction: past vs. future) x 2 (type of cue: object vs. setting) analyses of variance were carried out for each phenomenal characteristic. The results showed no difference between past and future events elicited with object-cues or with setting-cues, as regard to the *sensorial details index*.

Two main effects were observed for the *clarity of location index*:

- temporal direction, $F(1, 38) = 21.15, p < 0.001$, indicating that overall participants rated past events as spatially clearer (M = 5.41; SD = 1.06) than future events (M = 4.61; SD = 1.42);
- type of cue, $F(1,38) = 4.84, p = 0.03$ (with Bonferroni adjustment for multiple comparisons), indicating that overall spatial arrangement and clarity of location were better defined in events prompted by object-cues (M = 5.17; SD = 0.31) than in those prompted by setting-cues (M

= 4.85; SD = 0.17). This difference was particularly relevant for future episodes. Post-hoc t-tests revealed no difference between the *clarity of location index* in past episodes prompted either with a setting or with an object cue. On the contrary, future episodes were related to a higher *clarity of location index* when the prompt was an object (M = 4.85; SD = 1.42), rather than a setting (M = 4.35; SD = 1.38), $t(39) = 2.36, p = 0.02$.

Overall, the *temporal connotation* appeared clearer to participants for past episodes (M = 5.31; SD = 0.14) than for future episodes (M = 4.34; SD = 0.14), $F(1,38) = 24.34, p < 0.001$. No differences were observed on the basis of the different types of cue.

The same pattern was observed for the *structural index*, whereby, despite the lack of differences between the cue type, participants rated past events (M = 5.66; SD = 0.22) as being better than future events (M = 5.06; SD = 0.02), $F(1,38) = 10.21, p < 0.005$.

No differences were found concerning the *index of intensity*.

The results of the statistical analyses are displayed in Table 4.2 and 4.3.

| Index | Past Mean | Future Mean | Significance of the differences between Past and Future Means |
|-------------------|------------------|--------------------|--|
| Sensorial | 4.38(±1.6) | 4.3(±1.8) | n.s. |
| Location | 5.41(±1.06) | 4.61(±1.42) | $F(1, 38) = 21.15, p < 0.001$ |
| Temporal | 5.31(±0.14) | 4.34(±0.14) | $F(1,38) = 24.34, p < 0.001$ |
| Structural | 5.66(±0.22) | 5.06(±0.02) | $F(1,38) = 10.21, p < 0.005$ |
| Intensity | 5.2(±1.1) | 5.15(±1.1) | n.s. |

Table 4.2 - Mean ratings (± standard errors) as a function of temporal direction of the event (past vs. future) and the results of the ANOVAs.

| Index | Object-cue Mean | Setting-cue Mean | Significance of the differences between Object- and Setting-cue |
|-------------------|------------------------|-------------------------|--|
| Sensorial | 4.3(±1.1) | 4.3(±1.1) | n.s. |
| Location | 5.1(±0.3) | 4.8(±0.1) | $F(1,38) = 4.84, p = 0.03$ |
| Temporal | 4.7(±0.2) | 4.8(±0.2) | n.s. |
| Structural | 5.2(±0.1) | 5.4(±0.1) | n.s. |
| Intensity | 5.1(±1.1) | 5.2(±1.1) | n.s. |

Table 4.3 - Mean ratings (± standard errors) as a function of typology of cue (object vs. setting) and the results of the ANOVAs.

4.3.2 Scoring of internal and external details

The inter-rater reliability (r) between the two raters who scored the descriptions, calculated on a subset of 20 randomly selected protocols, was .94.

An overall ANOVA 2 (temporal direction: past vs. future) x 2 (detail: internal vs. external) x 2 (type of cue: object vs. setting) indicated the main effects of temporal direction ($F(1,38) = 16.65, p < 0.001$), details ($F(1, 38) = 259.57, p < 0.001$), and cue type ($F(1, 38) = 5.27, p < 0.05$). Furthermore, two interactions were significant, i.e., the interaction between details and cue type, $F(1,38) = 23.29, p < 0.001$, and the interaction between temporal direction and details, $F(1,38) = 10.62, p < 0.005$.

The three main effects showed that overall

- more details were generated in past events ($M = 7.7$; $SD = 3.6$) than in future events ($M = 6.4$; $SD = 2.4$);
- participants produced more internal ($M = 12.6$; $SD = 4.9$) than external ($M = 1.5$; $SD = 1.2$) details;
- more details were generated in response to setting-cue ($M = 7.3$; $SD = 3.3$) than to object cue ($M = 6.8$; $SD = 2.7$).

Post-hoc t-tests were carried out to further analyse the two interactions (i.e., detail x type of Cue and temporal direction x detail). The t-tests showed that the amount of internal details generated was greater in response to a setting-cue ($M = 13.35$; $SD = 5.7$) than in response to an object-cue ($M = 11.87$; $SD = 4.5$), $t(39) = -3.65, p < 0.005$. Furthermore, less external details were produced when the prompt was a setting-cue ($M = 1.34$; $SD = 1.2$) compared to an object-cue ($M = 1.75$; $SD = 1.5$), $t(39) = 2.89, p < 0.01$ (see Figure 4.1) (see Table 4.4). For what concerns the interaction between temporal direction and details, the t-tests suggested that a greater amount of internal details were generated in past events ($M = 13.8$; $SD = 6.3$) than in future events ($M = 11.42$; $SD = 4.18$), $t(39) = 3.75, p < 0.005$. No differences were observed as regard to external details.

| Typology of cue | Details | |
|-----------------|--------------------|-------------------|
| | Internal | External |
| Object | 11.87(\pm 4.5) | 1.75(\pm 1.5)* |
| Setting | 13.35(\pm 5.7)* | 1.34(\pm 1.2) |

Table 4.4 - Mean number (\pm standard deviations) of internal and external details prompted with object vs. setting-cues.

*** The mean of internal details elicited with the setting cue is significantly higher than that of internal details prompted with the object cue and the mean of external details prompted with the object cue is significantly higher than that of external details prompted with the setting cue.**

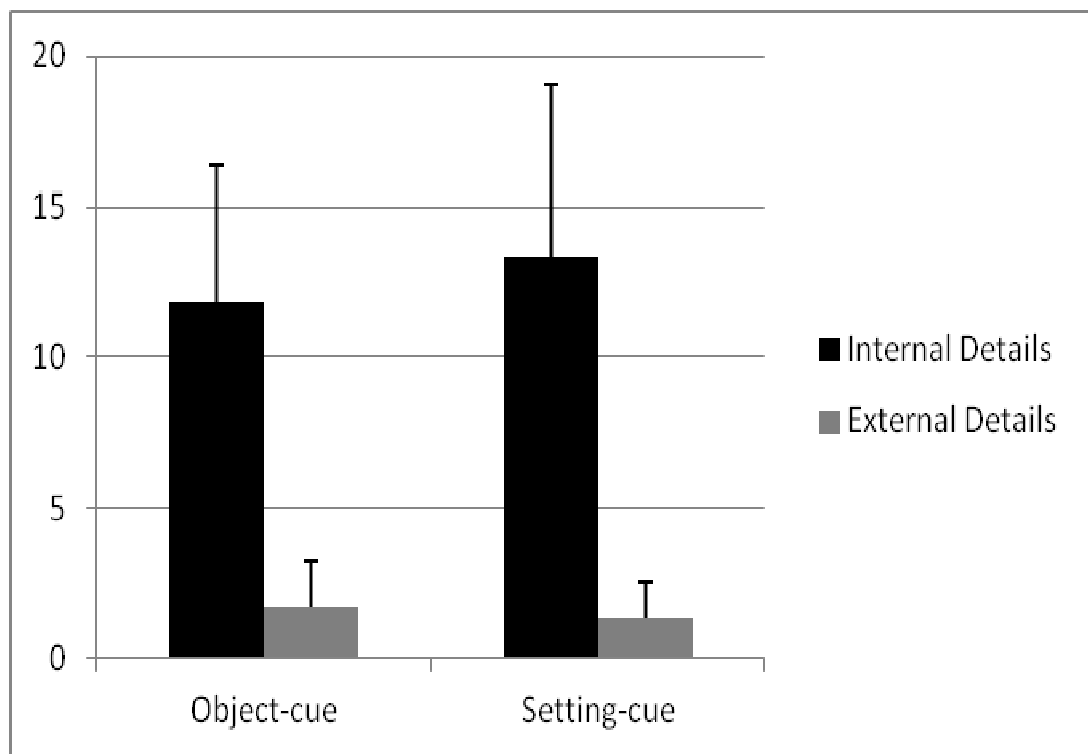


Figure 4.1 - Mean number of internal and external details prompted with object vs. setting-cues. Error bars indicate standard deviations.

Two separate 2 (detail: internal vs. external) x 2 (type of cue: setting vs. object) ANOVAs were conducted in the past and in the future conditions.

The 2 (detail: internal vs. external) x 2 (type of cue: setting vs. object) ANOVA conducted in the past condition showed a significant detail x type of cue interaction, $F(1,38) = 7.83, p < 0.01$. Post-hoc tests showed no significant difference in the amount of external details produced with the setting cue or with the object-cue. On the contrary, the number of internal details produced in response to setting cues was significantly greater ($M = 14.76, SD = 8.27$) than the number of internal details produced in response to object cues ($M = 12.84; SD = 5.15$), $t(39) = -2.27, p < 0.05$.

The separate 2 (detail: internal vs. external) x 2 (type of cue: setting vs. object) ANOVA conducted solely in the future condition revealed a significant detail x type of cue interaction, $F(1,38) = 4.27, p < 0.05$. Post-hoc t-tests showed no significant differences in the number of internal details generated with the two different types of cue. However, more external details were generated in response to object cues ($M = 1.69; SD = 1.56$) than in response to setting cues ($M = 1.28; SD = 1.18$), $t(39) = 2.28, p < 0.05$.

Finally, we analysed the time of response (in seconds) that elapsed between the presentation of the cue-word and the moment when the participant started reporting his description. An ANOVA 2 (past vs. future) x 2 (object-cue vs. setting-cue) revealed a main effect of the type of cue, $F(1,38) = 4.93, p < 0.05$, indicating that participants took longer to retrieve or construct past and future episodes when the cue was an object ($M_{\text{sec}} = 20.57; SD_{\text{sec}} = 18.51$) than when the cue was a setting ($M_{\text{sec}} = 15.73; SD_{\text{sec}} = 10.71$) (see Figure 4.2). Post-hoc t-tests revealed no significant difference in time of response of past recollections elicited with setting or object cues. The difference was, instead, significant as regard to the future episodes. Participants took longer to imagine future events when prompted by an object cue ($M = 21.15; SD = 25.21$), than by a setting cue ($M = 14; SD = 11.59$), $t(39) = 2.48, p < 0.05$.

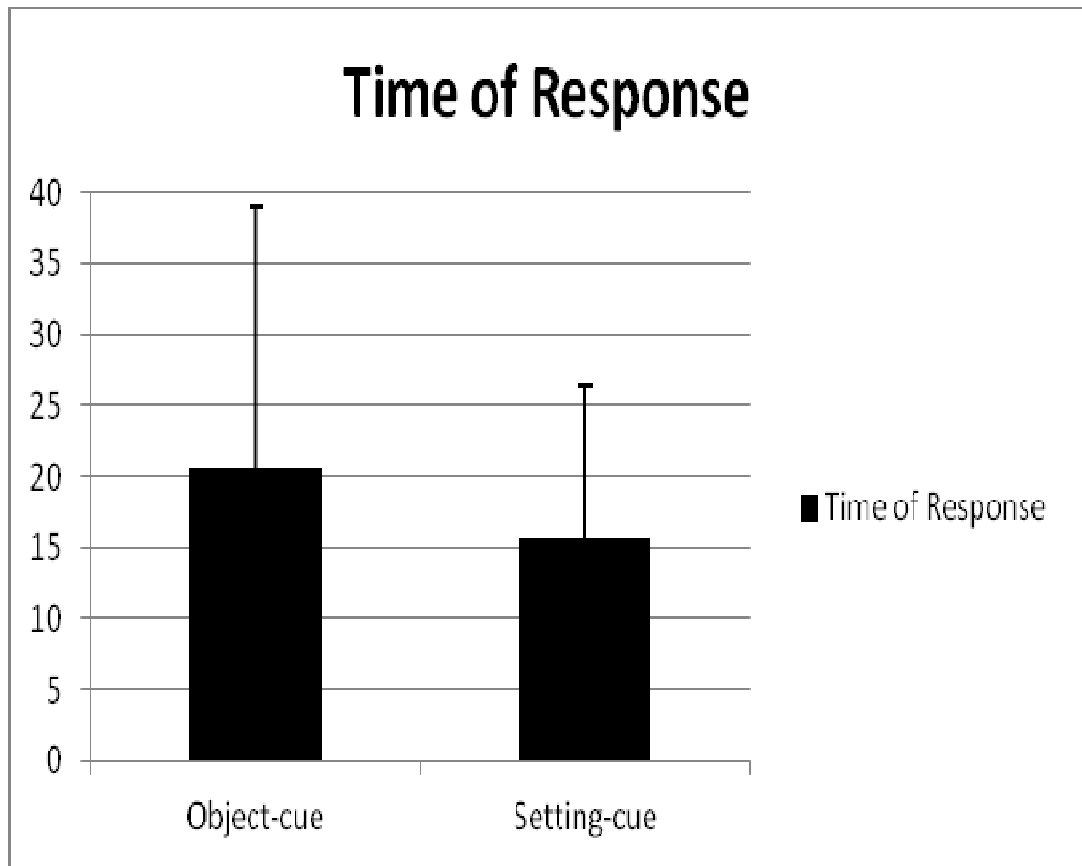


Figure 4.2 - Mean of time of responses expressed in seconds. Error bars indicate standard deviations.

4.4 Discussion

The findings that have been reported in this chapter reveal that participants generated more details in response to the setting-cues than in response to the object-cues. In particular, more internal details and less external details were generated when the prompt was a setting rather than when it was an object. Furthermore, participants took longer to generate an event elicited with an object-cue than with a setting-cue. However, the perceived *clarity of location index*, given by the spatial arrangement of people and objects and the clarity of location, was higher in episodes elicited by object-cues than in those prompted by setting-cues.

In particular, future events elicited with object-cues were richer in semantic (external) details, required more time to be constructed, and were related to a stronger clarity of location index, if compared to those elicited by setting-cues.

The present study adds a valuable contribution to the recent debate regarding the use of the cue in future thinking literature. Indeed, it shows, first, that the generation of future reports as that of past recollections might depend on the type of cue used, and that a more specific cue, representing in our case a setting, might more easily elicit past and future constructions with more episodic-related and less semantic details. At odds with what Hassabis et al. (2007) suggested, our results imply that a setting-cue might increase the dependence on less semantic memories.

The specificity of the cue is a matter of particular interest considering that, according to Conway (2001), “autobiographical memory knowledge base is highly sensitive to cues” (p. 1377). The cue-driven retrieval process (i.e., the process of retrieving memories when there is a voluntary intention of doing so) usually starts from a search of episodes at a general level. Most of the cues activate different general events or lifetime periods. For this reason, the activation is often weak and, consequently, it fades rapidly. “Direct access only occurs when a cue maps on to and, consequently, highly activates episodic memory (either a single or set of episodic memories) and activation spreads from here to a single general event and to an associated lifetime period” (Conway, 2001, p. 1378). However, as the author has noted, this occurrence is atypical, given that it is rare that a cue exactly matches the content of an episodic memory. Therefore, an intentional retrieval mechanism usually involves the elaboration of the cue, the memory search and the evaluation of the output obtained. When the outputs are not satisfying, they are further explored and another memory search initiates. Thus, the more general the cue, the more complex the activation of a specific episodic memory. When a general prompt is presented by the experimenter, the activation of a specific memory takes longer, as it requires a number of steps. Conway (2001) considered the case in which the cue-word *chair* is provided to the participant in the attempt of prompting the retrieval of an episodic past episode. The first step is to contextualize the object, putting it in an

environmental reference frame. Thus, for instance, the participant thinks of the chair he has got in the kitchen at home. Then, he will try to further elaborate on the cue, asking himself where he bought that chair, for example, trying to remember an episode in which this object appeared. The derived information produced a number of further searches more and more specific which finally allow the person to access the specific episodic memories and the related sensory-perceptual details.

Our findings support Conway's model, which suggests that generic memories are more likely to be activated by a generic word, like *chair*. In line with that model, the activation of generic memories is the first step of the retrieving process, in light of a hierarchical organization of autobiographical memory. A healthy person would find it easier to access specific memories with the aid of a specific prompt, because this would bypass the process of further elaborations of the cue in the attempt of contextualizing it. Therefore, according to this view, people are more likely to report generic memories in response to a general cue (e.g., a single word cue indicating an object) rather than to a more contextualized cue (e.g., a short description of a setting, or a single word cue representing a setting). Similarly, they would find it easier to construct "semanticized" future episodes (poor in event-related details) in response to a generic cue word rather than in response to a more specific cue.

The perceived *clarity of location index* was higher in episodes elicited by object-cues than in those prompted by setting-cues. This finding might be due to the fact that the process of constructing events prompted with an object-cue took longer than that required when the prompt was a setting-cue. When the cue was an object, in fact, participants had to search the details needed to set a scenario and recombine them. Thus, they had more time to mentally experience the future event and to organize the setting where the scenario would take place. This process might have increased the perceived clarity of the spatial arrangement of people and objects present and the clarity of location.

The longer time of response that we have found when the prompt was an object-cue rather than a setting-cue suggests that greater cognitive demands might be associated

to the former cue rather than to the latter one. Therefore, our results corroborate a number of previous observations (Race et al., 2011; Hurley et al., 2011; and Maguire and Hassabis, 2011) and stand in striking contrast with what Hassabis et al. (2007) stated. In line with Hurley et al. (2011), we suggest that an object-cue might be more challenging than a setting-cue, because it places a greater demand on strategic searching rather than on the event construction. And indeed, Hurley et al.'s patient (H.C.) was unimpaired at the construction of novel scenarios prompted by short verbal descriptions of settings, whereas she was impaired in a future task prompted by object cues (Kwan et al., 2010).

Some researchers (e.g., Race et al., 2011) preferred to use a very specific cue to decrease the probability that their patients rely on generic autobiographical knowledge when constructing future experiences. In light of the current findings, we opted instead to use in our experiments more generic cues (the object-cues), which load on both strategic searching and event construction, making the task more challenging, and, thus, more sensitive to detect impairments at each single step of episodic future thinking. Moreover, our findings reveal that object-cues might be associated to a stronger feeling of perceived clarity of location, which measures the spatial coherence and vividness of the constricted scenario. The strength of such feeling and the number of internal details present in the future episodes testified the contiguousness and the consistency of each future description. That is, although reports prompted by object cues might rely more on semantics, as Maguire and Hassabis (2011) suggested, this does not imply that they are less vivid and less coherent than those elicited by setting-cues, at odds with what Maguire and Hassabis themselves argued. However, it is worth specifying that we did not use a short verbal description in the present experiment. Our aim was indeed to follow two similar procedures and not to introduce other variables likely to add confusion. Therefore, the setting-cue that we used was only partly comparable to the short-sentence descriptor adopted by Hassabis et al. (2007). Both of them represent a setting, but Hassabis et al.'s cue was more detailed and did not possess any temporal indication (*"Imagine you are lying on a white sandy beach in a beautiful tropical bay"*); ours

instead did (*“Imagine an episode that might happen to you **in the next years** on a **beach**”*).

5. The role of past in the simulation of autobiographical future episodes⁴

5.1 Introduction

As we have seen in the introduction, many investigators have begun to approach episodic memory in a broader context that considers not only the ability of individuals to re-experience past events but also the capacity to envision oneself in a specific future scenario (Schacter & Addis, 2007a; Suddendorf & Corballis, 2007). The role that episodic memory plays in simulating personal future events has been formally stated in the aforementioned *constructive episodic simulation hypothesis* (Schacter & Addis, 2007a), which suggests that reminiscence and future thinking are the expression of the same neurocognitive system. This hypothesis states that the constructive nature of episodic memory allows one to draw on the past and to flexibly extract and recombine elements of previous experiences. The constructive episodic simulation hypothesis has received general support from evidence of cognitive and neural overlap between past and future events. For instance, it has been shown that the phenomenal characteristics associated with projecting oneself into the past and into the future are influenced by such factors as the temporal distance from the present (D'Argembeau & van der Linden, 2004; see also Addis et al., 2008; D'Argembeau & van der Linden, 2006; Spreng & Levine, 2006). Three neuroimaging studies have highlighted a common neural network, including bilateral frontopolar and medial temporal regions, when remembering past and imagining future events (Addis et al., 2007; Okuda et al., 2003; Szpunar et al., 2007). This common network of regions showed greater activation when participants envisioned their personal future or recollected their past as compared with control tasks, such as

⁴ Gamboz N, Brandimonte MA, de Vito S (2010). "The role of past in the simulation of autobiographical future episodes", *Experimental Psychology*, 6: 1-10.

imagining another person participating in specific events (Szpunar et al., 2007). These results indicate that these brain areas are preferentially engaged in self-referential mental activity. Not surprisingly, this network is remarkably similar to the network consistently involved in the retrieval of episodic memories of past autobiographical events (Maguire, 2001).

Most recently, this network of regions has been suggested to belong to an anatomically defined brain system (default network) that is activated when individuals engage in internally focused tasks including autobiographical memory retrieval, envisioning the future, and conceiving the perspectives of others (Buckner et al., 2008). The idea that thinking of the future is closely related to retrospective memory is also strengthened by evidence indicating that amnesic patients are highly impaired on both retrieving past and imagining future autobiographical events (Hassabis et al., 2007; Klein & Loftus, 2002; Tulving, 1985).

Taken together, these results are generally consistent with the view that reminiscence and future thinking are closely related activities and involve similar processes. However, we believe that there is an important question that should be addressed before any further theorizing on the common neurocognitive substrate of thinking about the past and of thinking about the future. That is, is it possible to spot a boundary between past and future thinking? We reasoned that, although both processes draw on elements of previous experiences, as stated by the constructive episodic simulation hypothesis, envisioning future scenarios is unquestionably cognitively more demanding than recollecting past experiences. Namely, mentally travelling forth to the future, more than travelling back to the past, involves both the retrieval of elements of past experiences and the construction of new representations of what might plausibly occur in the future. Accordingly, it has been observed that the ability of future thinking necessitates a greater neural activity (Okuda et al., 2003; Addis et al., 2007). Specific frontal polar regions are more active when thinking and verbally describing future prospects, than when thinking and reporting past events. Furthermore, infinite elements within the autobiographical episodic memory might be taken into account with the aim of contrasting a future simulation. Thus, future

thinking might be considered more effortful than remembering (Anderson et al., in press).

It seems, therefore, legitimate to wonder whether individuals who are engaged in imagining future events actually produce novel scenarios or whether they rather rely, more or less deliberately, on some alternative strategies. As a matter of fact, earlier studies concerned with episodic future thinking failed to acknowledge that people can employ different strategies to comply with the requirements of envisioning personal future experiences. Furthermore, participants were explicitly asked to imagine novel (i.e., not previously experienced) future events in some previous studies (e.g., Addis et al., 2007, 2008), whereas this request was not specified in other studies (e.g., D'Argembeau & van der Linden, 2004; Szpunar et al., 2007).

In the present study we aimed at assessing whether or not participants, who engage in episodic future thinking, are likely to retrieve, at least occasionally, events that have already taken place and adjust them to fit in with the test requirements. We believe that this may represent a suitable strategy, easy to implement in those cases in which envisioning future episodes does not appear easily achievable, as when participants are experimentally cued to imagine future events with a single word, maybe under time pressure (e.g., Addis et al., 2007, 2008). By addressing this issue we do not question human's ability to simulate future events, but we rather advocate the necessity to disentangle the construction of truly novel scenarios from the reproduction of real, though impoverished, past events when measuring future thinking.

To this end, in the present study, participants were required to mentally re-experience and pre-experience temporally close and distant autobiographical episodes and rated their phenomenal characteristics. In particular, we addressed the issue as to whether participants' future representations were really new events in two ways.

First, we explicitly asked participants to indicate the novelty of a future event by rating how often they experienced in the past the same or a very similar event. This is

the most straightforward way to explore whether participants' future representations resemble memories of events that had already taken place, rather than being true simulations of novel events. However, one important consideration is in order. The constructive episodic simulation hypothesis (Schacter et al., 2007) states that imagination of future scenarios is formed by retrieving and flexibly recombining elements of previous experiences in novel ways to create new and plausible representations. This process plausibly leads participants to think about events that are similar to previous experiences even when asked to think about events that have never happened before. It follows that, even when participants rate an imagined event as occurred very often, there is no direct evidence that indicates that participants simply remembered a past event and "tweaked" it. That is, an event can be very similar to past experiences but might still revolve around a totally novel scenario. However, when participants rate an imagined event as never occurred before, this provides an unquestionable evidence of the novelty of that event. It is the comparison between past events and imagined events rated as never occurred before and between past events and imagined events rated as occurred very often that can shed some light on the main issue of whether there are significant differences between past and future thought.

Second, participants performed a delayed recognition task on new, old-remember, and old-imagine words which also included remember-know judgments. This delayed recognition task was included to ascertain how successfully participants could discriminate between what they experienced in the past and what they imagined could happen in the future. The worse the discrimination, the more likely that participants reproduced past experiences as new episodes, somewhat impoverished or distorted in their phenomenal qualities. Accordingly, we predicted that participants should falsely attribute old-imagine words to remembered episodes.

Our goal, in the present study, is to assess whether or not participants, when asked to perform future thinking tasks, are likely to retrieve events that have already occurred. Our hypothesis is that, at least occasionally, participants engaging in episodic future thinking, might retrieve past events instead of constructing new future events, and

alter them to comply with the requirements of the question. This might be an effective strategy to avoid the difficulties associated with the creation of a future scenario.

5.2 Experiment 1

5.2.1 Method

5.2.1.1 Participants

Twenty-eight young adults from Suor Orsola Benincasa University participated in this experiment as volunteers. The average age and education were 25.0 (SD = 4.0) and 15.6 (SD = 1.8) years, respectively. All participants had no history of neurological or psychiatric disorders.

5.2.1.2 Materials and procedure

The experiment was conducted in two sessions. During the first session, participants mentally re-experienced and pre-experienced two temporally close (few weeks) and two temporally distant (few years) autobiographical episodes in response to eight cue words. The procedure was adapted from D'Argembeau and van der Linden (2004) and from Addis et al. (2007). Participants were encouraged to retrieve and imagine temporally and contextually specific events. Future events had also to be plausible, given the participant's plans, and novel, that is, not previously experienced by the participant. Sixteen words were selected from the Burani et al. (2001) Italian norms and were assigned to two sets of eight words each, matched for words' familiarity, frequency, imageability, and concreteness.

Fourteen participants saw one set of cue words, while the other fourteen participants saw the other set of cue words. Within each set, the cue words were cycled through conditions obtained by combining temporal direction (remember or imagine) and temporal distance (few weeks or few years). Each participant was then assigned to a counterbalanced version of the task with the constraint that half participants performed the past task first, followed by the future task, and the other half received the opposite sequence. Any one trial started with a cueing slide presented on the computer screen providing task instructions concerning the temporal direction (remember or imagine), the temporal distance (few weeks or few years), and the cue word.

Once an event had been retrieved or imagined (there was no time limit for retrieving and imagining an event), participants were given 60 s to retrieve or imagine as many details as possible. Then, participants rated, on 7-point scales, the phenomenal characteristics of each event using a modified version of the MCQ questionnaire (see D'Argembeau & van der Linden, 2004). More relevant for the purpose of the present research, we also included a question asking participants to indicate the novelty of a future event by rating how often they experienced in the past the same or a very similar event. This question was aimed at assessing the participant's tendency to retrieve an event that had already taken place and adjust it to fit in with the test requirements, rather than imagining truly novel scenarios. We included three further questions investigating how rich the representation of a specific future episode was with respect to familiar objects, places, and people. We do not expect that people imagine new elements – at least when they are explicitly required to think about plausible events, as in our experiments (but see Szpunar & McDermott, 2008) - but we rather expect that imagined future events will differ with respect to the number of familiar elements included in them. It is likely that the lower the novelty (high rating on frequency of occurrence), the more likely future events are rated as rich of familiar elements.

At the end of the first session, which lasted approximately 90 min, participants were asked to come back to the Laboratory a week later. All participants agreed to do so.

Therefore, in the second session, an unexpected recognition task (created *ad hoc* for each participant) was administered. The test consisted of 12 old-remember and 12 old-imagine words and 28 distractor items presented in a random order. Old-remember and old-imagine words were the four cue words plus eight words selected, for each participant, from the responses he/she provided when describing the four past and the four future episodes generated in response to the cue words. More precisely, two naïve students, unaware of the purpose of the study, listened to the recordings of each past and future event described by each participant and selected the five words they evaluated as the most representative of each specific event. Then, for each event, the experimenter selected the two words that both naïve students had evaluated as the most representative. The 28 distractor items, equivalent for each participants, were selected from the Burani et al. (2001) Italian norms and matched the 8 cue words for words' familiarity, frequency, imageability, and concreteness. In the recognition task, each word was presented on the computer screen and the participant was asked to make one of three possible judgments, that is, old-remember, old-imagine, or new.

Participants were instructed:

- (a) to give an old-remember response, when they recognized a word as one of the cues used to prompt recollection of a past event or as a word they produced when describing a past event;
- (b) to give an old-imagine response, when they recognized a word as one of the cues used to prompt imagination of a future event or as a word they produced when describing a future event; and
- (c) to give a new response, when they recognized a word as unrelated to the previous task.

We have also investigated the subjective experience of recognition by asking participants to assign (by key press) their old-remember and old-imagine responses as either Remember (R), Know, (K) or Guess (G) responses. The G response was added in order to prevent participants from using the K option in case of uncertainty

(Gardiner et al., 1996). Namely, participants were instructed to make an R response if they retrieved specific information relating the item to a previously retrieved or imagined event, a K response if they recognized the item on the basis of familiarity without recollection, and a G response if they were uncertain about whether or not the item was related to the event. This second session lasted approximately 30 min.

5.2.2 Results

5.2.2.1 Ratings of phenomenal characteristics

For both past and future events, the ratings of the two near and the two distant events were averaged into a single value for each phenomenal characteristic, for each participant.

| | Past Events | | Future Events | |
|--|-------------|------------|---------------|-----------|
| | Near | Distant | Near | Distant |
| Sensorial details | 4.4 (.19) | 4.5 (0.20) | 4.1 (.23) | 4.0 (.21) |
| Structure | 4.9 (.26) | 4.5 (.24) | 4.1 (.26) | 4.4 (.30) |
| Clarity of location | 5.6 (.19) | 5.2 (.26) | 4.8 (.28) | 4.3 (.31) |
| Temporal information | 5.2 (.28) | 4.9 (.32) | 3.3 (.38) | 3.4 (.39) |
| Valence | 4.9 (.28) | 4.6 (.29) | 5.1 (.30) | 5.5 (.25) |
| Intensity | 4.7 (.30) | 4.7 (.34) | 5.1 (.25) | 5.3 (.26) |
| Visual perspective | 1.9 (.06) | 1.9 (.05) | 1.9 (.04) | 1.9 (.06) |
| Richness (of familiar objects, people and places) | / | / | 4.8 (.21) | 4.1 (.29) |
| Frequency of occurrence (novelty) | / | / | 3.4 (.51) | 3.1 (.33) |

Table 5.1 - Mean ratings (and standard errors) as a function of event type (past and future) and temporal distance (near and distant) for Experiment 1. *Note.* Structure = My memory for this (the image of this future) event is: 1 = sketchy/7 = very detailed. Novelty decreases proportionately as frequency of occurrence increases, that is, the lower the rating, the higher the novelty.

In addition, the ratings for visual details, sound, smell, taste, and tactile details were averaged, for each participant, into a general sensorial details index. Similarly, the ratings for clarity of location, clarity of spatial arrangement of objects, and clarity of spatial arrangement of people were grouped into a single clarity of location index (D'Argembeau & van der Linden, 2004). Finally, the ratings for richness of representations of future events with respect to familiar objects, places, and people were grouped into a single richness index. The mean ratings are presented in Table 5.1.

| Ratings | Experiment 1 | | Experiment 2 | |
|---------|--------------|---------|--------------|---------|
| | Near | Distant | Near | Distant |
| 1 | 32.1 | 39.3 | 20.0 | 36.7 |
| 2 | 7.1 | 10.7 | 10.0 | 13.3 |
| 3 | 3.6 | 7.1 | 3.3 | 16.7 |
| 4 | 8.9 | 12.5 | 23.0 | 36.7 |
| 5 | 12.5 | 12.5 | 13.3 | 6.7 |
| 6 | 14.3 | 5.4 | 13.3 | 10.0 |
| 7 | 21.4 | 12.5 | 16.7 | 10.0 |

Table 5.2 - Frequency distribution of ratings concerning the novelty of future scenarios as a function of temporal distance (near and distant) for Experiments 1 and 2. Note. The numbers indicate the percentage of events that received ratings from 1 to 7 (out of 56 near events and 56 distant events in Experiment 1 and of 30 near events and 30 distant events in Experiment 2).

Separate 2 (event type: past vs. future) x 2 (temporal distance: near vs. distant) analyses of variance were carried out for each phenomenal characteristic. Results indicated that memories for past events contained more sensorial details than representations of future events, $F(1, 27) = 6.88, p < 0.01$, and were richer in internal details than representations of future events, $F(1, 27) = 5.47, p < 0.02$. As regards clarity of location, memories for past events were more clearly represented than representations of future events, $F(1, 27) = 18.59, p < 0.0001$, and both past and future near events were more clearly represented than distant events, $F(1, 27) = 9.05, p < 0.01$. Concerning temporal information, memories for past events were also clearer than representations of future events, $F(1, 27) = 26.19, p < 0.0001$.

With respect to the richness of future representations, results showed that near future events were rated as more rich of familiar elements (objects, places, and people) than distant future events, $t(27) = 2.63, p < 0.01$, that is, the novelty was significantly higher for distant future events than for near future events, $t(27) = 2.15, p < 0.05$, that is, envisaged distant future events were rated as less frequently experienced before. The remaining rating scales did not differ between past and future events or between near and distant events.

With respect to the novelty of future representations, we hypothesized that, to the extent that participants envisage truly novel scenarios, the novelty of their representations should be rated as high, that is, envisaged future events should be rated as never happened before. The inspection of frequency distribution of ratings (Table 5.2), however, suggests that this was not always the case. In fact, less than 40% of near and distant future events were rated as novel.

Next, we assessed to what extent past events differed from both future events rated as high in novelty and future event rated as low in novelty, with respect to their phenomenal characteristics. To this aim, from the original sample of 112 events (56 near and 56 distant) we selected only those events that had been assigned either a rating of 1 (never happened; 18 near and 22 distant events) or a rating of 7 (happened very often; 12 near and 7 distant events). When more highly novel events (either near or distant) belonged to the same participant, their ratings for each phenomenal characteristic were averaged into a single value. The same procedure was used for future events rated as low in novelty. In so doing, two samples of 19 and 11 participants, respectively, were obtained, who produced future events that were rated as high and low in novelty. In order to compare the phenomenal characteristics of past and future events that were high and low in novelty, for each participant in each group the ratings of the two near and the two distant past events were averaged into a single value for each phenomenal characteristic.

The results of repeated measure *t* tests indicated that highly novel future events were less clearly represented than the correspondent past events, with respect to location,

$t(18) = 2.83, p < 0.01$, and temporal information, $t(18) = 3.22, p < 0.005$. No such difference emerged between past and future events which were rated as low in novelty.

5.2.2.2 Recognition memory

Mean proportion of participants' responses (old-remember, old-imagine, and new) per word type are presented in Table 5.3. To examine participants' ability to discriminate between old and new items, a recognition index was calculated separately for old-remember and old-imagine items using the $[P(\text{old response}) - P(\text{false alarm})]$ formula. These measures were based on all correct "old" responses irrespective of whether these were associated with accurate source attribution. Results of repeated measure t tests indicated that the discrimination accuracy for old-imagine items was marginally higher than the discrimination accuracy for old-remember items, $t(27) = 2.02, p = 0.05$ (see Table 5.3).

| | Participants' responses | | | Recognition index | Correct source |
|---------------------|-------------------------|----------|----------|-------------------|----------------|
| | Remember | Imagine | New | | |
| <i>Experiment 1</i> | | | | | |
| Old-remember | .77(.04) | .07(.03) | .18(.03) | .74(.03) | .87(.06) |
| Old-imagine | .18(.04) | .71(.05) | .11(.02) | .80(.02) | .57(.09) |
| New | .05(.01) | .03(.01) | .91(.01) | | |
| <i>Experiment 2</i> | | | | | |
| Old-remember | .78(.04) | .04(.02) | .18(.03) | .75(.03) | .90(.04) |
| Old-imagine | .18(.04) | .65(.05) | .11(.03) | .76(.03) | .56(.11) |
| New | .02(.01) | .05(.01) | .91(.02) | | |

Table 5.3 - Recognition memory as a function of word type (old-remember, old-imagine, and new) and source attribution for Experiments 1 and 2. Standard errors are in parentheses.

To analyze participants' ability to identify the correct source of recognized items, a source-monitoring index (Johansson et al., 2002) was calculated separately for old-remember and old-imagine items using the following formula: $[P(\text{correct source attribution}) - P(\text{wrong source attribution})] / [P(\text{correct source attribution}) + P(\text{wrong source attribution})]$. Results of a Wilcoxon Matched Pairs Test indicated that old-remember items were attributed to their correct source at a higher rate than old-imagine items, $T = 31.5, p < 0.01$ (see Table 5.3).

| Item type | Remember | Know |
|-------------------------------------|----------|------|
| <i>Experiment 1</i> | | |
| Correct source attribution | | |
| Old-remember (254) | .90 | .10 |
| Old-imagine (238) | .89 | .11 |
| Incorrect source attribution | | |
| Old-remember (23) | .83 | .17 |
| Old-imagine (62) | .79 | .21 |
| <i>Experiment 2</i> | | |
| Correct source attribution | | |
| Old-remember (141) | .94 | .06 |
| Old-imagine (117) | .99 | .01 |
| Incorrect source attribution | | |
| Old-remember (7) | 1.0 | .00 |
| Old-imagine (32) | .97 | .03 |

Table 5.4 - Mean proportion of Remember and Know responses as a function of word type (old-remember, old-imagine, and new) and source attribution (correct and incorrect) for Experiments 1 and 2. *Note.* Parentheses indicate the total number of participants' old responses (out of 336 in Experiment 1 and out of 180 in Experiment 2); incorrect source attribution = old-remember and old-imagine items attributed to the wrong source (i.e., old-remember items recognized as old-imagine items and old-imagine items recognized as old-remember items).

With respect to the subjective experience of recognition (see Table 5.4), more R responses than K responses were assigned to both correctly recognized old-remember (R = 0.90, K = 0.10) and old-imagine items (R = 0.89, K = 0.11). None of the participants provided a G response. Most important, more R responses than K

responses were also assigned to old-remember ($R = 0.83$, $K = 0.17$) and old-imagine items ($R = 0.79$, $K = 0.21$) attributed to the wrong source, suggesting that the incorrect source attribution was also based on conscious recollection.

5.2.3 Discussion

Our goal in this experiment was to explore whether participants' future representations may sometimes reproduce memories of events that had already taken place, rather than being true simulations of novel events. As regards the phenomenal characteristics associated with mental time travel, overall, our results have replicated previous findings (e.g., Addis et al., 2008; D'Argembeau & van der Linden, 2004, 2006), indicating that real events contained more phenomenal details than imagined events, in line with the reality monitoring framework (e.g., Johnson et al., 1988). In addition, our findings that near future events were rated as richer of familiar objects, places, and people than distant future events fit well with the temporal construal theory of Trope and Liberman (2003), which suggests that representations of distant future events are more abstract and decontextualized than representations of near future events. Most important for the purpose of the present research, the results concerning the novelty of episodic future events indicated that some future events that have been evoked by participants were rated as having had already occurred or very similar to past events. It is interesting to note that the rating of frequency of occurrence (the higher the rate the lesser the novelty) of distant future events was significantly smaller than the rating of frequency of occurrence of near future events. To date, future events with a low novelty were indistinguishable from past events with respect to their phenomenal characteristics.

Results from the delayed recognition task have also provided important information on future events evoked by participants. We assumed that, the more past experiences are reproduced as new episodes, the harder it should be to correctly discriminate between past and future events. Discrimination accuracy for old-remember and old-imagine items was very high and almost equivalent. However, in line with our

hypothesis, participants falsely attributed old-imagine words to remembered episodes at a higher rate than the opposite (though the proportion of incorrect source attribution was quite low). Furthermore, both correct and incorrect source attributions were based on conscious recollection, as indicated by the larger proportion of R responses than K responses associated to both correctly recognized old-remember and old-imagine items and to old-remember and old-imagine items attributed to the wrong source.

The results of Experiment 1 therefore indicate that, on some occasions, participants reproduce events already occurred in the past or very similar to past events, rather than envisioning truly novel events. However, the results of the recognition task should be taken with caution because the words, selected ad hoc for each participant, may have contained idiosyncratic references that could have reminded a person of one of the several events he/she experienced in the past associated with that word. Namely, participants may have mistaken more frequently the source for old-imagine than for old-remember words because, in their life, they accumulated many different experiences associated with a particular word. It appears therefore essential to replicate Experiment 1 by checking whether participants' responses in the recognition task correspond to the original events reported during the first part of the task.

5.3 Experiment 2

5.3.1 Method

5.3.1.1 Participants

Fifteen young adults from the Suor Orsola Benincasa University participated in this experiment as volunteers. The average age and the average education were 27.5 (SD

= 5.1) and 14.4 (SD = 3.0) years, respectively. All participants had no history of neurological or psychiatric disorders.

5.3.1.2 Materials and procedure

The experiment was conducted in two sessions, lasting approximately 90 min each. The first session was the same as in Experiment 1. In the second session, a week later, participants performed the unexpected recognition task, which was the same as in Experiment 1 except for the inclusion of the request to indicate, after each old response, the event related to the item recognized as either old-remember or old-imagine. More precisely, after classifying their old-remember and old-imagine responses as either Remember (R), Know, (K) or Guess (G) responses, participants were instructed to shortly describe the event, either remembered or imagined during the first part of the experiment, that was related to that particular item that was recognized as old. This debriefing procedure was included to check whether participants' responses in the recognition task overlapped the original events reported during the first part of the task.

5.3.2 Results and discussion

5.3.2.1 Ratings of phenomenal characteristics

The analyses of the ratings for the phenomenal characteristics were the same as in Experiment 1. The mean ratings are presented in Table 5.5. As in Experiment 1, and in line with earlier studies (e.g., D'Argembeau & van der Linden, 2004, 2006), results indicated that, overall, past events contained more phenomenal details than imagined events. In particular, as regards the clarity of location, memories for past events were more clearly represented than representations of future events, $F(1, 14) =$

32.3, $p < 0.0001$, and both past and future near events were more clearly represented than distant events, $F(1, 14) = 6.85$, $p < 0.05$.

| | Past Events | | Future Events | |
|--|-------------|-----------|---------------|-----------|
| | Near | Distant | Near | Distant |
| Sensorial details | 4.5(.24) | 4.1 (.22) | 4.2 (.28) | 4.0 (.20) |
| Structure | 4.7 (.40) | 4.7 (.21) | 3.9 (.49) | 3.8 (.38) |
| Clarity of location | 5.7 (.26) | 5.2 (.24) | 4.6 (.29) | 3.9 (.32) |
| Temporal information | 4.7 (.51) | 4.5 (.32) | 3.3 (.34) | 2.5 (.37) |
| Valence | 4.8 (.35) | 4.4 (.38) | 5.03 (.31) | 4.8 (.37) |
| Intensity | 4.9 (.25) | 4.9 (.34) | 4.9 (.41) | 5.7 (.26) |
| Visual perspective | 1.8 (.08) | 1.7 (.09) | 1.7 (.08) | 1.7 (.09) |
| Richness (of familiar objects, people and places) | / | / | 4.7 (.38) | 3.7 (.26) |
| Frequency of occurrence (novelty) | / | / | 4.1 (.49) | 2.9 (.46) |

Table 5.5 - Mean ratings (and standard errors) as a function of event type (past and future) and temporal distance (near and distant) for Experiment 2. Note. Structure = My memory for this (the image of this future) event is: 1 = sketchy/7 = very detailed. Novelty decreases proportionately as frequency of occurrence increases, that is, the lower the rating, the higher the novelty.

Concerning temporal information, memories for past events were also clearer than representations of future events, $F(1, 14) = 14.18, p < 0.01$. Experiment 2 replicated results of Experiment 1 in that the rating of richness of familiar objects, places, and people for near future events was significantly higher than the rating of richness for distant future events, $t(14) = 2.67, p < 0.02$.

The novelty of distant future events was marginally higher than the novelty of near future events, $t(14) = 1.94, p = 0.054$ (i.e., envisaged distant future events were rated as less frequently experienced before). The remaining rating scales did not differ between past and future events or between near and distant events. The inspection of Table 2.2 illustrating future events' frequency of occurrence reveals that, as in Experiment 1, participants imagined novel scenarios (20% and 36.7% of near and distant future events, respectively, were rated as novel), but they also produced representations of events that were rated as already occurred. As in Experiment 1, we compared the phenomenal characteristics of past and future events which were rated as high or low in novelty. Two samples of, respectively, 11 and 5 participants were obtained, who produced future events that were rated as high (6 near and 11 distant events) or low (5 near and 3 distant events) in novelty. In line with results of Experiment 1, highly novel future events contained less sensorial details, $t(10) = 4.3, p < 0.001$, were less complex, $t(10) = 3.1, p < 0.01$, and less clearly represented with respect to both location, $t(10) = 5.0, p < 0.001$, and temporal information, $t(10) = 3.1, p < 0.001$, than past events. As in Experiment 1, no such difference emerged between past and future events which were rated as low in novelty.

5.3.2.2 Recognition memory

Mean proportions of participants' responses (old-remember, old-imagine, and new) are presented in Table 5.3 as a function of word type. Results from the delayed recognition task in Experiment 2 replicated results of Experiment 1, indicating that, although the overall discrimination accuracy for old-remember and old-imagine items was very high and equivalent, participants falsely attributed old-imagine words

to remembered episodes at a higher rate than the other way round, $T = 96.5$, $p < 0.001$ (see Table 5.3). With respect to the subjective experience of recognition (see Table 5.4), as in Experiment 1, more R responses than K responses were assigned to both correctly recognized old-remember ($R = 0.94$, $K = 0.06$) and old-imagine items ($R = 0.99$, $K = 0.01$).

| Item type | Same | Different |
|-------------------------------------|-------------|------------------|
| <i>Correct source attribution</i> | | |
| Old-remember (141) | .99 | .01 |
| Old-imagine (117) | 1.0 | .00 |
| <i>Incorrect source attribution</i> | | |
| Old-remember (7) | .14 | .86 |
| Old-imagine (32) | 1.0 | .00 |

Table 5.6 - Mean proportion of correct (same) and incorrect (different) matches between the events recognized as old and the original events described during the first part of the experiment, as a function of word type (old-remember and oldimagine) and source attribution (correct and incorrect) for Experiment 2. Note. Parentheses indicate the total number of participants' old responses (max 180); incorrect source attribution = old-remember and old-imagine items attributed to the wrong source (i.e., old-remember items recognized as old-imagine items and old-imagine items recognized as old-remember items).

Furthermore, more R responses than K responses were also assigned to old-remember ($R = 1.0$, $K = 0.00$) and to old-imagine items ($R = 0.97$, $K = 0.03$) attributed to the wrong source.

Finally, and most important, in Experiment 2 we compared participants' responses to the recognition task with the events remembered and imagined in the first part of the experiment. As it is illustrated in Table 5.6, in the presence of correct source attributions, the events described by the participants during the recognition task overlap those remembered and imagined during the first part of the experiment.

However, the most interesting result refers to those cases of incorrect source attributions. In fact, for the few cases in which an old-remember item was erroneously recognized as an old-imagine item, participants described an episode that was remarkably different from that reported in the first part of the experiment. To the opposite, when an old-imagine item was erroneously recognized as an old-remember item, participants described the same episode as reported in the first part of the experiment, with the difference that, now, they reported the episode as being really occurred in the past.

5.4 General discussion

In real life, projecting oneself forward in time to pre-experience an event is generally motivated by personal goals. In experimental settings, however, self-projection into the future may appear much more difficult and may consequently lead the participant to rely, more or less deliberately, on some alternative strategies. On the basis of this considerations, in this chapter we aimed to assess whether participants, who engage in episodic future thinking, produce genuine new scenarios or they rather might retrieve, at least occasionally, events that have already taken place and adjust them to fit in with the test requirements. We believe it is an important issue to ascertain how people comply with the task requirements of envisioning personal future experiences if we wish to fully understand the mechanisms underlying this important function of

everyday life. In the two experiments reported here, the analyses of the ratings indicated that the future events evoked by a number of participants were rated as being already occurred in the past or very similar to past events.

Notably, in both experiments, future events that were rated as low in novelty were indistinguishable from past events with respect to their phenomenal characteristics. To directly compare highly novel future events and future event rated as low in novelty with respect to their phenomenal characteristics, we run an additional analysis by collapsing results from Experiments 1 and 2. More precisely, we selected those participants who rated at least one future event as never occurred and at least one future event as occurred very often (six participants in Experiment 1 and three participants in Experiment 2). When more events (either near or distant) high or low in novelty belonged to the same participant, their ratings for each phenomenal characteristic were averaged into a single value.

In comparison to future events rated as low in novelty, highly novel future events contained less sensorial details, $t(8) = -2.9, p < 0.05$, were less clear with respect to temporal information, $t(8) = -3.8, p < 0.001$, and were less rich of familiar objects, places, and people, $t(8) = -5.0, p < 0.001$, (for similar results see Szpunar & McDermott, 2008).

An important result of this study concerns the extent to which participants reproduce specific memories when simulating future events. Specifically, the data suggest that participants were more likely to be relying upon personal memories when simulating near future events than distant future events. As such, it is interesting to see that near future events were rated as more vivid and less novel than distant future events.

These findings stimulate further hypotheses that go beyond the idea that people may occasionally adopt alternative strategies to comply with instructions. They, indeed, suggest that the tendency to remain “stuck” in real episodes that occurred in the past may be a general heuristic that stems from the relationship between direct experience and knowledge about an event, rather than a by-product of the procedure. Typically,

people expect near future events to resemble what they are currently experiencing, while distant future situations are much more amenable to transformations (Trope & Liberman, 2003). Therefore, it seems plausible that when we think of near future episodes, we not only engage in concrete processing orientation, which, in turn, leads us to construct more detailed representations, as suggested by the temporal construal theory (Trope & Liberman, 2003), but we may even envisage future scenarios that reproduce what we have already experienced. This hypothesis is strengthened by our results showing that, in both experiments, near future events were rated as more rich of familiar objects, places, and people than distant future events. On the other hand, when we imagine distant future events, we are more prone to approach the task with an abstract processing orientation and we are more likely to disengage from direct experience. It is relevant to note that the rating of frequency of occurrence and the rating of richness of familiar elements (collapsed across Experiments 1 and 2 and averaged across near and distant events) significantly correlated (Spearman's $\rho = 0.40, p < 0.01$). This result supports our hypothesis that the lower the novelty, the more likely that future events are rich of familiar elements.

These findings highlight an important caveat: when investigating episodic future thinking, it seems most appropriate to test participants on distant future events rather than on near ones, to make it less likely that people reproduce past personal memories.

With respect to the delayed recognition tasks we found that, although overall correct recognition rates were – not surprisingly – quite high, participants falsely attributed old-imagine words to remembered episodes at a higher rate than the other way round, both in Experiments 1 and 2, in line with predictions. The incorrect source attributions were based on conscious recollection, as indicated by the larger proportion of R responses than K responses.

Additionally, in Experiment 2, in which participants were invited to shortly describe each event associated to the items they had recognized as old, when an old-imagine item was erroneously recognized as an old-remember item, most participants

described the same episode as reported in the first part of the experiment, with the difference that, now, they reported the episode as really occurred in the past.

Overall, results concerning recognition memory are largely in line with our predictions. It is, however, important to acknowledge that our results may be accounted for by addressing issues different from source attribution errors. For instance, test items were not fully under experimenter control. Only the four cue words could be counterbalanced, but the other eight test words in each condition were derived from subjects' study responses and could not be counterbalanced. One might, therefore, raise the concern that the differences between the old-remember and old-imagine items were, at least partially, due to item differences. However, the analyses of recognition memory for the cue words only (collapsing results from Experiments 1 and 2) revealed a pattern of results equivalent to the main pattern of results obtained in Experiments 1 and 2.

Another concern refers to the fact that imagining an event negatively affects one's ability to discriminate between recently performed and planned actions (e.g., Goff & Roediger, 1998; Mammarella, 2007; Thomaset al., 2003) and there is evidence that imagination might induce people to falsely remember childhood memories that never happened (e.g., Mazzoni & Memon, 2003). One might therefore object that, in the present research, participants may have sometimes confused future events with experienced events due to imagination inflation. Two important considerations are, however, in order. Confusions between recently imagined and experienced episodes emerge only when events consist of simple, discrete actions such as *flip the coin*, *open the book*, *polish the spoon* (e.g., McDaniel et al., 2008), which lack all those phenomenal, spatial, temporal, and emotional details that characterize more complex autobiographical events, such as those investigated in the present research. As long as false childhood memories are concerned, the probability of falsely remembering childhood memories that have never happened seems to be strictly related to the pressure at imagining such events. Multiple imagination trials, combined with other suggestive procedures (e.g., Hyman & Pentland, 1996), are indispensable elements in order to increase the likelihood that people falsely remember childhood memories. In

our paradigm, participants imagined only once future events and their recognition memory was tested relatively soon, afterwards. It is, therefore, unlikely that participants' larger difficulty to attribute the correct source to old-imagine items was determined by the experimental procedure adopted in this study. Nevertheless, the possibility remains that at least some envisioned future events reflected situations which participants thought of quite often (e.g., when envisioned future events incorporate wishes and goals).

In conclusion, we believe that these new findings may have implications for the theory of episodic future thinking. Although these results are not at odds with what the constructive episodic simulation hypothesis maintains, they suggest that intending at investigating future thinking, in the next chapters, we should always take into account that participants may occasionally rely, more or less deliberately, on some alternative strategies, when invited to project themselves into their personal future and that it may be misleading to assume that participants' future representations are always truly novel events without first obtaining relevant empirical evidence.

6. What does differentiate episodic future thinking from complex scene imagery?⁵

6.1 Introduction

Episodic Future Thinking (EFT) refers to our ability to *pre-experience* the future by simulating it in our minds. Until recently, most of the research on EFT focused on better characterizing the similarities and the differences between EFT and memory. Converging evidence from cognitive, neuropsychological, and neuroimaging studies indicate that these two processes rely indeed on common psychological and neural processes (for reviews, see Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter, Addis, & Buckner, 2007, 2008; Szpunar, 2011). Yet, there has been little consideration of what makes EFT a distinct process that differentiates it from the related concept of complex scene imagery. Both tasks involve, indeed, the process of “scene construction” which refers to the generation, maintenance and visualization of a complex spatial setting in which an event (real or imaginary) can be mentally experienced (Hassabis & Maguire, 2007). Note that this kind of complex "scene" imagery differs markedly from "object" imagery (e.g., for faces or single objects) in that it requires the binding of disparate (possibly multimodal) elements of a scene into a coherent whole (Hassabis, Kumaran, & Maguire, 2007). Hassabis and Maguire (2007) hypothesized that scene construction is a core process that underlies a host of cognitive functions that crucially rely on constructing, maintaining and visualizing complex scenes such as, for example, autobiographical memory, EFT, imagination, spatial navigation, and that this can account for a large proportion of the overlapping network found in neuroimaging studies of these functions.

Given that EFT and autobiographical memory are tightly intertwined, our quest for the key aspects differentiating EFT from complex scene imagery should start from

⁵ de Vito S, Gamboz N, Brandimonte MA. What does differentiate episodic future thinking from complex scene imagery? *Consciousness and Cognition*, **in press**.

considering what differentiates a retrieved autobiographical event (i.e., remembering my last summer barbecue on a Greek beach) from an imagined complex scene (i.e., imagining to walk in a tropical jungle).

Almost all would agree that it is the subjective sense of time, the connection to the self, the feelings of familiarity and a special kind of consciousness, termed *autonoetic consciousness*, that enables one to be aware of the self in subjective time (Tulving, 2002). These elements may be present in imagined fictitious experiences either to a much lesser extent or not at all (Hassabis et al., 2007). Similarities and differences between complex scene imagery and autobiographical memory are well documented in the neuroimaging study of Hassabis et al. (2007). These authors showed that a distributed brain network involving the hippocampus, parahippocampal gyrus, retrosplenial cortices, posterior parietal cortices, and ventromedial prefrontal cortex, was recruited during both autobiographical memory recall and recall of previously constructed fictitious experiences that were well-matched for difficulty, age, detail and vividness. These specific conditions have been investigated because the comparison between them allowed to partial out the effects of scene construction, and to ask which brain regions underpin the special properties of autobiographical memory. Activation of specific brain areas, i.e., the posterior cingulate cortex, the anterior medial prefrontal cortex, and precuneus, was indeed observed only during episodic memory recall, suggesting that these regions may support functions most likely reflecting self-projection in time, self-relevance and sense of familiarity that are specific to autobiographical memory over and above scene construction (Tulving, 2002).

As noted by Hassabis et al. (2007), the pattern of activation specific to autobiographical memory resembles the network found to support EFT (e.g., Addis, Wong, & Schacter, 2007). One may therefore argue that recalling past experiences and thinking about plausible, autobiographical future events share the same key, defining processes. Indeed, when individuals remember past or simulate future events, they imaginatively place themselves into specific settings that are temporal in nature (settings that pertain to their past and to their future). Furthermore, when

envisioning events that will occur in the future, especially in the near future, individuals imagine themselves in the context of familiar settings (see Chapter 5). This is not to say that familiarity of setting is a defining feature of EFT, as it is for autobiographical memory. We can indeed pre-experience an event expected to occur somewhere we have never been before and, still, scene construction is surely not restricted to events represented in unfamiliar settings. However, empirical evidence indicates that familiarity of setting is indeed an important modulator of the characteristics of EFT (e.g., Szpunar & McDermott, 2008).

The specific contribution of self-projection in time and self-relevance over and above the role of scene construction in EFT is currently rather speculative. For instance, does mentally projecting an imaginary event into the future make it any different from imagining it in the present (e.g., “Imagine to walk in a sunny garden next year” vs. “Imagine to walk in a sunny garden”)? Similarly, is there any difference between imagining oneself doing an activity and imagining familiar others doing the same activity (e.g., “Imagine to walk on the beach next year” vs. “Imagine Silvio Berlusconi walking on the beach next year”)? So far, only few studies have provided initial insights into this issue. With respect to the role of the temporality of imagined events in EFT, it is important to refer to the original patient study on imagination of Hassabis, Kumaran, Vann, and Maguire (2007). These authors reported on five memory-impaired patients with a bilateral hippocampus damage having troubles in constructing novel events. Their imagined experiences were deficient in spatial coherence, relative to controls, resulting in their constructions being fragmented and lacking in richness. Hassabis et al. (2007) tested patients and controls on both episodic future thinking scenarios (e.g., imagining a possible Christmas event) and a-temporal imagined scenarios (e.g., “Imagine you are standing in the middle of a bustling street market”). No difference in descriptions was found (so the results were presented collapsed across scenario type. This result suggests that a-temporal and future imagined events may be represented in a very similar way. The opinion of Hassabis and Maguire (2007; 2009) is that the time-stamp of an event, imagined or remembered, should not be elevated to the status of a key property of recollection and prospection, as some have suggested (e.g., Buckner & Carroll 2007; Tulving,

2002), but it should rather be considered as a piece of semantic knowledge that might or might not be included or logically deduced at the point an event is remembered or imagined. This view is surely quite radical but, nevertheless, it draws attention to the need to clarify the status of the temporal nature of mental representations of events.

Concerning the contribution of self-relevance to EFT, in a neuroimaging study (Szpunar, Watson, & McDermott, 2007) the core brain network common to past and future thinking was found to show greater activation when participants envisioned their personal future (or recollected their past) as compared with a control task requiring participants to imagine a familiar individual participating in life-like events with no explicit temporal reference (Bill Clinton at his birthday). This result thus highlights a neural differentiation between envisioning a personal future experience and imagining the experience of someone else. However, given that the two types of mental representations included in Szpunar et al.'s (2007) study differed also with respect to the temporality of the imagined events, the unique and specific contribution of selfness to EFT still remains to be defined.

As for the role played by the familiarity of setting in EFT, it is clear that humans can mentally simulate virtually infinite future possibilities, up to the extreme situation of imagining or even daydreaming about unlikely events. However, as noted by Szpunar (2010), episodic future thoughts generally revolve around the short-term concerns of participants (D'Argembeau, Renaud, & Van der Linden, 2011; Spreng & Levine, 2006). Accordingly, the contents of episodic future thoughts are typically characterized by familiar contextual information (see Chapter 5). When participants are prompted by the experimenter to imagine autobiographical future events occurring in unfamiliar settings (e.g., Jungle, North Pole, Great Wall of China), their representations are rated as containing less sensorial details, as occurring in a less clear context, and as having a weaker subjective experience as compared to when they engage in episodic future thought occurring in familiar contexts (e.g., home, friend's apartment, pub; Szpunar & McDermott, 2008). It has also been shown that the regions within the posteromedial parietal cortex and the medial temporal lobes, typically engaged when individuals imagine themselves in familiar contexts (or

retrieve personal memories; e.g., Szpunar et al., 2007), exhibit relatively little neural activity when participants generate personal future episodes occurring in unfamiliar contexts (Szpunar, Chan, & McDermott; 2009). These findings thus indicate that the familiarity of setting can modulates the characteristics of EFT and substantiate the prominent claim that past and future thoughts both involve the reinstatement of familiar context from memory (e.g., Schacter et al., 2008).

In the present study we aimed at further investigating on the specific contribution that the temporality of imagined events (i.e. whether an imagined event is considered to occur in the future or it is timeless), the self-relevance of imagined events (i.e., whether imagined events involve ourselves or familiar others) and familiarity of settings (i.e. whether an imagined event occur in a familiar or in an unfamiliar setting) makes to EFT over and above scene construction. To this purpose we conducted 2 behavioural studies in which phenomenal as well as other characteristics of imagined events differing with respect to the temporality of imagined events, self-relevance and familiarity of settings were analyzed. As stated earlier, although episodic future thoughts are, in theory, orthogonal to whether the setting is familiar or unfamiliar, empirical evidences indicate that individuals tend to imagine themselves in the context of familiar settings. Accordingly, we decided to consider the representations of autobiographical future events occurring in familiar settings as the index of EFT against which to compare the other experimental conditions included in our Experiments differing from the episodic future thoughts with respect to their temporality, self-relevance and familiarity of settings.

6.2 Experiment 1

In this Experiment, participants were asked (a) to imagine themselves carrying out an activity in the future in familiar settings (this condition corresponds to EFT), (b) to imagine themselves carrying out an activity in the future in unfamiliar settings, and (c) to imagine themselves carrying out an activity in familiar settings with no reference to any specific time. In this Experiment, self-relevance was maintained

constant. The comparison between the first two conditions was thought to assess the role of familiarity of settings in EFT, whereas the comparison between the first and the third condition intended to assess the role of temporality of imagined events in EFT. On the basis of earlier findings (Szpunar & McDermott, 2008) we expect the images of future events occurring in familiar settings to be more clearly represented than images of future events occurring in unfamiliar settings. Furthermore, to the extent that the temporality is a specific component of EFT over and above scene construction, as it is the case for episodic memory, imagined future autobiographical events should significantly differ (as having either higher or lower subjective and objective details ratings) from imaged a-temporal events.

6.2.1 Method

6.2.1.1 Participants

Thirty young adults (18 females) from Suor Orsola Benincasa University participated in this experiment as volunteers. The average age and education were 31.34 (SD = 4.61) and 17.13 (SD = 2.18) years, respectively. All participants had no history of neurological or psychiatric disorders.

6.2.1.2 Materials

A pilot study was conducted in order to select appropriate familiar and unfamiliar settings. A list with 40 familiar settings belonging to common everyday experiences (e.g., home, friend's apartment, pub, shop) and 40 unfamiliar settings belonging to unlikely experienced events (e.g., jungle, North Pole, Great Wall of China) were presented to 40 young adults (mean age = 30.35; SD = 2.62), who did not participate in Experiment 1. Participants were instructed to rate each setting on a 5-point scale (1= not familiar at all; 5 = very familiar). Then, 14 scenarios chosen by the participants as being highly familiar (Home, School, Lecture Hall, Beach, Kitchen,

Friends' Home, Supermarket, Living Room, Restaurant, Cinema, Mall, Church, Pub, Relatives' Home) and 14 chosen as being no familiar at all (Cuba, Thailand, Hawaii, Polynesia, Madagascar, Nile, Brazil, Savannah, Japan, Kenya, The Great Wall of China, North Pole, Mount Everest, South Pole) were selected for proper testing. The selected familiar and unfamiliar settings reported a mean score of 3.8 and 1.8, respectively. The selected familiar and unfamiliar settings were used equally often across participants.

6.2.1.3 Procedure

Participants imagined two future events occurring in familiar settings, two future events occurring in unfamiliar settings, and two a-temporal events occurring in familiar settings in response to short verbal cues. Precisely, participants were presented with 6 sheets of paper, each displaying the instruction to imagine an event occurring in a specific setting (familiar or unfamiliar). For future events, the instruction also indicated the time period (next year). An example of the three conditions included in this Experiment is as follows: (a) future familiar setting: "Imagine to walk in a sunny garden next year"; (b) future unfamiliar setting: "Imagine to walk in a tropical jungle next year"; (c) a-temporal familiar setting: "Imagine sitting in your preferred coffee shop". Participants were instructed to imagine temporally and contextually specific events. Future and a-temporal events had also to be plausible and novel, that is, not previously experienced by the participants. The experimenter further explained that the events had to be imagined in as much detail as possible. The order of presentation of experimental conditions was fully counterbalanced across participants.

Once an event had been imagined (there was no time limit for imagining an event), participants were asked to verbally describe the event (responses were recorded using a digital audio-recorder for later transcription). Then, participants rated on 7-point scales the characteristics of the mental representation they had just formed (Szpunar & McDermott, 2008). Specifically, each event was rated on three measures that were

summed to form a sensorial details index (visual details, sounds, smell/taste; 1 = none, 7 = a lot), three measures that were summed to form a clarity of context index (clarity of location, clarity of spatial arrangement of objects, clarity of spatial arrangement of people; 1 = vague, 7 = very clear), and an index of the subjective experience associated with the mental image (feeling of experiencing the event, 1 = none, 7 = a lot). Furthermore, participants also indicated the novelty of each imagined event by rating how often they experienced in the past the same or a very similar event (1 = never; 7 = very often). This question was aimed at assessing whether participants retrieved an event that had already taken place and adjusted it to fit in with the test requirements, rather than imagining truly novel scenarios (see Chapter 5).

The quality of imagined events was estimated using the standardized scoring procedure developed by Levine, Svoboda, Hay, Winocur, and Moscovitch (2002) in the Autobiographical Interview. More precisely, for each event produced by participants, the central event was first identified. Then, the transcription was segmented into (a) internal details, i.e. episodic informational bits indicating happenings, places, time, perceptual details, emotions/thoughts pertaining directly to the main event, and (b) external details, i.e., non-episodic informational bits that were not uniquely specific to the main memory event being described and not anchored to the time and place of the main event, such as general facts/knowledge related to the context of the event, details concerning unrelated events, and metacognitive statements. The detail subtypes within each category were summed to form, for each event, an internal and an external detail composite score, which were the primary measures of interest. The transcriptions were segmented into internal and external details by a single trained rater, who was blind to the hypotheses of the study. This rater scored events in a manner that was highly reliable with the ratings provided by the experimenter. The inter-rater reliability (r), calculated on a subset of 30 randomly selected events, was 0.70 and 0.77 for internal and external details, respectively.

6.2.1.4 Statistical analysis

Mean rating on sensorial details, clarity of context and feeling of experiencing indexes, as well as the number of internal and external details were analysed by means of separate one-way repeated measures analyses of variance (ANOVA) with Type of Imagined Event (future familiar setting, future unfamiliar setting, a-temporal familiar setting) as the dependent variable. After each ANOVA planned comparison contrasted future events occurring in familiar setting to future events occurring in unfamiliar setting and to a-temporal events occurring in familiar setting in order to assess, respectively, the role of familiarity of settings and the role of temporality of imagined events in EFT. In order to correct for multiple comparisons, significance was set at $\alpha=0.02$. With respect to the novelty of imagined events, both future events occurring in unfamiliar settings were rated as never occurred before. Therefore, only the ratings of frequency of occurrence for future and a-temporal events occurring in familiar settings were analyzed by means of a t-test for related measures.

6.2.2 Results

6.2.2.1 Ratings for phenomenal characteristics

The mean ratings on sensorial details, clarity of context, feeling of experiencing and novelty of imagined events indexes are presented in Table 6.1. With respect to the number of sensorial details, clarity of context and feeling of experiencing results showed main effects of Type of Imagined Event, $F_s(2, 58) > 5.9$, $p_s < .01$, $\hat{\eta}_{ps}^2 > .17$. Planned comparisons indicated that future events occurring in familiar settings were rated as containing more sensorial details, $t(29) = 2.92$, $p < .01$, $\hat{\eta}_t^2 = .23$, as being more clearly represented, $t(29) = 3.57$, $p < .01$, $\hat{\eta}_t^2 = .16$, and as being associated to a stronger feeling of experiencing $t(29) = 3.01$, $p < .005$, $\hat{\eta}_t^2 = .24$ than future events occurring in unfamiliar settings. However, future events occurring in familiar settings were indistinguishable from a-temporal events occurring in familiar settings with respect to all these indexes (sensorial details, $t(29) = 0.81$; clarity of context t

(29) = 1.06; feeling of experiencing, $t(29) = 0.98$). With respect to the novelty of imagined events, in the previous Chapter (5) it was hypothesized that, to the extent that participants envision truly novel scenarios, the novelty of their representations should be rated as high, that is, envisaged events should be rated as never having happened before. As can be seen in Table 6.1, and not surprisingly, future events occurring in unfamiliar settings were rated as never occurred before. The rating of frequency of occurrence for future and a-temporal events occurring in familiar settings were generally very low and not significantly different from each other, $t(29) = 1.0$.

| | Sensorial Detail^a | Clarity of Context^a | Feeling of Experiencing^a | Novelty |
|------------|---|---|--|----------------|
| FFS | 5.5 (.23) | 5.3 (.26) | 5.6 (.32) | 2.0 (.28) |
| FUS | 3.8 (.27) | 4.4 (.36) | 4.5 (.39) | 1.0 (.00) |
| AFS | 4.4 (.26) | 5.1 (.30) | 5.8 (.28) | 1.6 (.20) |

Table 6.1 - Means (and standard errors) of ratings for phenomenal characteristics of imagined events in Experiment 1, for the FFS (Future Familiar Setting), FUS (Future Unfamiliar Setting) and AFS (A-Temporal Familiar Setting). Note: Novelty decreases proportionately as frequency of occurrence increases, i.e., the lower the rating, the higher the novelty.

^a Significant contrasts between future events occurring in familiar settings and future events occurring in unfamiliar settings, $p_s < 0.01$.

6.2.2.2 Number of internal and external details

The mean number of internal and external details is presented in Figure 6.1. With respect to internal details, results showed a marginally significant effects of Type of Imagined Event, $F(2, 58) = 2.7$, $p = .07$, $\eta_p^2 = .10$. Planned comparisons showed that future events occurring in familiar settings contained more internal details than future events occurring in unfamiliar settings, $t(29) = 2.8$, $p < .01$, $\eta^2 = .21$, but that they were indistinguishable from a-temporal events occurring in familiar settings, $t(29) = 1.2$. As regards external details, results showed a marginally significant effects of Type of Imagined Event, $F(2, 58) = 2.9$, $p = .06$, $\eta_p^2 = .10$. Future events occurring in familiar and in unfamiliar settings did not differ from each other, $t(29) = 1.14$. However, future events occurring in familiar settings contained less external details than a-temporal events occurring in familiar settings, $t(29) = 2.54$, $p < .01$, $\eta^2 = .18$.

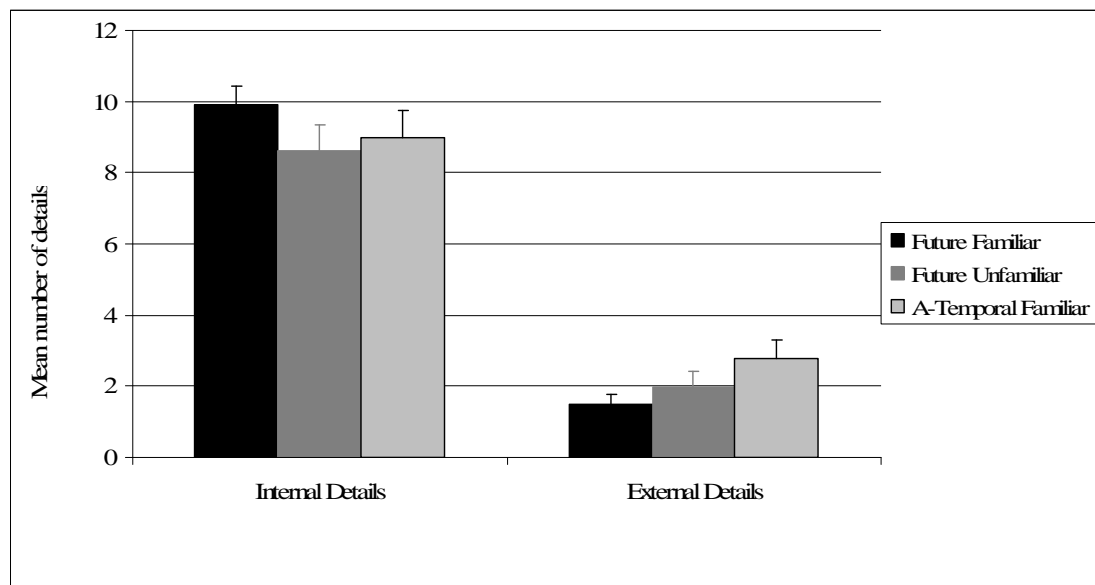


Figure 6.1 - Mean number of internal and external details for future events occurring in familiar and unfamiliar setting and a-temporal events produced in Experiment 1. Error bars are standard errors of the mean.

6.2.3 Discussion

The results of this Experiment indicate, in line with earlier findings (Szpunar & McDermott, 2008), that imagined future events occurring in familiar settings were rated as being more vivid (as indicated by higher rating on sensorial detail and clarity of context indexes) and as being associated to a stronger feeling of experiencing than imagined future events occurring in unfamiliar setting. Imagined future events occurring in familiar settings also contained more internal details than future events occurring in unfamiliar setting. Furthermore, our results show that imagined future events occurring in familiar settings are completely indistinguishable, with respect to the rating on sensorial details, clarity of context and feeling of experiencing indexes, as well as the number of internal details, from a-temporal events occurring in familiar settings. These findings are open to different interpretations. First, the lack of differences between future and a-temporal events may have arisen because participants' future and a-temporal representations reproduced memories of events that had already taken place, rather than being true simulations of novel events. This may occasionally occur in experimental settings, as indicated in Chapter 5. However, the results concerning the novelty of imagined events indicated that all participants constructed novel experiences. Second, one may hypothesize that participants envisaged future scenarios even when they were asked to imagine experiences that were not explicitly temporal in nature. To this respect, it is important to note that the short verbal sentences used to cue participants to imagine a-temporal events were equivalent to those used to cue future events with no temporal reference. It may, therefore, be the case that cueing a person to "imagine to sit in his/her preferred coffee shop" or "to imagine to walk in a big sunny garden next year" does not make any difference in terms of mental time travel in the future, i.e., the inclusion of a time period in the cue sentence does not seem crucial to trigger prospection. It may occur that, as far as a person is engaged in imagining doing something plausible in a familiar context, he/she spontaneously projects into his/her personal future.

Interestingly, Moulton and Kosslyn (2009) recently argued that the primary function of all imagery, even of the most trivial form of imagery, i.e., object imagery, is to

allow us to predict the imminent or distant future. Alternatively, it may have occurred that, in the present Experiment, participants failed to project into the future even if they were deliberately instructed to do so. In order to assess whether future and a-temporal events imagined in the present Experiment were both characterized by self-projection in the future, we analyzed whether their descriptions differed in terms of mean number of temporal statements (such as “I will be”, “I plan to” and “I’m going to” and presence of future tense; see Hassabis, Kumaran, & Maguire, 2007 for a similar procedure). Results of a Wilcoxon Matched Pairs Test indicated that the descriptions of future events contained significantly more temporal statements ($M = 2.9$, $SD = 2.3$) than the descriptions of a-temporal events ($M = 0.1$; $SD = 0.3$), $T = 4.5$, $p < 0001$. The implications of the results concerning the equivalence between future and a-temporal events will be considered in the General Discussion.

6.3 Experiment 2

In this Experiment, participants were asked (a) to imagine themselves carrying out an activity in the future (this condition corresponds, as in Experiment 1, to EFT), (b) to imagine familiar others (i.e., self-irrelevant) carrying out an activity in the future, and (c) to imagine themselves carrying out an activity with no temporal reference. In this Experiment, the familiarity of settings was maintained constant. The comparison between the first two conditions was thought to assess the role of self-relevance in EFT, whereas the comparison between the first and the third condition was intended, as in Experiment 1, to assess the role of temporality of imagined events in EFT. When individual envision future autobiographical events they are, most likely, guided by self-referential processes strictly connected to the content of their memory (D’Argembeau et al., 2010). Therefore, if self-relevance is a specific component of EFT over and above scene construction, and if EFT is based upon the contents of memory, as suggested by the constructive episodic simulation theory (e.g., Schacter et al., 2008), then future autobiographical events should be expected to be more richly imagined (as indicated by higher subjective and objective details ratings) that

future events involving familiar others. As for the results concerning the comparison between future and a-temporal events, our expectations are as indicated in Experiment 1: to the extent that the temporality is a specific components of EFT over and above scene construction, imagined future autobiographical events should clearly differ (as having either higher or lower subjective and objective details ratings) from imaged a-temporal events.

6.3.1 Method

6.3.1.1 Participants

Twenty-six young adults (17 females) from Suor Orsola Benincasa University participated in this experiment as volunteers. The average age and education were 27.46 (SD = 5.05) and 16.46 (SD = 2.26) years, respectively. All participants had no history of neurological or psychiatric disorders.

6.3.1.2 Materials

A pilot study was conducted in order to select appropriate familiar individuals to cue participants to imagine self-irrelevant events. A list of 80 famous individuals from the current political national and international context and from the cultural Italian environment (literature, TV, cinema) were presented to 40 young adults (mean age = 30.35; SD = 2.62), who did not participate in either Experiment 1 or 2. Participants were instructed to rate the popularity of each individual on a 5-point scale. Then, 8 famous individuals chosen by the participants as being highly familiar (Silvio Berlusconi, Paolo Bonolis, Bill Clinton, Dario Fo, Madonna, Barack Obama, Nicolas Sarkozy, Roberto Saviano) were selected for proper testing. The selected famous individuals reported a mean score of 3.8. The eight selected famous individuals were used equally often across participants. Note that in Experiment 2 participants were

cued to imagine events occurring in familiar settings. The familiar settings were the same as in Experiment 1. These were randomly cycled across conditions.

6.3.1.3 Procedure

Participants imagined two future self-relevant events, two future self-irrelevant events, and two a-temporal self-relevant events in response to short verbal cues. Precisely, as in Experiment 1, participants were presented with six sheets of paper, each displaying the instruction to imagine an event (self-relevant or self-irrelevant) occurring in a specific setting. For future events the instruction also indicated the time period (next year). An example of the three conditions included in this Experiment is as follows: (a) future self-relevant: “Imagine to walk in a big, sunny garden next year”; (b) future self-irrelevant: “Imagine that Silvio Berlusconi will walk on the beach next year”; (c) a-temporal self-relevant: “Imagine to lie on a sunny, crowded beach”. The rest of the procedure of Experiment 2 was the same as in Experiment 1. With respect to the number of internal and external details, the inter-rater reliability (raters were the same as in Experiment 1), calculated on a subset of 30 randomly selected events, was .79 and .71 for internal and external details, respectively.

6.3.1.4 Statistical analysis

Mean rating on sensorial details, clarity of context and feeling of experiencing indexes, as well as the number of internal and external details were analysed as in Experiment 1. With respect to the novelty of imagined events, future events not relevant for the self were rated as never occurred before. Therefore, only the rating of frequency of occurrence for future and a-temporal self-relevant events were analyzed by means of a t-test for related measures. After each ANOVA, planned comparisons contrasted future self-relevant events to future self-irrelevant events and future self-relevant events to a-temporal self-relevant events in order to assess the role of self-

relevance and of role of temporality of imagined events in EFT. In order to correct for multiple comparisons, significance was set at $\alpha=0.02$.

6.3.2 Results

6.3.2.1 Ratings for phenomenal characteristics

The mean rating on sensorial details, clarity of context, feeling of experiencing and novelty of imagined events indexes are presented in Table 6.2.

With respect to the number of sensorial details and clarity of location, the effect of Type of Imagined Event was not significant, $F_s(2,58) < 3.2$, indicating that future self-relevant events were indistinguishable from both self-irrelevant future events, $t(29) = 2.1$, and self-relevant a-temporal events $t(29) = 1.5$. Concerning the subjective experience associated with imagining the events, results showed a main effect of Type of Imagined Event, $F(2,58) = 22.8$, $p < .0001$, $\hat{\eta}_p^2 = .48$. Planned comparisons showed that self-relevant future events were associated to stronger feelings of experiencing than self-irrelevant future events, $t(29) = 6.90$, $p < .0001$, $\hat{\eta}^2 = .69$. Self-relevant future events were however indistinguishable from self-relevant a-temporal events $t(29) = 1.53$. With respect to the novelty of imagined events, as indicated in Table 6.2, future events not relevant for the self were rated as never occurred before. The rating of frequency of occurrence for self-relevant future and a-temporal events were generally very low and not significantly different from each other, $t(29) = 1.7$.

| | Sensorial Detail | Clarity of Context | Feeling of Experiencing ^a | Novelty |
|------------|---------------------|-----------------------|---|-----------|
| FSR | 4.9 (.23) | 5.4 (.30) | 6.0 (.21) | 1.6 (.2) |
| FSI | 4.3 (.26) | 4.8 (.33) | 3.0 (.42) | 1.0 (.00) |
| ASR | 4.6 (.21) | 5.3 (.21) | 5.3 (.20) | 2.1 (.30) |

Table 6.2 - Means (and standard errors) of ratings for phenomenal characteristics of imagined events in Experiment 2, for FSR (Future Self-Relevant), FSI (Future Self-Irrelevant) and ASR (A-Temporal Self-Relevant) events. Note: Novelty decreases proportionately as frequency of occurrence increases, i.e., the lower the rating, the higher the novelty.

^a Significant contrast between self-relevant future events and self irrelevant future events, $p < 0.0001$.

6.3.2.2 Number of internal and external details

The mean number of internal and external details is presented in Figure 6.2. With respect to internal details, results showed significant effects of Type of Imagined Event, $F(2, 58) = 19.3$, $p < .0001$, $\hat{\eta}^2_p = .43$. Self-relevant future events contained more internal details than self-irrelevant future events, $t(29) = 5.2$, $p < .0001$, $\hat{\eta}^2 = .47$. Self-relevant future events were however indistinguishable from self-relevant a-temporal events, $t(29) = 1.35$. As external details is concerned, self-relevant future events, self-irrelevant future events and self-relevant a-temporal events did not differentiate from each other, $F(2,58) = 1.3$.

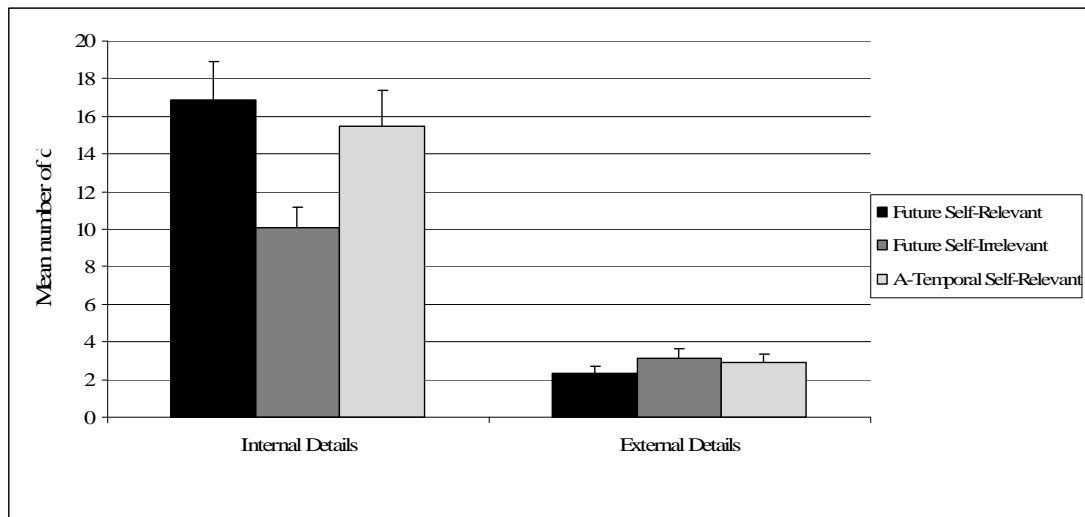


Figure 6.2 - Mean number of internal and external details for self-relevant and self-irrelevant future events and a-temporal events produced in Experiment 2. Error bars are standard errors of the mean.

6.4 Discussion

The results of Experiment 2 indicated that future self-relevant and self-irrelevant events were indistinguishable with respect to sensorial details and clarity of context indexes. This is not an unlikely result if we consider that the events contained in both mental images occurred in familiar settings. Participants may have therefore experienced equivalent feelings of contextual vividness when they were imagining themselves as well as when they were imagining familiar others doing something in a familiar context. Conversely, as it was likely to expect, self-relevant future events were associated to stronger feelings of experiencing than self-irrelevant future events. The number of internal details was also significantly larger for self-relevant than for self-irrelevant future events. The results of Experiment 2 replicated results of Experiment 1 indicating that imagined self-relevant future events and self-relevant a-temporal events were completely indistinguishable with respect to the rating on sensorial details, clarity of context and feeling of experiencing indexes, as well as the number of internal details. Furthermore, as in Experiment 1, the descriptions of future events contained significantly more temporal statements ($M = 0.8, SD = 1.2$)

than the descriptions of a-temporal events ($M = 0.05$; $SD = 0.2$), $T = 2.0$, $p < 0.01$. The implications of the results concerning the equivalence between future and a-temporal events will be considered in the General Discussion.

6.5 General discussion

Episodic future thinking has always been conceptualised as the process that allows individuals to imaginatively place themselves into specific settings that are temporal in nature. So far, however, only few studies have considered the specific contribution that self-projection in time and self-relevance provides to EFT. The main purpose of this study was, therefore, to assess whether EFT differs from imagined future events involving familiar others and from imagined a-temporal events. In addition, we assessed the role played by familiarity of settings in envisioning autobiographical future events by comparing autobiographical future events supposed to occur in familiar settings to autobiographical future events supposed to occur in unfamiliar settings. As stated in the Introduction, familiarity of setting is not considered as a measure that discriminates between EFT and scene construction. In fact, the original definition of EFT refers to the ability of pre-experiencing a personal future event and, as such, it is orthogonal to whether the setting is familiar or unfamiliar. However, episodic future thoughts are typically characterized by familiar contextual information and some empirical evidence indicates that familiarity of setting is indeed an important modulator of the characteristics of EFT.

With respect to familiarity of setting and self-relevance, the results of our Experiments are quite straightforward. The images of future events occurring in familiar settings are “richer” than the images of future events occurring in unfamiliar settings: they are perceived as more vivid (as indicated by higher rating on sensorial detail and clarity of context indexes) and as being associated to a stronger feeling of experiencing (for similar results, see Szpunar & McDermott, 2008), and the verbal protocols provided by participants to describe them are richer of episodic details. Similarly, the images of future events involving ourselves are, overall, “richer” than

the images of future events involving familiar others: they are perceived as being associated to a stronger feeling of experiencing and the verbal protocols provided by participants to describe them are richer of episodic details. Two theories account for these results: the constructive episodic simulation hypothesis (Schacter & Addis, 2007), which states that future events are generated by reassembling and flexibly recombining stored event details, and the reality monitoring theory (e.g., Johnson, Foley, Suengas, & Raye, 1988), which posits that the mental images based on personal experience are more vivid than the mental images based on imagination. It is, therefore, plausible that mental representations of future events created by sampling from past experiences are perceived as more vivid than mental representations of future events based on imagination.

The comparison between future and a-temporal events revealed however that future autobiographical events are completely indistinguishable from a-temporal autobiographical events with respect to the rating on sensorial details, clarity of context and feeling of experiencing indexes, as well as the number of internal details. The possibility that participants reproduced memories of events that had already taken place rather than simulating novel events is not a factor of concern in the interpretation of this result. The results concerning the novelty of imagined events indicated that all participants indeed constructed novel experiences. One may therefore hypothesize that either participants envisaged future scenarios even when they were asked to imagine experiences that were not explicitly temporal in nature or, alternatively, they failed to project themselves into the future even if they were deliberately instructed to do so. However, these possibilities seem unlikely for two reasons. First, Experiment 1 and 2 involved different participants but nevertheless we obtained the same pattern of results in both Experiments. It is therefore unlikely that both groups of participants did not accomplish task requirements. Second, the descriptions of future events contained significantly more temporal statements than the descriptions of a-temporal events, suggesting that participants engaged in mental time travel, at least, when instructed to do so.

Thus, our results suggest, in accordance with Hassabis and Maguire's (2007; 2009) opinion, that future and a-temporal events, as long as they are plausible (as in the present Experiments) are mentally represented in a similar way. There is indeed a need for future research to further analyze similarities and differences between episodic future thoughts and imagined events timeless in nature from different angles. For instance, it could be that the difference between these two kinds of events lies in the temporal progression of the activation of different kinds of knowledge structures (personal semantic information, general events, specific events) during the construction process (D'Argembeau & Mathy, 2011). It may also be of indubitable relevance focusing, in future research, on assessing whether there is a neural differentiation between future and a-temporal episodic thoughts matched for both subjective and objective details ratings. In a recent neuroimaging study (Nyberg et al., 2010), aiming at highlighting the neural correlates of mental time travel into "non present" times (future and past), a set of regions was found to be more active while envisioning the future than while imagining a-temporal events, suggesting that these two types of mental representation are indeed distinguishable. In this study, however, participants were instructed to imagine doing a simple, discrete action, i.e., taking a short walk from point A to point B in a familiar setting, that likely lacked all those phenomenal, spatial and temporal details that characterize more complex autobiographical events, such as those characterizing episodic future thoughts.

7. Episodic future thinking in amnesic mild cognitive impairment⁶

7.1 Introduction

As we have seen in the introduction, in recent years, an increasing number of cognitive, neuropsychological, and neuroimaging studies have suggested that remembering the past and imagining the future rely on common psychological and neural processes. For instance, it has been shown that the phenomenal characteristics associated with both projecting oneself into the past or into the future are influenced by similar factors, such as the temporal distance from the present (D'Argembeau & van der Linden, 2004; see also Addis, Wong, & Schacter, 2008; D'Argembeau & van der Linden, 2006; Spreng & Levine, 2006). Recent neuroimaging studies have demonstrated that remembering past events and imagining novel scenarios that might happen in the future rely on a common network of neural regions (e.g., Addis, Pan, Vu, Laiser & Schacter, 2009; Addis, Wong, & Schacter, 2007; Okuda et al., 2003; Szpunar, Watson & McDermott, 2007). This common network of prefrontal, medial temporal lobe, and posterior regions, including the posterior cingulate and retrosplenial cortex, is remarkably similar to the network involved in the retrieval of episodic memories of past autobiographical events (e.g., Cabeza & St Jacques, 2007; Maguire, 2001). Most recently, this network of regions has been suggested to belong to an anatomically defined brain system (*default network*) that is activated when individuals engage in internally focused tasks including autobiographical memory retrieval, envisioning the future, and conceiving the perspectives of others (Buckner, Andrews-Hanna, & Schacter, 2008). There is also evidence that amnesic patients highly impaired on retrieving past events may be also impaired in imagining future autobiographical events (Hassabis, Kumaran, Vann, & Maguire, 2007; Klein &

⁶ Gamboz N, de Vito S, Brandimonte MA, Pappalardo S, Galeone F, Iavarone A, and Della Sala S. Episodic future thinking in amnesic mild cognitive impairment. *Neuropsychologia*, 48(7): 2091-2097, 2010.

Loftus, 2002; Tulving, 1985). In light of such findings, it has been proposed that the constructive nature of episodic memory allows one to draw on the past and to flexibly extract and recombine elements of previous experiences (Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter & Addis, 2007a). This conceptualization is often referred to as the *constructive episodic simulation hypothesis* (Schacter & Addis, 2007).

One key outstanding issue that still needs to be clarified concerns the precise relationship between future event simulation and episodic memory in patients suffering from episodic memory impairments. As mentioned above, in the neuropsychological literature, two amnesic patients suffering from total loss of episodic memory, K.C. (Tulving, 1985) and D.B. (Klein & Loftus, 2002), were described as being highly impaired on both retrieving past and imagining future autobiographical events. K.C. suffered from an extensive brain damage, affecting medial temporal, prefrontal and other brain regions, while little information was provided concerning the location of D.B.'s lesion. Most recently, Hassabis et al. (2007) have found that imagined experiences of five patients with amnesia deriving from bilateral hippocampal damage were deficient in spatial coherence, relative to controls, resulting in their constructions being fragmented and lacking in richness. In this study, however, participants were required to construct seven common place scenarios and only three episodic future events, hence leaving open the possibility that patients with hippocampal damage suffer from a more general event simulation deficit in constructing novel scenes, irrespective of time period (Schacter, Addis, & Buckner, 2008). Therefore, these studies do not allow one to draw precise conclusions concerning the basis for the patients' future events simulation deficit and its relation to their episodic memory problems. The idea that thinking of the future is closely related to retrospective memory received strong support by recent evidence indicating that healthy older adults (Addis et al., 2008) and patients with Alzheimer's disease (AD; Addis, Sacchetti, Allyc, Budson, & Schacter, 2009) show impairments, although different in severity, in autobiographical memory as well as in future event simulation.

As far as healthy aging is concerned, studies on autobiographical memory have demonstrated that, compared to young people, older adults tend to recollect fewer details about happenings, locations, perceptions, and thoughts, whereas they produce an equivalent, or larger, number of semantic details that are not connected to any particular time or place (e.g., Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Piolino, Desgranges, Benali, & Eustache, 2002). These specific age related differences in the qualities of autobiographical recollections have been accounted for within recent models of autobiographical memory (e.g., Conway, 2001; Conway & Pleydell-Pearce, 2000). Such models distinguish between the episodic component of autobiographical memory, providing lower level event specific sensory and perceptual episodic information, which is affected by healthy aging, from the semantic component of autobiographical memory, containing a more abstract autobiographical knowledge base and the conceptual self, which is preserved in healthy aging. Recently, Addis et al. (2008) demonstrated that the age related reduction of episodic specificity, evident for past events, extends also to future events. In particular, when probed to generate autobiographical events from the past and the future, older adults produced fewer internal episodic details and more external non episodic details, as assessed by the scoring procedure of Levine et al.'s (2002) Autobiographical Interview. Furthermore, the number of internal event specific details and external semantic details were correlated across past and future events, and the number of internal details for both past and future events correlated significantly with a measure of relational memory (paired associate learning) that is known to be dependent on the hippocampus (Giovanello, Schnyer, & Verfaellie, 2004). This pattern of results suggests that both retrieving past and imagining future detailed autobiographical events rely on relational memory, i.e., the ability to recombine and integrate details from various episodic memories. The pattern of decreased internal and increased external details for past and future events likely reflects an increased reliance on external semantic details when people are unable to generate internal episodic details (Addis et al., 2008).

With respect to AD, in addition to episodic memory problems, which are the hallmark and the earliest manifestation of this neurodegenerative disease, there are also major semantic memory dysfunctions (e.g., Chertkow & Bub, 1990; Hodges &

Patterson, 1995). This conjoined pattern of deficits, which is clearly detectable by traditional laboratory and neuropsychological tests, also affects the content of autobiographical memory. In general, there have been several studies, using a variety of methods, showing a deficit in the retrieval of autobiographical memories with a shallow temporal gradient indicating more successful retrieval of earlier memories (e.g., Hou, Bruce, Kramer, & Kramer, 2005; Ivanoiu, Cooper, Shanks, & Venneri, 2006; Kopelman, Wilson, & Baddeley, 1989; Nestor, Graham, Bozeat, Simons, & Hodges, 2002; Piolino et al., 2002; Snowden, Griffiths, & Neary, 1996). As far as the integrity of the episodic and semantic components of autobiographical memory is concerned, most studies documented some level of impairment in one or both types of memory. However, results of recent studies that used different memory tests, such as the Autobiographical Memory Questionnaire of Kopelman, Wilson, and Baddeley (1990) and the Autobiographical Interview of Levine et al. (2002), converged in showing severe deficits in AD patients in both the episodic and semantic component of autobiographical memory (e.g., Ivanoiu et al., 2006; Leyhe, Müllera, Miliana, Eschweiler, & Saura, 2009). In a very recent study, Addis, Sacchetti, et al. (2009) tested the ability of AD patients and age matched controls to generate past and future autobiographical events. Results showed that AD patients exhibited deficits in both remembering past events and simulating future events, generating fewer internal and external episodic details (as estimated by the scoring procedure of the Autobiographical Interview) than healthy older controls. In line with the results of Addis et al. (2008), the internal and external detail scores were strongly correlated across past and future events. The authors attributed the semantic autobiographical deficit evident in AD (for both past and future events) to the progression of the atrophy of the hippocampus, beyond the medial temporal regions to larger portions of the neocortex supporting semantic memory (Leyhe et al., 2009). The results of Addis, Sacchetti, et al.'s (2009) study therefore suggest a close association between future thinking and retrospective memory. However, mild AD patients participating in this study may have been impaired on cognitive functions other than episodic memory that may have contributed – to some extent – to their future event simulation deficits. Neuropsychological testing indeed revealed some impairment in executive functioning (as assessed by the Trial Making Test Part B). The supposed symmetry

of past and future episodic deficits should be further investigated in populations affected by selective memory impairment.

The aim of the current study is to assess the relation between past and future thinking in patients suffering from amnesic Mild Cognitive Impairment (aMCI). The term MCI has become widely used to describe a condition in old people whose memory and/or other cognitive abilities are below the normal level, but who do not meet the accepted criteria for dementia. Clinically, different subtypes of MCI have been recognized, with the amnesic subtype having an elevated risk of progressing to Alzheimer's Disease (AD; rate of conversion to AD is 10–15% per year; Gauthier et al., 2006; Petersen & Negash, 2008; Petersen et al., 2001). Amnesic MCI is characterized by a selective and isolated impairment of episodic memory, while the other cognitive functions and the ability to deal with daily living activities are relatively preserved. Patients with aMCI typically show atrophy of the hippocampus and other medial temporal lobe regions (e.g., Jack et al., 2000; Killiany et al., 2002). The isolated impairment of episodic memory, due to hippocampal malfunctioning, renders aMCI a clinical condition particularly suitable for a direct assessment of the relation between past and future thinking. If, as suggested by the constructive episodic simulation hypothesis, people use episodic memory to imagine future autobiographical events, and as aMCI is considered to be a transitional stage between healthy aging and AD, and given that both these extremes of the aging process show some form of impairment in autobiographical memory as well as episodic future thinking, aMCI patients should show an impairment in autobiographical memory and episodic future thinking somehow intermediate to that of normal aging and AD. In this respect, it is important to note that there is some evidence showing that autobiographical memory is indeed impaired in aMCI. For example, using the Autobiographical Interview (Levine et al., 2002), Murphy, Troyer, Levine, and Moscovitch (2008), found that, although aMCI and healthy controls generated protocols of similar length, the aMCI group produced fewer episodic, event specific details and an increased number of semantic details in their recollections, as compared to controls. This pattern of reduced episodic but elevated semantic autobiographical memory in aMCI as compared to healthy controls magnifies finding

with healthy older adults relative to younger adults for past events.

The study described in the present Chapter, which for the first time assesses episodic future thinking in aMCI, will help track the course of the deficit in past and future thinking, thus providing potentially important information on the relation between these two supposedly associated cognitive processes.

7.2 Method

7.2.1 Participants

Fourteen old adults affected by aMCI and 14 healthy controls participated in this experiment.

The participants with aMCI were selected from a larger panel at the Laboratory of Neuropsychology of Aging of the Department of Geriatrics (ASL Napoli 1). The diagnosis of aMCI was reached according to the criteria proposed by Petersen et al. (1999), including (a) exclusion criteria for dementia (DSMIV, APA, 1994); (b) memory complaints documented by the patient or by a collateral source; (c) a performance of at least 1.5 standard deviations below age and education matched controls on at least one of the measures assessing episodic memory included in the Mental Deterioration Battery (MDB – Carlesimo, Caltagirone, & Gainotti, 1996); (d) no evidence of significant deficits in other cognitive domains explored by means of the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975; Italian norms in Measso et al., 1993), the MDB (Carlesimo et al., 1996), and the Frontal Assessment Battery (FAB – Dubois, Slachevsky, Litvan, & Pillon, 2000; Italian norms in Iavarone et al., 2004); (e) a score of at least 26 on the MMSE; (d) no evidence of difficulties in everyday activities; (f) no history of stroke or other cerebrovascular disease; (g) no evidence of metabolic, endocrine, or nutritional deficiencies.

Healthy older adults were members of different, non academic, local associations. Individuals assuming psychoactive pharmacological treatment able to alter normal memory skills, with a history of neurological and psychiatric disorders and the elderly with a score less than 26 on the MMSE were excluded from the study.

There were no significant differences (all $ps > 0.05$) between aMCI and controls on demographic variables related to age (aMCI, $M= 74.7$, $SD = 7.4$; controls, $M= 73.5$, $SD = 8.0$), education (aMCI, $M= 12.8$, $SD = 5.1$; controls, $M= 13.0$, $SD = 2.0$), and on the MMSE scores (aMCI, $M= 24.8$, $SD = 2.8$; controls, $M= 26.3$, $SD = 1.3$). Elderly with aMCI and controls gave informed written consent prior to the commencement of the study and did not receive financial compensation for participation.

The study procedure was approved by the local ethical committee and was performed in accordance with the Declaration of Helsinki.

7.2.2 Materials and procedure

The experiment was conducted in one single session. Participants mentally re-experienced and pre-experienced four autobiographical episodes (occurred or occurring within the past or next year) in response to eight cue words. More precisely, two sets of eight words, matched for familiarity, frequency, imageability, and concreteness, were selected from Italian norms (Burani, Barca, & Arduino, 2001). Within each set, the words were randomly cycled through temporal direction (remember or imagine). Each participant was then assigned to one of these two lists of words. Half participants performed the past task first, followed by the future task, the other half received the opposite sequence. The experimental procedure was adapted from D'Argembeau and van der Linden (2004) and from Addis et al. (2008). Participants were encouraged to retrieve and imagine temporally and contextually specific events. Future events also had to be plausible, given the participant's plans, and novel, that is, not previously experienced by the participant. Each cue word was

displayed on the computer screen together with task instructions concerning the temporal direction (remember or imagine) and the time period (last year or next year). Once an event had been retrieved or imagined (there was no time limit for retrieving or imagining an event), participants were given 60 s to retrieve or imagine as many details as possible. Participants then described their past and future representations (their responses were recorded using a digital audio recorder for later transcription) and rated each event, using a 7point scale (Szpunar & McDermott, 2008), on (a) three measures that were summed to form a sensorial details index (visual details, sounds, smell/taste; 1 = none, 7 = a lot), (b) three measures that were summed to form a clarity of context index (clarity of location, clarity of spatial arrangement of objects, clarity of spatial arrangement of people; 1 = vague, 7 = clear), and (c) a measure of the subjective experience associated with the mental image (feeling of experiencing the event, 1 = none, 7 = a lot). Furthermore, participants also indicated the novelty of each imagined event by rating how often they had experienced in the past the same or a very similar event (1 = never; 7 = very often). This question was aimed at ensuring that participants were imagining truly novel scenarios rather than retrieving an event that had already taken place and adjusting it to fit in with the test requirements (see Chapter 5).

The qualities of the autobiographical recollections and simulations were estimated using the standardized scoring procedure developed by Levine et al. (2002). More precisely, for each past and future event produced by participants, the central event (the event discussed in most detail that occurred over a brief timeframe) was first identified. The central event was then segmented into details, i.e., unique occurrences, observations, or thoughts (that typically occur as grammatical clauses defined by a subject and predicate, such as “I dropped my sandwich”). Details were classified as internal or external, internal details being those that were specific to time and place, and considered to reflect episodic re-or pre-experiencing, and external details being those that pertained to extraneous information that was not uniquely specific to the main event being described and not anchored to the time and place. Internal details were divided into further subcategories: (a) event (happenings,

people involved, actions, nature of the environment), (b) place (information about where the event occurred), (c) time (date, season, or time of day), (d) perceptual (sensory information) and (e) emotion/thought relating to the event. External details were also subcategorized: (a) event (specific details from other incidents, from all of the above categories, external to the main event recalled or imagined), (b) semantic (general knowledge or facts, ongoing events, extended states of being), (c) repetition (unsolicited repetition of details), and (d) other (meta-cognitive statements, editorializing). The transcriptions were segmented into internal and external details by a single trained rater, who was blind to the hypotheses of the study. It is relevant to note that this rater scored events in a manner that was highly reliable with the ratings provided by the experimenter. The inter rater reliability (r) was .82 and .88 for internal and external details, respectively.

7.3 Results

7.3.1 Design of the analyses

Results concerning group differences in the phenomenal characteristics of past and future events will be reported first. Then, group differences in the qualities of the autobiographical recollections and simulations (i.e., in the number of internal and external details) will be examined. Finally, following Addis et al. (2008), the correlations between internal and external details of past and future events will be reported.

7.3.2. Ratings of phenomenal characteristics

Separate 2 (Group: aMCI vs. controls) \times 2 (Temporal Direction: past vs. future) mixed analyses of variance (ANOVA) were carried out for each phenomenal characteristic. The mean ratings are presented in Table 7.1. Results indicated that there were no group differences, $F(1, 26) = 1.47$, or differences between memories for past events and representations of future events, $F(1, 26) = 0.14$, in terms of

sensorial details. Analogously, the interaction between Group and Temporal Direction was not significant, $F(1, 26) = 0.37$. As regards clarity of location, there were no group differences, $F(1, 26) = 0.24$. However, results indicated that memories for past events were more clearly represented than representations of future events, $F(1, 26) = 5.13, p < 0.05$. A significant Group \times Temporal Direction interaction, $F(1, 26) = 4.59, p < 0.05$, revealed that the difference between past and future events was evident only in the aMCI group.

| | Past events | | Future events | |
|--|-------------|-----------|---------------|-----------|
| | C | aMCI | C | aMCI |
| Sensorial details | 4.2 (1.1) | 3.6 (1.3) | 4.0 (1.3) | 3.6 (1.0) |
| Clarity of location | 5.1 (1.0) | 5.7 (0.6) | 5.1 (0.9) | 4.8 (0.9) |
| Feeling of experiencing | 6.2 (0.9) | 5.1 (1.6) | 6.0 (0.9) | 4.4 (1.7) |
| Frequency of occurrence (novelty) | - | - | 1.6 (0.9) | 4.2 (1.5) |

Table 7.1 - Mean ratings (and standard deviations) as a function of event type (past, future) and group (aMCI, control). Note: Novelty decreases proportionately as frequency of occurrence increases, i.e., the lower the rating, the higher the novelty.

Concerning the subjective experience associated with the mental image, the control group showed stronger feelings of experiencing the events, $F(1, 26) = 12.91, p < 0.001$, than aMCI patients. The main effect of Temporal Direction, $F(1, 26) = 2.05$, and the interaction between Group \times Temporal Direction, $F(1, 26) = 0.72$, were not significant.

With respect to the novelty of future representations, in Chapter 5 we hypothesized that, to the extent that participants envisage truly novel scenarios, the novelty of their representations should be rated as high, that is, envisaged future events should be rated as never having happened before. However, an inspection of the frequency distribution of ratings (Table 7.2) suggests that this was the case only for the control

group in this study. In fact, less than 30% of future events produced by aMCI patients were rated as novel. In contrast, the control group rated 66% of future events as novel. Group differences in the mean rating of frequency of occurrence were indeed significant, $t(26) = -5.48, p < 0.0001$.

| Ratings | aMCI | C |
|----------------|-------------|----------|
| 1 | 28.6 | 66.1 |
| 2 | 1.8 | 26.8 |
| 3 | 3.6 | 0.0 |
| 4 | 12.5 | 0.0 |
| 5 | 17.9 | 5.4 |
| 6 | 12.5 | 0.0 |
| 7 | 23.2 | 1.8 |

Table 7.2 - Frequency distribution of ratings concerning the novelty of future scenarios in aMCI patients and controls. Note: The numbers indicate the percentage of events that received ratings from 1 to 7 (out of 56 near events and 56 distant events).

7.3.3 Number of internal and external details

A 2 (Group: aMCI vs. controls) \times 2 (Details: internal vs. external) \times 2 (Temporal Direction: past vs. future) mixed analysis of variance (ANOVA), with Group as a between subjects factor, and Details and Temporal Direction as within subjects factors, was conducted on the mean number of details produced by aMCI and controls (see Fig. 7.1).

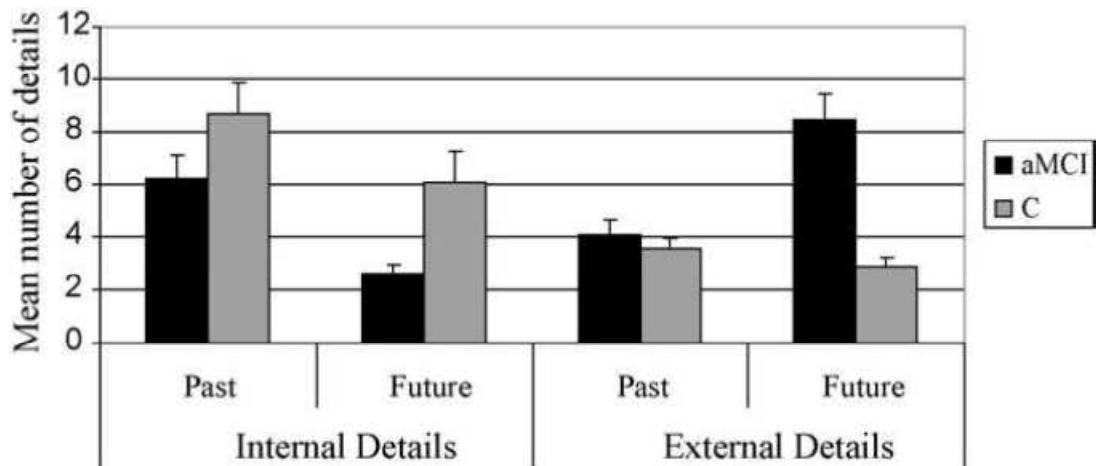


Figure 7.1 - Mean number of internal and external details per event generated for past and future events by aMCI patients and controls. Error bars are standard errors of the mean.

Results showed that, overall, aMCI patients ($M= 5.33$; $SD = 3.06$) and controls ($M= 5.36$; $SD = 3.31$) produced an equivalent number of details, $F(1, 26) = 0.005$, indicating that both groups produced protocols of similar length. Given that group differences in general conversational style may affect the interpretation of the results, we further analyzed whether there were group differences in the mean number of words used to describe past and future events. Results of a 2 (Group: aMCI vs. controls) $\times 2$ (Temporal Direction: past vs. future) mixed ANOVA showed that there were no differences between groups $F_s(1, 26) < 0.76$. The mean numbers of words used by controls to describe past and future events were 105.23 ($SD = 40.65$) and 103.89 ($SD = 34.55$) respectively; the mean numbers of words used by aMCI patients to describe past and future events were 90.55 ($SD = 36.64$) and 96.03 ($SD = 51.36$) respectively. A total of 12 controls and 11 aMCI patients participating in the present study were tested with a scene description task. The output of this verbal description task could be used to further analyse group differences in conversational style. The results show that the number of utterances did not differ significantly between the two groups: aMCI patients ($M= 47.10$; $SD = 22.59$), controls ($M= 64.25$; $SD = 27.02$), $t(21) = 1.68$.

The main effect of Details, $F(1, 26) = 5.11, p < 0.05$, was significant, indicating that, overall, participants produced more internal ($M = 5.89$; $SD = 3.15$) than external details ($M = 4.75$; $SD = 3.12$). The interaction between Group and Details, $F(1, 26) = 35.72, p < 0.0001$, and between Group and Direction, $F(1, 26) = 7.10, p < 0.01$ were significant. These interactions showed, respectively, that controls produced more internal details ($M = 7.42$; $SD = 1.98$) than aMCI patients ($M = 4.42$; $SD = 1.87$), $t(27) = 4.11, p < 0.0001$, whereas aMCI patients produced more external details ($M = 6.31$; $SD = 2.26$) than controls ($M = 3.23$; $SD = 1.36$), $t(27) = -4.37, p < 0.0001$, and that controls produced more details for past ($M = 6.14$; $SD = 1.80$) than for future events ($M = 4.53$; $SD = 1.38$), $t(13) = 3.38, p < 0.005$, whereas aMCI patients produced an equivalent number of details for past ($M = 5.50$; $SD = 1.85$) and for future events ($M = 5.58$; $SD = 1.60$), $t(13) = -0.67$. The interaction between Details and Temporal Direction was also significant, $F(1, 26) = 72.71, p < 0.0001$, indicating that more internal details were produced for past ($M = 7.48$; $SD = 3.0$) than for future events ($M = 4.35$; $SD = 2.5$), $t(27) = 6.50, p < .0001$, whereas more external details were produced for future ($M = 5.71$; $SD = 3.7$) than for past events ($M = 3.88$; $SD = 2.0$), $t(27) = -2.77, p < 0.01$. Finally, the Group \times Details \times Temporal Direction interaction was also significant, $F(1, 26) = 28.13, p < 0.0001$. In order to better describe this three-way interaction, we conducted two separate follow-up Group \times Temporal Direction ANOVAs for internal and external details. The results of the ANOVA on internal details showed main effects of both Group and of Temporal Direction, $F_s(1, 26) > 16.83, p_s < 0.0001$, indicating that aMCI patients produced less internal details as compared to controls and that, overall, more internal details were produced for past than for future events. The difference between the number of internal details for past and future events was equivalent in the two groups of participants, as indicated by a non significant Group \times Temporal Direction Interaction (see Fig. 7.1). The results of the ANOVA on external details showed a main effect of Group and of Temporal Direction, $F_s(1,26) > 15.57, p_s < 0.0001$, indicating that aMCI patients produced more external details as compared to controls, and that, overall, more external details were produced for future than for past events. However, a significant Group \times Temporal Direction interaction, $F(1, 26) = 28.82, p < 0.0001$, revealed that

the difference between the number of external details for past and future events was significant only for the aMCI patients, $t(13) = -5.46, p < 0.0001$ (see Fig. 7.1).

7.3.4 Correlations

We computed correlations between internal and external details for past and future events across all participants. In line with results reported by Addis et al. (2008), we found a significant correlation between past and future internal details ($r = .58, p < 0.001$) and a marginally significant correlation between past and future external details ($r = 0.35, p = 0.06$). These positive correlations have been accounted for as evidence of the striking overlap between the specificity of past and future events (Addis et al., 2008). However, we also found a significant negative correlation between future internal and external details ($r = -.55, p < .01$). It is important to note that recently Addis, Sacchetti et al. (2009) found a negative correlation between future internal and external details, computed using data from healthy old adults and AD patients, that approached significance when few covariates (MMSE, phonemic and semantic fluency) were controlled for. The authors suggested that their finding might indicate that, when controlling for cognitive decline and fluency abilities, those subjects who generate more external details also generate fewer internal details. In the present study, there were no significant differences between aMCI and controls on the MMSE scores. In addition, performance of all aMCI patients in the phonemic fluency task (Carlesimo et al., 1995) was within the normal range for age and education (range = 17–45; $M = 28.1$; $SD = 6.8$; data on controls were not available).

It seems, therefore, plausible to conclude that, in general, the pattern of decreased internal and increased external details for past and future events, commonly observed across the aging process, likely reflects an increased reliance on external semantic details when unable to generate internal episodic details, as originally suggested by Addis et al. (2008).

7.4 Discussion

In this chapter episodic future thinking in aMCI patients is assessed for the first time.

Results revealed that aMCI patients produced fewer episodic, event specific details, and an increased number of semantic details in their recollections and simulation of past and future as compared to controls. Furthermore, both groups produced more internal details for past than for future events, whereas the number of external details was higher for future than past events only for aMCI patients.

Differences between controls and aMCI patients in general conversational style were not a factor of concern in the interpretation of these results. In fact, when describing past and future events, aMCI patients and controls produced, overall, an equivalent number of details and used an equivalent mean number of words.

These novel results fill the gap in the current literature concerning the ability to simulate future events in patients with episodic memory impairments. On the one hand, it is well known that healthy older adults produce fewer episodic and more semantic details, as compared to younger adults, for both past (Addis et al., 2008; Levine et al., 2002; Piolino et al., 2002) and future (Addis et al., 2008) events. On the other hand, it has been recently shown that AD patients produce fewer internal and external details as compared to healthy older adults for both past (Addis, Sacchetti, et al., 2009; Ivanoiu, Cooper, Shanks, & Venneri, 2006; Leyhe et al., 2009) and future (Addis, Sacchetti, et al., 2009) events. Furthermore, there is evidence of reduced episodic specificity in autobiographical memory in aMCI patients (Murphy et al., 2008).

Recently, Addis, Sacchetti et al. (2009) acknowledged that “while amnesic MCI patients exhibit significant declines in memory for internal episodic details, as do AD patients, it appears they can still rely on strategies also used by older adults when describing past and future events” (p. 2668). The results of the present study extend the impaired episodic spared semantic trend to simulating future events in aMCI,

placing the performance of aMCI patients at an intermediate position between that of healthy elderly and AD patients. We suggest, in line with Addis et al. (2009), that the three stages – from healthy aging, through aMCI, to AD – of the impairments affecting past and future thinking may reasonably reflect the progress of the neuropathological changes associated with these conditions, i.e., from initial functional and structural changes that affect the medial temporal area in normal aging (Driscoll et al., 2003), encompassing the hippocampus and surrounding cortical regions, to a more severe, though selective, impairment of the hippocampus and other medial temporal lobe regions in aMCI (e.g., Jack et al., 2000; Killiany et al., 2002), to a more extensive atrophy beyond the medial temporal regions to larger portions of the neocortex (supporting semantic memory) in AD (Leyhe et al., 2009).

Therefore, the results of the present study, in conjunction with the findings of Addis et al. (2008), Addis, Sacchetti, et al. (2009) and of Murphy et al. (2008), provide evidence for the close linkage between remembering the past and imagining future.

There are, however, some relevant issues that need to be considered.

One issue pertains to the status of the semantic component of autobiographical memory in aMCI. In line with results of Murphy et al. (2008), we found a pattern of reduced episodic but elevated semantic autobiographical memory in aMCI, as compared to controls.

However, it is important to note that, in a recent study, Leyhe et al. (2009) detected an impairment in both the semantic and the episodic components of autobiographical memory in aMCI patients.

These different results may be due to differences in the experimental task used to assess autobiographical memory. Like Murphy et al. (2008), we used the Autobiographical Interview by Levine et al. (2002), which extracts indices of semantic and episodic autobiographical information from within a single narrative. In contrast, Leyhe et al. (2009) used the Autobiographical Memory Interview by

Kopelman, Wilson, and Baddeley (1990), which probes episodic and semantic memory separately, through the recall of specific past events and names, and addresses, respectively, across the lifespan.

It has been argued that these separate measures artificially divide these two forms of autobiographical memory, which co-occur and interact in naturalistic autobiographical discourse, assessing them with tasks unmatched in sensitivity, content, and psychometric characteristics (Murphy et al., 2008).

A further relevant issue pertains to our findings concerning the novelty of imagined future events. In the present study, almost all aMCI participants rated their imagined future events as already occurred, more or less frequently, in the past. In contrast, only a small percentage of events produced by controls were rated as already occurred in the past. It is relevant to note that, in Chapter 5 we stated that self-projection into the future may appear much more difficult than remembering the past and may consequently lead the participant to rely, more or less deliberately, on some alternative strategies. In line with this hypothesis, we showed that, occasionally, people do indeed reproduce events that have already occurred in the past or that are very similar to past events, rather than envisioning truly novel events.

Given that, in the present study, aMCI patients tended, more than controls, to produce future events that were rather similar to past events, it could be posited that they had difficulty constructing scenarios that had never happened and therefore fell back (partially) on old episodic memories. If this were the case, this finding would cast some doubt on the accrued wisdom that future thinking and remembering involve primarily similar processes. One could argue, at least on the basis of this observation, that future thinking involves additional cognitive processes which are impaired in aMCI. This hypothesis is indirectly supported by results of neuroimaging studies. Recently, Addis, Pan, et al. (2009) identified, in healthy young adults, two subsystems within the network involved in remembering and imagining events, the *imagining subsystem* and the *remembering subsystem*, consisting, respectively, of neural regions that responded more strongly to imagining than remembering, and of

regions showing the reverse pattern. The authors suggested that the imagining subsystem may reflect the increased cognitive demands related to recombining episodic details into an imaginary scenario, as opposed to the recasting of an entire past event. Future research should therefore focus on identifying the neural correlates of remembering and imagining in aMCI patients, as well as in other pathological conditions.

This approach, associated with the analyses of subjective and objective detail ratings (i.e., according to Levine et al.'s procedure) may significantly improve our understanding of patients' ability to simulate future events.

Finally, another result that is worthy of notice in the present chapter is the number of internal and external details produced by controls and aMCI patients. Healthy older adults and aMCI patients who participated in earlier studies produced a mean number of internal and external details larger than controls and aMCI patients in the present study. In Levine et al. (2002), in Murphy et al. (2008), in Addis et al. (2008) and in Addis, Sacchetti, et al. (2009) the mean numbers of internal and external details produced by older adults during recall of events of the previous year were (appreciatively) 19 and 26, 22 and 14, 35 and 28, and 50 and 40. The numbers of internal and external details produced by older adults during imagination of future events were 27 and 28 in Addis et al. (2008), and 35 and 48 in Addis, Sacchetti, et al. (2009). For aMCI patients, in Murphy et al. (2008) the mean numbers of internal and external details produced during recall of events of the previous year were (appreciatively) 13 and 15.

The differences in the number of details seem not to be related to differences in the participants' selection criteria, as the groups of aMCI patients and controls were almost equivalent across the studies with respect to mean age and education.

Therefore, it appears more reasonable that these divergent findings are associated with factors inherent to the specific task used in the different studies. For instance, in Levine et al. (2002) and in Murphy et al. (2008) participants were asked to choose, in

the context of the Autobiographical Interview (Levine et al., 2002), a personal past memory event that happened at a specific time and place for specific life periods. These events were presumably the most accessible and, therefore, the most likely to yield detailed recollections. On the other hand, in the studies by Addis et al. (2008), Addis, Pan, et al. (2009) and Addis, Sacchetti et al. (2009) participants were cued to recollect past events (and to simulate future events) by means of single words. This procedure is unquestionably more demanding than freely recollecting past experiences. However, these authors also used general probes to clarify instructions and encouraged further description of details. In the study by Murphy et al. (2008) general probes were also given to encourage recall of detailed information, particularly if the participant had trouble coming up with a specific detailed memory or provided a very brief recollection.

In the present study, a relevant aspect of the procedure was that participants were cued to recollect and simulate past and future events by means of single words and no general probe was provided.

Apparently, the procedure of the present study provides the participants with the lowest support for recollection and simulation of events, and may thus be responsible for the overall lower number of details produced by controls and aMCI.

Overall, the analysis of extant results in the literature reveals that research in this area is still in its infancy and needs to be further informed in the future by advances in understanding of both the quantitative and qualitative differences in the ability of normal and pathological populations to engage in episodic future thinking.

8. Future thinking in Parkinson's Disease: an executive function?⁷

8.1 Introduction

It has long been posited that an intimate relation underpins episodic past and future thoughts: “It may be said that we have no grasp of the future without an equal and corresponding outlook over the past” (Bergson, 1913, p. 69-70). Bartlett (1932) noticed that remembering is not entirely distinct from imagining or from constructive thinking, but it has a close linkage with them. In 1973 it was already “abundantly clear that human behaviour is active in character, that it is determined not only by past experiences, but also by plans and designs formulating the future” (Luria, 1973, p. 13). Therefore, when people with memory disorders cannot completely rely on their past, their future remains “hazier, more vague and more confused” (Lidz, 1942, p. 596).

Consistent with these early intuitions, the presence of a common core network, which underlies autobiographical episodic remembering and future thinking, has been recently experimentally supported (for a review see Schacter et al., 2008; Szpunar, 2010). Certain cortical areas (specifically the medial prefrontal cortex, posterior regions in medial and lateral parietal cortex, lateral temporal cortex, and the medial temporal lobe including the hippocampus) have been shown to be associated with episodic memory and imagination of the future (e.g., Hassabis et al., 2007; Schacter et al., 2007; Schacter & Addis, 2009). This evidence has led to the claim that we need to access past experiences in order to anticipate future events (Szpunar, 2010; Schacter et al., 2008; Schacter & Addis, 2007).

⁷ de Vito S, Gamboz N, Brandimonte MA, Barone P, Amboni M, and Della Sala S. Future thinking in Parkinson's Disease: an executive function? *Neuropsychologia*, [in press](#).

Patient studies corroborated this hypothesis. It has been noted, for example, that amnesic patients (O.S., Lidz, 1942; K.C., Tulving, 1985; D.B., Klein et al., 2002), seemed almost mentally locked in a permanent present, since the preceding events were “not available to meet the new” ones (Lidz, 1942, p. 595). The famous patient H.M., who became amnesic in 1953 after the bilateral resection of medial temporal lobe structures, was interviewed in 1992 by Suzanne Corkin. When asked "What do you think you'll do tomorrow?", he answered "Whatever is beneficial", since he “had no database to consult” to respond about his personal future (S. Corkin, personal communication, 01/26/11).

Similarly, Hassabis et al. (2007) reported on five memory-impaired patients with a bilateral hippocampus damage, four of whom had difficulty constructing detailed and spatially coherent fictitious scenarios. Lastly, patients with Alzheimer's disease (AD; Addis et al., 2009) presented impairments in envisaging new experiences.

However, it is as yet unclear which specific cognitive deficits play a fundamental role in determining these observed impairments. In particular, it is still debated whether episodic memory deficits are indeed the sole relevant factor in determining difficulties in imaging own future and whether the hippocampus plays the crucial role in the construction of future scenes (Squire et al., 2010). The findings gleaned from the literature are controversial. Hassabis et al. (2007) reported that focal amnesics had troubles in constructing novel events. Likewise, patients suffering from amnesic MCI, a subtype of Mild Cognitive Impairment characterized by a selective and isolated deficit of episodic memory (presumably due to hippocampal malfunctioning), generated fewer details in a future thinking task than their matched controls (see Chapter 7). On the other hand, Squire et al. (2010) obtained different results with patients suffering from a well-characterized hippocampal lesion. Despite their impairment in recollecting recent personal memories, these patients performed similarly to controls when simulating future episodes. The authors concluded that, in view of these findings, difficulty in imaging the future is unlikely to be due only to pure amnesia if the past-future network of brain areas postulated by Schacter et al. (2007) is largely spared (Squire et al., 2010).

Indeed, little information regarding the lesion location of some amnesic patients, like O.S. and D.B., is provided, and when it is, like in the case of K.C., it indicates widespread damage. Even the patients tested by Hassabis et al. (2007) apparently suffered from lesions encroaching upon areas other than the hippocampus (for a discussion, see Squire et al., 2010 and ensuing correspondence, Maguire & Hassabis, 2011; Squire et al., 2011), including areas associated with executive functions (e.g., Samarasekera et al., 2007). Equally, AD patients, who show a widespread range of neuropathological changes, suffer from dysfunctions involving brain areas other than hippocampus.

Moreover, neuroimaging studies have indicated a frontopolar activation during future thoughts. Future thinking tasks recruit several additional regions compared to the construction of past episodes, such as frontopolar cortex and left ventrolateral prefrontal cortex (Addis et al., 2007). Okuda et al. (2003) demonstrated that specific frontal polar areas, including Brodmann area 10 (BA 10), were more activated when imaging the future than when remembering the past. In particular, the activity of the right frontopolar cortex (BA 10) positively correlates with the amount of details comprising the future events (Addis & Schacter, 2008). Furthermore, damage to the prefrontal cortex can impair the conscious awareness of one's self continued experience in a subjective time. This ability, also known as chronesthesia, might be closely related to the capacity of projecting themselves toward the future (for a review see Wheeler et al., 1997; Szpunar, 2011).

Thus, Squire and his colleagues (2010) proposed that different cognitive processes unrelated to episodic memory play a crucial role in imagination of the future. Specifically, other functions aside from episodic memory itself are likely to underlie the episodic future details generation.

According to this idea, some authors noted strong correlations between event-related details generation tasks and tasks engaging executive functions. Addis, Wong and Schacter (2008) observed that the episodic specificity of past recollections and future constructions correlates with a standardized measure of executive control, the

Backward Digit Span task, known to activate the dorsolateral prefrontal cortex (Hoshi et al., 2000). To test this hypothesis, Addis and colleagues (2010) adopted a novel experimental recombination paradigm, which required healthy older and younger adults to recombine details when simulating an event that might occur in their future or that might have happened in their past. Interestingly, the authors documented that the age-related difficulty in producing episodic details, already shown by Addis et al. (2008), extended to a condition involving solely the recombination of different details into an integrate episode. A new task was also designed by Summerfield, Hassabis and Maguire (2010), in order to better investigate the process of constructing coherent and vivid scenarios. The participants of this study were instructed to begin the trial clearing their imagination. Then, they were auditorily presented with single scene elements (from three to six) in a serial manner. They had to imagine the first element in a “clean state” (i.e., with no context) and, successively, they had to combine each single element together with the previous ones to build up naturalistic scenes of increasing complexity. In this study, fMRI showed the activation of the different areas of the core network (Schacter et al., 2007), being engaged and disengaged, as required during each step. The hippocampus and the dorsolateral prefrontal cortex were both significantly activated during the oral presentation of the first element. The addition of the second element required an increasing activity of the dorsolateral prefrontal cortex (maybe to allow the maintenance of the two elements in working memory, as the authors suggested). However, crucially, in this phase, the hippocampus (together with other areas of the core network activated during the first step) down-regulated. With the introduction of the third element, the authors observed a greater activity in additional regions (i.e., the medial parietal cortex) and once more an up-regulation of many areas, like the hippocampus, activated during the first phase, but down-regulated in the second phase. Such observations provide us with clues as to the possible alternative role played in the scene construction by hippocampus-related memory functions and by frontally based executive functions.

Taken together, these lines of evidence suggest that executive functioning plays an essential part in the production and recombination of event-related details. Should

this be the case, an executive dysfunction ought to cause a significant impairment in the episodic simulation of future events, even when episodic memory is spared.

We sought to further our understanding of this issue by testing people with Parkinson's disease (PD). PD is a neurodegenerative disorder that progresses slowly and is characterized by degeneration of the dopaminergic system. The main motor symptoms are bradykinesia (i.e., slowness when initiating voluntary movements), tremor, muscular rigidity and postural instability. A wide range of cognitive impairments is often associated with PD, the most prominent of which is a dysexecutive syndrome, that resembles the typology of cognitive impairment found in frontal lobe patients (Bosboom et al., 2004; Rowe, 2002). The choice of this particular population, early non amnesic PD, was directly linked to the question posed in our study, i.e. whether people with no overt memory problems, and who might have other mild cognitive deficits, could nonetheless present with FT deficits.

The present study assesses for the first time episodic future thinking in PD patients. It aims at casting a light on the alternative role played by executive functions in episodic future thinking, when memory is totally preserved.

8.2 Method

8.2.1 Participants

Thirty-one old adults affected by PD and 31 healthy controls took part in this experiment.

The participants with PD were selected from a larger panel at the Parkinson and Movement Disorder Centre, Department of Neurological Sciences (Federico II University, Naples). The diagnosis of PD fulfilled the UK Parkinson's disease Society Brain Bank clinical diagnostic criteria (Gibb & Lees, 1988). All patients were under anti-parkinsonian treatment at a stable and optimized daily dosage during

the 4 weeks prior to study entry. Twenty of our PD patients were under a treatment comprising both levodopa ($M_{mg} = 477,5$; $SD_{mg} = 260,3$) and other dopamine-agonists ($M_{mg} = 297,5$; $SD_{mg} = 212,42$); 6 of them were taking only dopamine-agonists ($M_{mg} = 321,66$; $SD_{mg} = 63,37$) and 5 of them were being treated only with levodopa ($M_{mg} = 460$; $SD_{mg} = 178,18$).

Exclusion criteria were: (1) dementia according to clinical diagnostic criteria for dementia associated with PD (Emre et al., 2007); (2) major depression according DSM-IV criteria for current major depression (American Psychiatric Association, 1994); (3) clinically significant or unstable medical condition including serious cardiovascular or cerebrovascular disease; and (4) anti-cholinergic or neuroleptic treatment.

Our patients were selected for being at the very early stages of the disease. Their magnetic resonance imaging had to be normal. According to Hohen and Yahr' s classification (1967), our PD patients were to be maximum at the second stage of the Parkinson' s disease. More specifically, 16 of them were at the stage 2; 11 of them were at the stage 1,5 and 4 of them were at the stage 1.

Furthermore, specific tests were selected from the Mental Deterioration Battery (MDB; Carlesimo et al., 1996) in order to recruit solely people with (a) no deficit in immediate and delayed recall test (Rey' s 15 word Immediate Recall and Delayed Recall; scores, respectively, above 28.53 and 4.69); (b) spared logical reasoning (Raven' s Progressive Matrices'47; scores above 18.96); and (c) a fluent language (Phonological Verbal Fluency; scores above 17.35). Moreover, the participants should have a score of at least 30, i.e., above cut-off, on the Attentional Matrices, which assesses attention by means of timed visual search (Della Sala et al., 1992).

There were no significant differences (all $p_s > 0.05$) between PD patients and controls on demographic variables such as age (PD, $M = 64.4$, $SD = 6.7$; controls, $M = 67.9$, $SD = 8.5$) and education (PD, $M = 11.0$, $SD = 4.3$; controls, $M = 11.5$, $SD = 4.2$), or the MMSE scores (PD, $M = 27.5$, $SD = 1.7$; controls, $M = 26.9$, $SD = 0.9$).

The healthy individuals were members of different, non-academic, local associations. We did not recruit people under psychoactive pharmacological treatment likely to modify normal memory abilities or people with a history of neurological and psychiatric disorders.

No honorarium was offered to participants. Before starting the testing session, they were asked to sign an informed written consent.

The study procedures were approved by the local ethical committee and were carried out in accordance with the Declaration of Helsinki.

8.2.2 Materials and experimental procedure

Each testing was carried out in one single session. All participants were tested individually and sat facing the same experimenter in a quiet testing environment.

The Frontal Assessment Battery (FAB; Dubois et al., 2000) was also administered, with the aim of exploring, by the means of six subtests, some skills related to frontal lobe functions, in particular conceptualization, mental flexibility, and inhibitory control. It should be noted that since the PD patients recruited for the study did not present with deficits in verbal fluency, visual search or logical reasoning known to be associated with frontal activation (Prabhakaran et al., 1997), the FAB battery was meant to identify minor executive disturbances, and we did not expect a large subgroup being impaired.

Finally, participants were given the experimental battery. They were initially briefed that they would be required to mentally re-experience and pre-experience twelve autobiographical episodes (eight “temporal”, i.e., occurred or occurring within the past or next year; four “non temporal”, i.e., that not necessarily are going to occur) in response to randomly presented cue words (for the “temporal” events) or short verbal cues (for the “non temporal” episodes).

Aiming at eliciting the “temporal” (past or future) events, two sets of eight words, matched for familiarity, frequency, imageability, and concreteness, were selected from Italian norms (Burani et al., 2001). Within each list, the words were randomly assigned to the two temporal directions. Then, each participant was given one of these two sets. The experimenter further explained that the events had to be remembered or imagined in as much detail as possible. Participants also were encouraged to produce temporally and contextually specific events and to vividly imagine novel and plausible future episodes, given their current plans. This procedure followed those of D’Argembeau and van der Linden (2004) and of Addis et al. (2008).

In order to elicit the “non temporal” events, we used ten short sentences, which outlined a variety of common-place scenarios (e.g., “*Imagine you are standing in a open field by the banks of river*” or “*Imagine you are standing on the deck of a ship leaving port on a voyage*”). The short descriptions were randomly assigned across the participants. Participants were instructed to richly invent new fictitious experiences, never occurred before, and not temporal in nature and to describe them in as many details as possible. The events had to be contextually specific, but not necessarily plausible, neither even possible. The procedure and the short verbal cues were adapted from the paradigm devised by Hassabis et al. (2007).

Order of presentation of temporal connotation (past, future, non temporal) was counterbalanced.

The cues were displayed, one at a time, on the computer screen with the instructions about the temporal direction (remember or imagine in the future or invent fictitious experiences). Once an episode had been recalled or imagined, it was recounted by each participant. There was no time limit. Participants were allowed to keep on verbally illustrating the event until they thought that nothing else could be added. Recollections and simulations were digitally recorded to enable later transcriptions and subsequent scoring of participants’ responses.

After the transcription, a trained rater, who was blind to the hypothesis of the study, used the standardized scoring procedure developed by Levine et al. (2002) to systematically parse the details generated in the past and future events. This first allowed to segment the main event (i.e., the most talked about, with a brief timeframe) into details and then to distinguish between (a) internal details (i.e., episodic information pertaining to the main event, specific to time and place) and (b) external details (general knowledge related to the event). A second rater, trained for this purpose, was also required to score 20 protocols from the original participants, 10 from the PD sample and 10 from the controls.

Internal details were further categorized into: (a) event (happenings, individuals present, physical/emotional actions and reactions, weather), (b) place (information about the environment where the event occurred), (c) time (date, season, month, day of the week, time of day), (d) perceptual (sensory information, body position) and (e) emotion (emotional state, thoughts).

External details were categorized into: (a) external event (specific details from other incidents, from all of the above categories, external to the main event), (b) semantic (general knowledge or facts, ongoing events, extended states of being), (c) repetition (unsolicited repetition of details), and (d) other (metacognitive statements, editorializing).

8.3 Results

The entire group of patients presented with a mean on the FAB of 14.14 (± 2.04). Thirteen patients scored below the cut-off (i.e., below 13.5) and eighteen patients scored above the cut-off (i.e., above 13.5). The full outcome of the FAB is reported in Table 8.1, showing the results from each of its subcomponents.

On the experimental procedure, considering the three conditions together, PD patients and controls generated an equivalent number of details (PD, $M = 14.5$, $SD = 6.4$; controls, $M = 15.7$, $SD = 5.8$), $t(60) = -0.7$, n.s.

| PD | C | MF | MP | STI | IC | EA | FAB total |
|---------------------|----------|-----------|-----------|------------|-----------|-----------|------------------|
| Total (n.31) | 1.7(.7) | 2.5(.6) | 2.3(.7) | 2.7(.7) | 1.8(.9) | 3(0) | 14.1(2.04) |
| Groups (FAB) | | | | | | | |
| Exe (n.18) | 2.05(.7) | 2.8(.42) | 2.7(.46) | 2.9(.3) | 2.05(.9) | 3(0) | 15.5(1.3) |
| Dysex (n.13) | 1.4(.6) | 2.2(.7) | 1.7(.7) | 2.5(.9) | 1.4(.6) | 3(0) | 12.3(1.2) |
| Groups (FT) | | | | | | | |
| Hi-FT (n.24) | 1.91(.7) | 2.6(.6) | 2.4(.6) | 2.9(.2) | 1.8(.9) | 3(0) | 14.6(1.8) |
| Po-FT (n.7) | 1.3(.7) | 2.3(.7) | 1.8(.9) | 2(1.1) | 1.7(.9) | 3(0) | 12.5(1.9) |

Table 8.1 - The table reports the mean (standard deviation) of the results obtained at the six subtests of the FAB, i.e., conceptualization (C), mental flexibility (MF), motor programming (MP), sensitivity to interference (STI), inhibitory control (IC), and environmental autonomy (EA), by the whole patient group (total); by the subgroup of executive patients (Exe; who scored above the cut-off of 13.5 at the FAB) vs. the subgroup of dysexecutive (Dysex; who scored below the cut-off of 13.5 at the FAB); and by the subgroups of the 24 patients who obtained higher FT scores (Hi-FT) and the 7 patients who performed poorer (Po-FT).

A 2 (Group: PD vs. Controls) x 2 (Details: Internal vs. External) x 3 (Temporal Connotation: Past vs. Future vs. Non temporal) mixed analysis of variance (ANOVA), with Group as a between-subjects factor, and Details and Temporal Connotation as within-subjects factors, was conducted on the mean number of details generated by PD and controls (see Figure 8.1). The inter-rater reliability (r) between the two raters, who scored the descriptions, was .94.

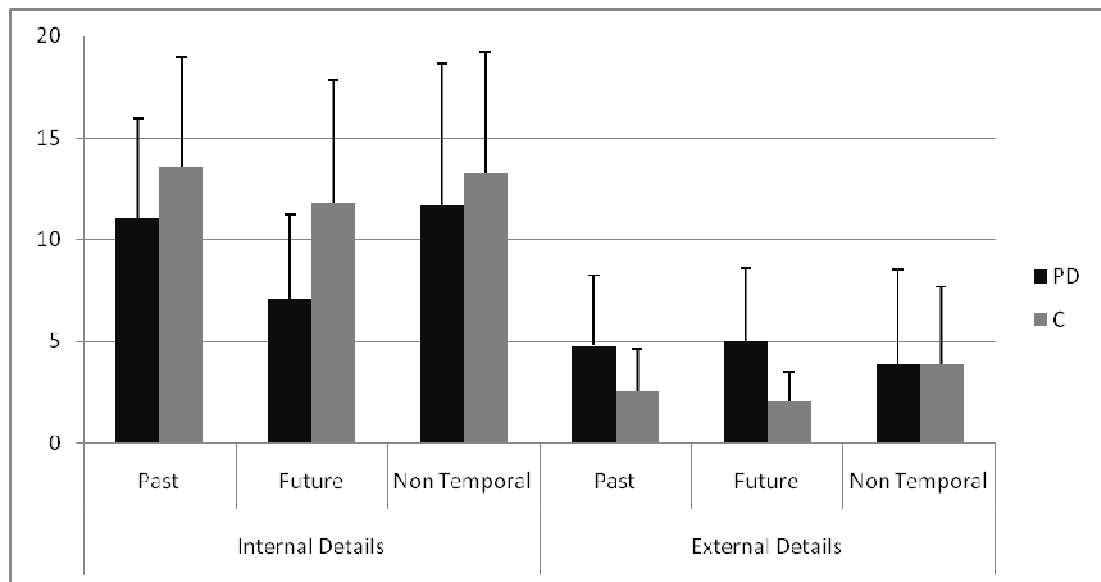


Figure 8.1 - Mean number of internal and external details produced for past, future, and non temporal events by PD patients (PD) and controls (C). Error bars indicate standard deviations.

The results showed a highly significant main effect of Details, $F(1, 60) = 165.9, p < 0.001, \eta^2_p = 0.73$, indicating that, on the whole, participants produced more internal ($M = 11.4, SD = 4.9$) than external details ($M = 3.7, SD = 2.8$). The interaction between Details and Groups, $F(1, 60) = 15.16, p < 0.001, \eta^2_p = 0.2$, was also significant; post-hoc t-tests suggested that the amount of internal details generated by PD patients ($M = 9.9, SD = 4.7$) was significantly less than that produced by controls ($M = 12.8, SD = 4.7$), $t(60) = -2.4, p < 0.02, \eta^2_p = 0.09$, and that, on the contrary, the number of external details in PD patients' reports ($M = 4.5, SD = 3.3$) was greater compared to the quantity of external details recounted by controls ($M = 2.8, SD = 1.9$), $t(60) = 2.5, p < 0.02, \eta^2_p = 0.09$. The interaction

between Details and Temporal Connotation was also significant, $F(1, 60) = 6.8$, $p < 0.005$, $\eta^2_p = 0.1$; post-hoc t-tests indicated that both groups produced more internal details when remembering past episodes ($M = 12.3$, $SD = 5.2$) than when imagining future events ($M = 9.4$, $SD = 5.6$), $t(61) = 4.9$, $p < 0.001$, $\eta^2 = 0.29$, and more internal details when inventing non temporal events ($M = 12.4$, $SD = 6.4$) than when imagining future events ($M = 9.4$, $SD = 5.6$), $t(61) = -4.4$, $p < 0.001$, $\eta^2 = 0.24$. Finally, the three-way interaction concerning Groups, Details and Temporal Connotation was also significant, $F(1, 60) = 6.45$, $p < 0.005$, $\eta^2_p = 0.9$. With the aim of better explaining the latter interaction, two different following-up ANOVA were carried out for internal and external details. As regards the internal details, the results revealed main effects of both Group, $F(1, 60) = 5.9$, $p < 0.05$, $\eta^2_p = 0.09$ and Temporal Connotation, $F(1, 60) = 13.8$, $p < 0.001$, $\eta^2_p = 0.18$. These indicate that PD patients generated less internal details compared to controls and that, overall, more internal details were generated for past ($M = 12.3$, $SD = 5.2$) and non temporal ($M = 12.4$, $SD = 6.4$) events than for future events ($M = 9.4$, $SD = 5.6$). It is important to note that, overall, an equivalent amount of the subtype of internal details previously labelled as “events” (mainly happenings and physical/emotional actions and reactions of the individuals present in the episode) was generated in future ($M = 3.8$, $SD = 2.3$) and non temporal ($M = 3.4$, $SD = 1.9$) tasks, whereas, overall, more “perceptual” internal details (mainly sensory information) were produced in non temporal ($M = 5.9$, $SD = 3.6$) than in future ($M = 2.9$, $SD = 2.2$) tasks, $t(61) = -5.8$, $p < 0.001$, $\eta^2 = 0.36$.

A significant interaction between Group and Temporal Connotation, $F(1, 60) = 3.1$, $p < 0.05$, $\eta^2_p = 0.5$, indicates that PD patients produced fewer internal details compared to controls for future events (PD, $M = 7.0$, $SD = 4.1$; controls, $M = 11.8$, $SD = 5.9$), $t(60) = -3.6$, $p < 0.002$, $\eta^2 = 0.18$. In particular, the difference between the two groups for future events was highly significant for the subtype of internal details regarded as “events” (PD, $M = 2.9$, $SD = 1.6$; controls, $M = 4.8$, $SD = 2.4$), $t(60) = -3.5$, $p < 0.002$, $\eta^2 = 0.17$. The mean number of the subcategories of internal details produced for past, future and non-temporal events by PD patients and controls are presented in Figure 8.2.

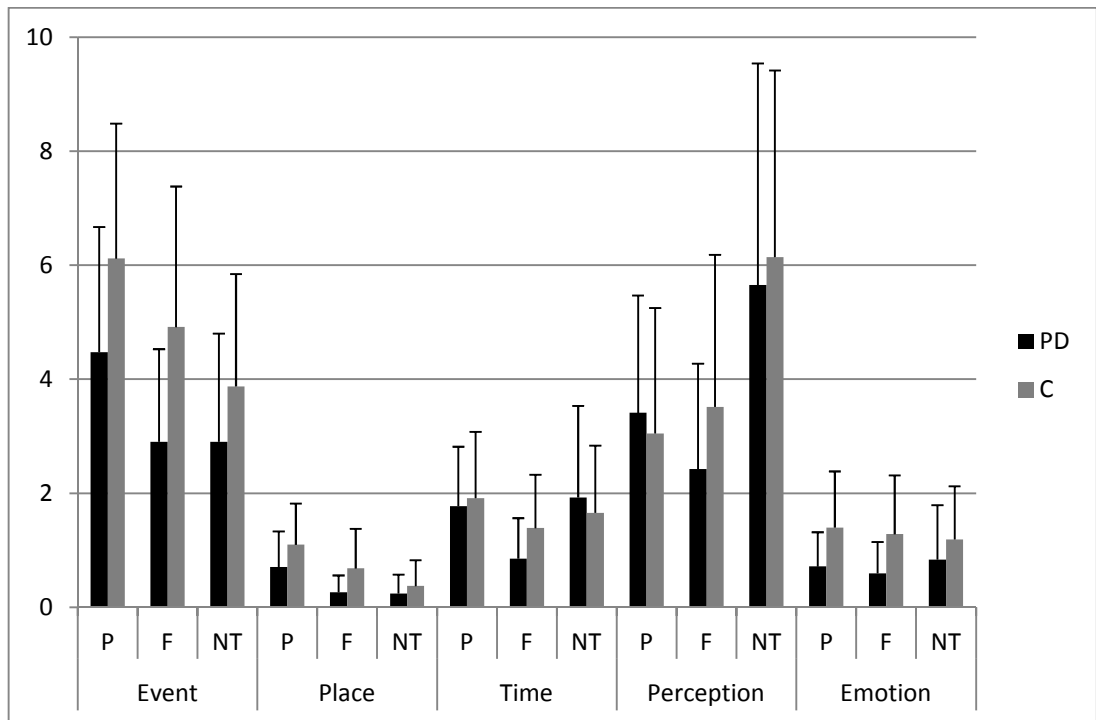


Figure 8.2 - Mean number of the subcategories (i.e., event, place, time, perception and emotion) of internal details produced for past (P), future (F), and non temporal (NT) events by PD patients (PD) and controls (C). Error bars indicate standard deviations.

The ANOVA conducted on external details showed a main effect of the Group, $F(1, 60) = 6.3, p < 0.02, \eta^2_p = 0.9$, indicating that PD patients generated an increased number of external details as compared to controls. The interaction between Group and Temporal Connotation was also significant, $F(1, 60) = 6.0, p < 0.005, \eta^2_p = 0.09$, indicating that the group of PD produced more external details than controls for past (PD, $M = 4.7, SD = 3.5$; controls, $M = 2.6, SD = 2.0$), $t(60) = 3.0, p < 0.005, \eta^2 = 0.18$, and for future (PD, $M = 5.0, SD = 3.6$; controls, $M = 2.0, SD = 1.4$) events, $t(60) = 4.3, p < 0.001, \eta^2 = 0.24$.

We also ran an ANOVA including only past and future scores. It showed a significant Group x Past/Future interaction for internal details ($F(60) = 3.73, p = 0.05$). Post-hoc tests comparing the past and future condition showed that PD

patients performed significantly better on the past task ($M = 11.08$; $SD = 4.86$) than on the future task ($M = 7.04$; $SD = 4.18$), $t(31) = 6.25$, $p < 0.001$. On the other hand, controls' performances in the past condition ($M = 13.6$; $SD = 5.32$) and in the future condition ($M = 11.81$; $SD = 5.93$) did not significantly differ. The control and the PD groups produced an equal number of repetitions in all the experimental conditions.

In order to further explore the performance of the PD group, a subgroup of seven patients was selected, on the basis of number of internal details recounted in future thinking. More specifically, these seven patients clearly performed outwith the range of controls in the future task (the lowest mean reported in the control group was 3.5), reporting a mean of internal details of 2.3 ($SD = 1.2$). Their performance on future task ($M = 2.3$, $SD = 1.2$) significantly diverged from the remaining 24 PD ($M = 8.4$, $SD = 3.7$), $t(29) = 4.2$, $p < 0.001$, $\eta^2 = 0.23$.

Interestingly, the mean score achieved on the FAB by the subgroup of 7 dysexecutive PD patients ($M = 12.5$, $SD = 1.9$) was significantly lower compared to the rest of the group ($M = 14.6$, $SD = 1.8$), $t(29) = 2.6$, $p < 0.02$, $\eta^2 = 0.10$.

There were no significant differences (all $p_s > 0.05$) between the two subgroups when compared on variables concerning age, education, duration of disease, or the MMSE.

We further dichotomised the data according to the performance on FAB (other than, as we have already done, according to the performance on the key experimental variable), dividing the patients in two groups, those presenting with FAB deficits vs. those scoring above cut-off. The two groups, dysexecutive (D; $n=13$) and executive (E; $n=18$), did not differ on any of the experimental conditions. The group D scored significantly worse than the controls solely in the future condition, $t(47) = -2.86$, $p < 0.01$. The same pattern was observed for group E's performance, $t(42) = -2.78$, $p < 0.01$. The two groups (E and D) did not show significant differences on the past or on the non-temporal task, when compared to controls.

Furthermore, performance on the FAB does not correlate with any of the experimental variables.

Finally, an example narrative from one control and two example narratives from two different patients are reported:

Imagine an event that might happen to you in the next year with the word “table”.

Control’s response: “We are sitting at a table with a group of people. I have just stopped cooking and in this moment I’m serving spaghetti. One of my friends appreciates the consistency of the pasta and I rebuke him, because he has tasted before everyone is sitting, he replies for fun “Daniele, you are always so fussy!”. We are sitting, I uncork the bottle of wine and leave it oxygenating before serving. A friend of mine asks for white wine, and I have just uncorked red wine. Another friend says that she doesn’t like that type of tomato sauce, she would prefer another sauce to dress the spaghetti. My mother enters the kitchen, a friend stands up to say hi, another friend also turns towards my mother and, in turning her head, throws her long hair on the face of the person sitting close to her. This person looks annoyed, since he has got glasses, that were about to fall from his face, but my friend turns towards him and gently caresses his face, so that he brightens up”

P01’s response: “Ok... so a very simple episode. I’m in pizzeria to eat pizza with my relatives and the table is not stable and all the dishes with the pizzas fall and we laugh at the end. And we are all around the table”

P02’s response: “If you say table.. I always think of a dining table. So the table in the kitchen. We are waiting for the other daughter coming back from the university. She is late and so we are waiting for her to eat. The table has already been set, there is the other daughter, my wife who’s preparing, the water is boiling, the television is on... my wife is cooking pasta”

8.4 Discussion

The main question from which this study originated was whether difficulties in future thinking could be observed in the absence of impairments in episodic memory.

Patients with Parkinson's Disease (PD), who did not present with memory deficits, performed normally on past memories and non temporal constructive simulations, whereas they were impaired on episodic future thinking. That is, the reduction in specificity of PD patients' simulations was limited to future events and did not extend to fictitious scenarios. Furthermore, our results showed that, compared to controls, PD patients reported fewer internal, event-related details in their simulations of future events, while they reported more semantic details both when recollecting the past and imagining future episodes. General differences in conversational, narrative style cannot easily account for these results, as PD patients and controls generated overall the same amount of details considering the three experimental tasks together (Past, Future, and Non Temporal). In addition, the PD patients performed within normal limits on the Phonological Verbal Fluency task (which evaluates the richness of lexical production). The patients' emotional state could in principle contribute to explain our findings. The reduction in specificity of patients' simulations might suggest that they are imagining less because of clinical depression. However, one of the exclusion criteria that we adopted was the presence of major depression according DSM-IV criteria (American Psychiatric Association, 1994). Moreover, PD patients uttered less details only in one of the three conditions. This argues against the account that they might have generally spoken (or imagined) less because of clinical depression.

Taken together, these data emphasize striking differences not solely between time periods (past and future), but also between constructing non-temporal experiences and future thinking tasks.

Recently, the possibility of a dissociation between performances concerning past memories and future thinking has gained ground. Squire et al. (2010) reported on five densely amnesic patients, who had a strikingly preserved capacity to imagine the future. In particular, patient G.P., who showed a remarkable deficit in remembering remote and recent episodes, was nonetheless fully intact at future envisaging (see also Squire et al., 2011). Berryhill et al. (2010) assessed patients with unilateral prefrontal lesions, with spared autobiographical memory but who showed a moderate

deficit on a constructed experience task. Our results revealed that the seven patients, who obtained the poorest scores on the future thinking task (generating less event-specific details), achieved a significantly lower mean score on the Frontal Assessment Battery compared to the rest of the PD group. These seven PD patients expressed their own incapability to take distance from their memories in favour of the imagination of completely novel scenarios, “Strangely, when I try to imagine the restaurant where my granddaughter is going to get married, the restaurant where my daughter got married comes up into my mind”, said a patient. And another one complained, “Although I do try to imagine something new, I end up with remembering a past event. I can’t help it”. Their spared memories are paradoxically considered by these patients as an obstacle to overcome when they aim at performing the future thinking task. The difficulty in reshuffling details from different memories is translated by one of our patients with the feeling that some scenarios “stay still” in mind, as they could not be fragmented into pieces to be differently used. Such a feeling reflects the default of mechanisms underlying a flexible search inside memory repositories. This essential role is indeed played by executive functions.

Therefore, the present study documents a dissociation between spared episodic memory and the impaired envisaging future episodes raising the possibility of the involvement of executive functions in generating episodic future thinking (see also Squire et al., 2010). The PD patients recruited for the current study were, indeed, exempt from other cognitive deficits likely to disrupt their performances.

It might be argued that the data should be analysed in terms of patients presenting with FAB deficits vs. those scoring above cut-off, rather than, as we have done, to dichotomise the data according to the performance on the key experimental variable, and then compare their cognitive profiles. But we think that it is debatable which dichotomy should come first, and different researchers have used different approaches. In this particular case, the approach that we have chosen is preferable as the patients were recruited to be extremely mild in their cognitive deficits. Indeed, they had no memory problems, and performed well on the verbal fluency task. We were not aiming at investigating whether or not patients with executive dysfunctions

performed worse than those without executive dysfunctions. Rather we were interested in investigating whether patients without memory problems, or better without overt memory problems, could still present with future thinking deficits. And if so, whether or not those who did differ in any way from those who did not. Hence, the analyses based on the dichotomy that we reported are more pertinent to address the question from which the study sprang.

It was also observed a dissociation between past recollections and future simulations. This dissociation might be due to the greater neural activity that the ability of simulating future events necessitates (Okuda et al., 2003; Addis et al., 2007). Okuda et al. (2003) revealed that frontal lobes were activated when normal participants foresaw. In particular, specific frontal polar regions were more active when participants thought and reported their future prospects. In addition, the activity of the right frontopolar cortex (BA 10) was found to positively correlate with the number of elements reported in future events (Addis & Schacter, 2008). Recently, Anderson et al. (in press) have suggested that future thinking might be considered more effortful than past memory. Executive functions underlie both processes by monitoring and combining the different details. But whereas past episodes require “a search for a unique combination of information; in contrast, a future event can be formed from any combination of an infinite array of information within autobiographical memory” (Anderson et al., in press, p. 2). Future thinking is supposed to place a greater demand on executive functions. And this would explain why, in case of executive dysfunction, patients show a severe impairment in future imagining, albeit the spared ability to reconstruct their past.

At this point, we should wonder why our patients' impairment did not encroach upon their constructions of non-temporal, fictitious episodes. A possible interpretation of the difference between the two tasks (non temporal and future) might be the involvement of self-related processes present in the future thoughts but not in the non-temporal constructions. A number of studies have shed light on the peculiar part played in future tasks, but not in non-temporal tasks, by subjective time, which is specifically involved in the ability to mentally time travel. A problem in processing

conscious awareness of one's own "continued existence" (Szpunar, 2011) in a subjective time, also labelled "chronesthesia" (Tulving, 2002) or "temporal consciousness" (Dalla Barba, 2002), could have been at the root of the difference documented in our study, as this deficit could have interfered solely with the attempt to projecting oneself towards the future. However, this would imply that PD patients presented with clear disorientation in time which was not detected by the detailed clinical interview nor did they confabulated or showed time-based incongruences in their reports.

An alternative account could capitalise on the different procedures that hallmark the two tasks (future thinking and non-temporal construction). Addis et al. (2007) observed that the aforementioned greater activation, shown during future tasks, was evident solely during the initial phase of event generation, the so-called construction phase. Accordingly, in the non-temporal condition, when a full-sentence descriptor was provided, the construction phase might have been facilitated. Basically, the non-temporal condition required the elaboration of a ready scenario, instead of the construction of a complex scenario. The part played by the task used when testing non-temporal or future events is still debated. Maguire & Hassabis (2011) highlighted, for instance, the bias likely to be caused by using different cues to prompt constructive experiences. They claimed that the single-word cues used by Squire et al. (2010) would more easily elicit descriptions of episodes based on semantics, whereas the full-sentence descriptors adopted by Hassabis et al. (2007) would prompt richer visualization. Accordingly, we contrasted the different cuing procedures in our experimental conditions: non-temporal (Hassabis-like) versus temporal (Squire-like). We noticed a relevant difference in the performance of PD patients on the two tasks; our patients failed specifically the temporal task based on single word cueing, showing that at least in these patients the single-word cuing was not enough to compensate their future thinking deficits. Overall, the number of "internal events", which describe the core of the event (people present in the scene, their actions and reactions, happenings), was equivalent in future and non-temporal tasks. The key difference concerned the "perceptual" internal details, which was greater in non-temporal than in future performances, as assumed by Maguire and

Hassabis (2011). Yet, PD patients found this task, prompted by short verbal sentences, easier to accomplish. Of course, since the temporal connotation and the type of cue differ, one would need to better disentangle their respective component. Furthermore, patients with hippocampal damage (Hassabis et al., 2007) and with medial temporal lobe damage (Race et al., 2011) have been found to be impaired in future thinking also using a full-sentence descriptor. Nonetheless, it is possible that an impairment at constructing scenarios might be detected with one type of cue but not with a different cue. Patient H.C., for instance, was found to be impaired (Kwan et al., 2010) and unimpaired (Hurley et al., 2011) in two independent studies that used different methodologies. The discrepancy between these findings led Hurley and his colleagues to suggest that H.C.'s difficulties in the former research could have been influenced by the specific single word cue (i.e., coffee) adopted by Kwan et al. (2010), that might have greatly constrained the patient, making the task more challenging.

Our data do show that single-word cues elicit clear future thinking deficits in non-amnesic PD patients, and that this specific deficit is further exacerbated by the presence of executive impairments. This findings do not exclude the possibility that people rely on their past to imagine their future. However, we observed that, even when past memories are spared and people can reconstruct their past and elaborate a complex scenario, they might still have serious difficulties in simulating their future. Berryhill et al. (2010) maintained that performing future thinking tasks necessitates a widespread range of cognitive functions. Consequently, they raised the possibility that lesions to several brain areas might disrupt future thinking performance for different reasons. Our findings empirically demonstrated that this could indeed be the case, hence future thinking performance benefits from the orchestrated participation of a large network, and future thinking deficits do not represent a specific feature of amnesia.

9. Executive dysfunction in Parkinson's disease does not impair descriptions of current scenes

9.1 Introduction

In the previous chapter we aimed at investigating whether patients without memory problems could still present with future thinking deficits. And if so, whether or not those who did present with future thinking deficits differ in any way from those who did not. To this end, performance on past, future thinking and non temporal construction tasks of thirty-one patients with Parkinson's disease (PD) and without memory deficits, had been analysed. Our findings revealed that on the whole, PD patients uttered fewer specific, event-related snippets when imagining future episodes compared to controls, while their performances did not diverge from those of controls on past and non-temporal construction tasks. We analysed further the performance of those patients showing deficits in future imaging. We scored the output of each patient in terms of mean number of internal, specific, event-related details generated. The poorest scores on future task were observed in a subgroup of seven patients. Their future performances fell clearly below the range of controls. An investigation of the similarities and differences between this subgroup and the rest of the PD group highlighted the following characteristics:

- the subgroup did not differ from the rest of the PD group and controls on any of the neuropsychological measures available, including MMSE, long and short-term memory tests;
- but, they scored worse in the Frontal Assessment Battery (FAB - Dubois et al., 2000), compared to the rest of the PD group.

The difference in the FAB scores was the only overt difference between the two subgroups, given that our patients were recruited to be exempt from other cognitive deficits likely to impair their performances. Therefore, we suggested that the future thinking deficit shown by this subgroup of patients could not be accounted for in terms of memory problems. Indeed, even when past memories were spared and they were able to reconstruct their past and elaborate a complex scenario, they had difficulties simulating personal future.

In the previous chapter we maintained that future thinking does not represent a specific feature of amnesia and that factors other than memory contribute to the ability of future thinking. Given the executive deficits exhibited by the subgroup with the lowest scores on future thinking, we suggested that a flexible searching activity of past elements might play a crucial role to construct personal future experiences. We concluded, in line with Berryhill et al. (2010), that future thinking benefits from the contributions of a range of cognitive functions. Therefore, a deficit impinging upon future imaging could conceal different roots, not necessarily involving an episodic memory impairment.

Recently Zeman et al. (submitted) studied a group of seven patients suffering from amnesia and presenting with severe difficulties both in remembering past episodes and in imagining future events. Zeman et al.'s amnesic patients scored significantly worse than controls on measures of future thinking, thus replicating previous findings. However, they reported also a striking impairment on tasks requiring the patients to describe current experiences, both live (e.g., a room in a museum or the interior of a church) and through viewing illustrations of famous paintings. The authors explained their results positing a possible effect of amnesia on narrative construction.

However, as the authors themselves acknowledge, the patients they recruited were rather heterogeneous and were not completely immune from non memory cognitive deficits, including measures of executive functions such as verbal fluency which was apparently below cut-off in some of the patients. Therefore, this patient group might

also present with impairments out with the domain of memory which might have caused the problem of poor description of the present as well as the deficit in future thinking. Indeed, patients' reports were impoverished not only when concerning the future, but also, and more interestingly, when concerning a current context. Thus, the researchers concluded that a task, which requires to describe current experiences, might represent an important control condition in studies that examine the relations between amnesia and future thinking.

We used the same paradigm in the present study. In so doing, we further investigated the utterances of those patients who had the worst performance in future thinking and the lowest scores in the FAB. In this case, the executive dysfunction might have caused a general impoverishment of descriptions, likely to compromise abilities over and above the future thinking.

Zeman et al. instructed their participants (amnesiacs and healthy controls) to imagine new experiences (following the approach reported by Hassabis et al., 2007) and, in a second condition, to fully describe two detailed paintings ("The calling of Peter and Andrew" by Ghirlandaio and "The banquet in the pine forest", by Botticelli) and two real-life settings (a room in a museum and the interior of a church), while they were observing the paintings or while they were physically present in the settings. In Zeman et al.'s study the number of uttered elements did not significantly differ between the two experimental settings. Thus, we chose to provide our participants solely with one of the two conditions. We required them to describe the testing room while physically present in it.

For this experiment we considered the performance of the 5 patients with the poor performance on the future thinking task, who also scored below the cut-off (i.e., below 13.5) on FAB, 5 patients with no executive deficits, but otherwise matched for neuropsychological profile with the former group of patients, and 5 healthy controls, matched for age and education.

9.2 Method

9.2.1 Participants

Two subgroups each of 5 patients (dysexecutive and executive, respectively) and one subgroup of 5 healthy volunteers were selected from the sample of patients with Parkinson's disease and from the sample of healthy participants that were recruited in the experiment described in the previous chapter.

| | Executive (n.5) | Dysexecutive (n.5) | Controls (n.5) |
|---|------------------------|---------------------------|-----------------------|
| Age | 68(5.83) | 65.4(8.64) | 67.4(4.87) |
| Education | 11.2(3.83) | 9.4(4.92) | 11(4.47) |
| FT scores | 8.3(1.02) | 2.35(1.18) | 13.4(3.75) |
| FAB | 14.98(0.75) | 11.68(1.65) | - |
| Rey's 15 word Immediate Recall | 38.94(5.84) | 36.36(5.62) | - |
| Rey's 15 word Differite Recall | 8.32(1.64) | 8.54(1.11) | - |

Table 9.1 – Means (standard deviations) of the three subgroups (executive PD patients, dysexecutive PD patients and controls) of age and education, and mean score (standard deviations) on the future thinking task (FT scores) (see Chapter 8), on the Frontal Assessment Battery (FAB), and on immediate (Rey's 15 word Immediate Recall) and delayed recall (Rey's 15 word Differite Recall) test.

The characteristics of these three groups are illustrated in Table 9.1.

Separate One-Way ANOVAs were conducted for age, education and future thinking scores achieved by the three subgroups.

The three subgroups did not significantly differ (all $p_s > 0.05$) on age and education.

The scores obtained on the future thinking task (see Chapter 8) were instead significantly different across the subgroups, $F(2, 12) = 27.72, p < 0.001$. Post-hoc t-

tests revealed significant differences in the mean number of internal details produced by:

- the subgroup of Dysexecutive vs. the subgroup of Executive, $t(8) = 8.52, p < 0.001$;
- the subgroup of Executive vs. Controls, $t(8) = -2.92, p = 0.019$;
- and by the subgroup of Dysexecutive vs. Controls $t(8) = -6.27, p < 0.001$.

Furthermore, the scores obtained on the FAB by the subgroup of Executive and the subgroup of Dysexecutive significantly differed, $t(8) = 4.06, p < 0.005$.

No differences were observed between the performances of the two subgroups (Executive and Dysexecutive) on the immediate and delayed recall tests (all $p_s > 0.05$).

The participants with PD were recruited for being at the very early stages of the disease. According to Hohen and Yahr' s classification (1967), patients were to be maximum at the second stage of the Parkinson's disease. Thus, within the Executive subgroup, 2 at stage 1.5 and 3 at stage 2. Within the dysexecutive group, 2 patients were at stage 1; 1 at stage 1.5 and 2 at stage 2. Their magnetic resonance imaging had to be normal.

Patients were selected from a larger panel at the Parkinson and Movement Disorder Centre, Department of Neurological Sciences (Federico II University, Naples). The diagnosis of PD fulfilled the UK Parkinson's disease Society Brain Bank clinical diagnostic criteria (Gibb & Lees, 1988). All patients were under anti-parkinsonian treatment at a stable and optimized daily dosage during the 4 weeks prior to study entry. Exclusion criteria were: (1) dementia according to clinical diagnostic criteria for dementia associated with PD (Emre et al., 2007); (2) major depression according DSM-IV criteria for current major depression (American Psychiatric Association, 1994); (3) clinically significant or unstable medical condition including serious

cardiovascular or cerebrovascular disease; and (4) anti-cholinergic or neuroleptic treatment.

Specific tests were selected from the Mental Deterioration Battery (MDB; Carlesimo et al., 1996) in order to recruit only people with (a) no deficit in immediate and delayed recall test (Rey's 15 word Immediate Recall and Delayed Recall; scores, respectively, above 28.53 and 4.69); (b) spared logical reasoning (Raven's Progressive Matrices'47; scores above 18.96); and (c) a fluent language (Phonological Verbal Fluency; scores above 17.35). Moreover, the participants should have a score of at least 30, i.e., above cut-off, on the Attentional Matrices, which assesses attention by means of timed visual search (Della Sala et al., 1992).

The healthy individuals were volunteer members of different, non-academic, local associations. We did not recruit people under psychoactive pharmacological treatment likely to modify normal memory abilities or people with a history of neurological and psychiatric disorders.

Before starting the testing session, they were asked to sign an informed written consent. The study procedures were approved by the local ethical committee and were carried out in accordance with the Declaration of Helsinki.

9.2.2 Materials and experimental procedures

Participants, who sat in front of the experimenter, were required to describe the testing room, which was maintained unchanged throughout the duration of the experiment.

With this task, which we named "Description Task", we aimed at assessing participants' ability to describe a current experience in a real-life context, while they were staying in it. Participants were given no time limit and were encouraged to provide a fully detailed description of the setting. They were asked to describe the

room until they thought that nothing else could be added. Descriptions were digitally recorded to enable later transcriptions and consequent scorings. After the transcriptions, a trained rater segmented the descriptions in single details. Following Zeman et al.'s procedure, a general description score was assigned to each description, hence to each participant, on the bases of the sum of the number of elements present in each report. Repetitions and irrelevant utterances were not included in the sum. Furthermore, each segment was assigned to one of the four categories adopted by Hassabis et al. (2007): 1) Entity Presence, i.e., people and objects present in the scene; 2) Sensory Description, i.e., the qualifier adjectives mentioned to describe the characteristics of people and objects; 3) Spatial Reference, i.e., the descriptions of the spatial relationships between the entities; 4) Thought/Emotion/Action.

9.3 Results

In the Description Task, the mean number of elements produced did not significantly differ between the three subgroups ($p > 0.05$). The Executive subgroup generated a mean of 10.4 details (SD = 5.2); the Dysexecutive subgroup produced a mean of 7.4 elements (SD = 3.2) and the Control subgroup produced a mean of 15 details (SD = 5.7) (see Figure 9.1).

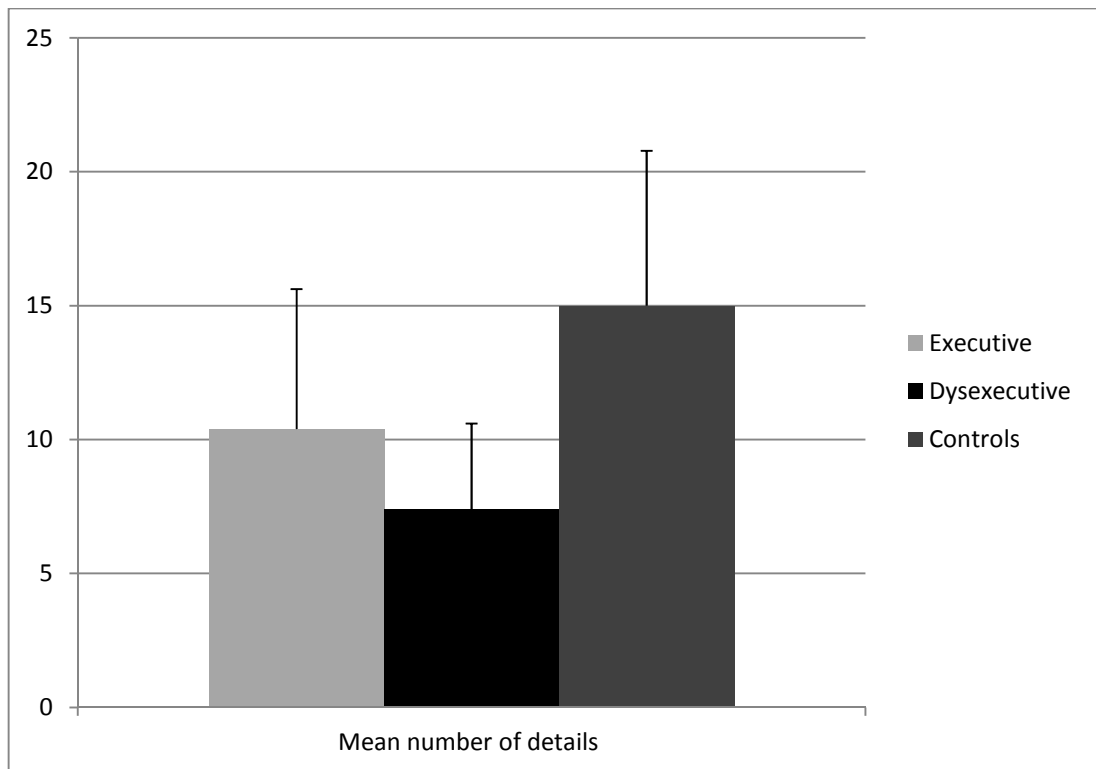


Fig. 9.1 - Mean number of details per description produced by the three subgroups (Executive, Dysexecutive and Controls). Error bars indicate standard deviations.

Figure 9.2 shows the number of details assigned to the different categories (entity presence, sensory description, spatial reference and thought/emotion/action). Repetitions and irrelevant utterances were not included.

Separate One-Way ANOVAs were carried out for each category.

The mean number of entity presences (Executive: $M = 5.6$; $SD = 4.5$; Dysexecutive: $M = 4.4$; $SD = 2.5$; Controls: $M = 5.2$; $SD = 2.7$) produced did not differ between the three subgroups ($p > 0.05$).

The mean number of sensory descriptions (Executive: $M = 2.8$; $SD = 1.6$; Dysexecutive: $M = 1.4$; $SD = 1.1$; Controls: $M = 6$; $SD = 2.5$) generated was found to be significantly different across the subgroups, $F(2, 12) = 7.94$, $p < 0.05$. Post-hoc

t-tests revealed a significant difference only between the number of sensory descriptions uttered by the Dysexecutive group and that generated by Controls, $t(8) = -3.68, p < 0.01$.

The mean number of spatial references (Executive: $M = 0.4$; $SD = 0.54$; Dysexecutive: $M = 0.20$; $SD = 0.44$; Controls: $M = 2.2$; $SD = 3.4$) did not significantly differ between the three subgroups ($p > 0.05$).

Finally, the mean number of thoughts/emotions/actions (Executive: $M = 1.6$; $SD = 1.5$; Dysexecutive: $M = 1.4$; $SD = 1.5$; Controls: $M = 1.6$; $SD = 2.0$) did not significantly differ ($p > 0.05$).

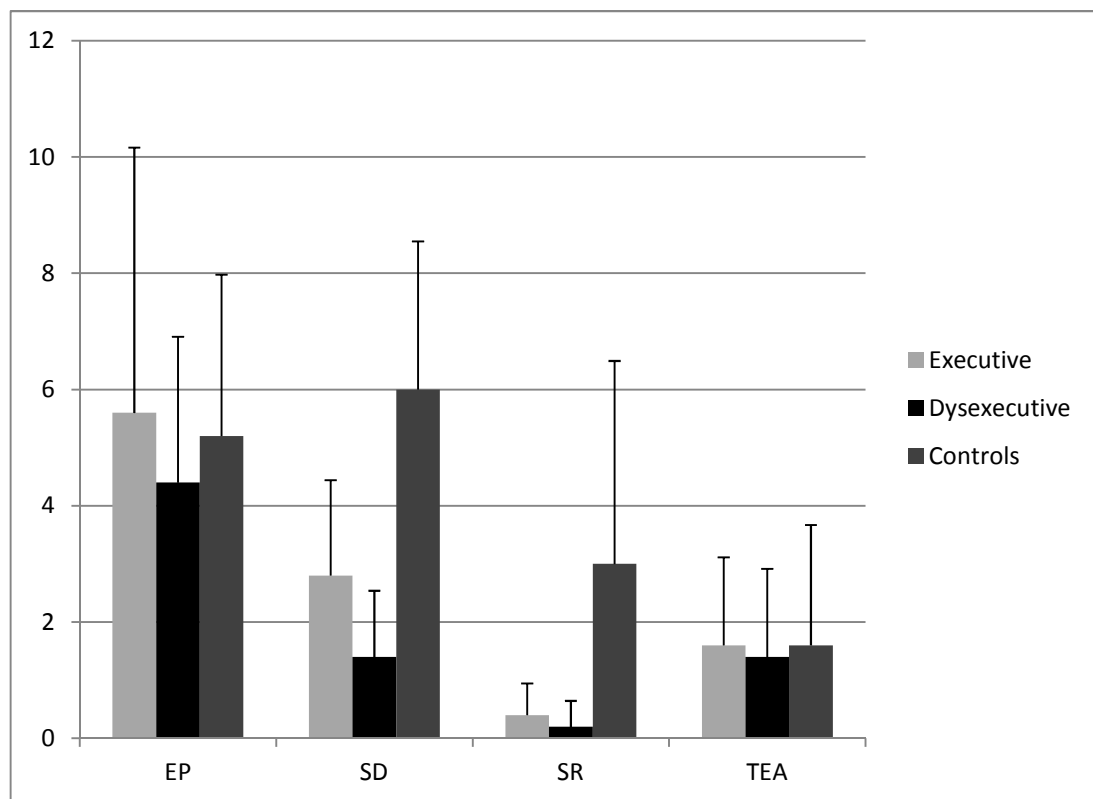


Fig. 9.2 - Mean number of the details produced by the three subgroups (Executive, Dysexecutive and Controls) per each category (Entity Presence, EP; Sensory Description, SD; Spatial Reference, SR; Thought/Emotion/Action, TEA). Error bars represent standard deviations.

Three examples of descriptions of the testing room, one produced by an Executive patient (EP01), one by a Dysexecutive patient (DP01) and one by a Control (C01), are reported:

Could you please describe this room in as much details as possible?

EP01's description: "It's a pretty much big room. There are a lot of books. It's airy and, then, there is a very nice view. I mean there is a lot of green and it makes me happy".

DP01's description: "This room is a library, where you can make studies on something. Thus, there are a lot of books. We are sitting at a rectangular table, where usually, I suppose, doctors and other people sit to visit and to be visited. There are chairs".

C01's description: "This is a library. In that point there is a slide-projector, where you can project videos. Maybe they give lectures here. There is a desk; then we have a copying machine. That is a wheelchair. There are usually a lot of doctors. And there is a rectangular table".

9.4 Discussion

In the previous chapter, we raised the possibility that damage to structures other than hippocampus, not leading to overt memory problems, might nevertheless contribute to future thinking impairments. A recent study (Zeman et al., submitted) noted that the same patients who are impaired in future thinking may also show deficits in describing current experiences. However, these findings could be taken to task by supposing that deficits other than memory were responsible for the poor performance on the "current" condition.

We aimed at investigating the possibility that dysexecutive patients with future thinking deficits might also show impairments (relative to controls) in describing

current scenes. This was, in fact, not the case of PD patients with executive deficit. Our findings revealed that the total elements produced by the three subgroups assessed (i.e., executive, dysexecutive and controls) when describing the testing room, did not statistically differ. Therefore, on one hand, we can rule out the hypothesis that a general impoverishment of verbal output might have compromised the ability of future imaging in our patients. On the other we land support to Zeman et al.'s observation that their own amnesic patients might have had a genuine problem in describing current experiences, not due to a masked dysexecutive problem. However, it has to be considered that, given the low number of participants per group in this experiment, the power of the analyses might be low and these results might be better considered as trends.

Recently, Gaesser et al. (2011) have showed how older adults are less prone than younger adults to generate internal details across different conditions, comprising past, future and description tasks. However, this age variable was irrelevant in our studies (the study described in Chapter 8 and the study described in the present Chapter), given that, in both cases, the groups were matched for age, other than education.

We suggest that the unique significant difference observed in the number of details classified as sensory description does not suffice to account for a general reduction in specificity of dysexecutive patients. Given that the overall amount of details did not statistically differ between executive and dysexecutive patients, and between dysexecutive patients and controls, it might be suggested that the lack of sensory details is somehow balanced in the reports by other types of internal details. Indeed, in line with Zeman et al.'s procedure, we did not included repetitions and irrelevant utterances within the sum of the details produced.

Our PD patients performed as well as controls when remembering the past and when constructing new experiences (Hassabis et al.'s approach – see Chapter 8). Thus, a general verbal impoverishment account is unlikely. However, we identified a possible bias caused by the type of cue (Maguire and Hassabis, 2011). We used two

different cues, namely a short description of a setting to elicit the scene construction and a single-word cue representing an object to prompt future episodes. As we had previously observed in a study with healthy participants (see Chapter 4), a setting-cue is more likely to elicit more detailed descriptions than an object-cue. Therefore, a more generic cue (the object-cue), which loads on both strategic searching and event construction, might make the task more challenging and lead to less detailed descriptions. Furthermore, the hypothesis cannot be excluded that in remembering the past and in constructing new experiences participants had provided frequently retold and retrieved stories (although they were discouraged to do so), which had become anecdotal, and “semanticized” to some extent. These two tasks might have not shown any impoverishment simply because patients might have retrieved episodes already well constructed.

The description procedure proposed by Zeman et al. appears face value to be less challenging than a future thinking task. Zeman et al. suggested, with respect to their patients, that the process of describing current experience is likely to engage a widespread range of functions involving perceptual, attentional, executive, linguistic and mnemonic abilities. However, the executive dysfunction of our patients did not disrupt their overall descriptions of the real-life setting.

Similar results were observed by Race et al. (2011) in eight amnesic patients with a medial temporal lobe damage. In their study participants were presented with drawings of common-place scenarios and were required to construct stories about what was happening into the scenes. In this particular condition patients showed no deficits, whereas they were impaired in remembering the past and imagining the future. The authors suggested that a medial temporal lobe damage might not affect the narrative construction when the to-be-described elements are “readily available” in a picture (as it happened in our description task) or in a drawing (as in their study). This explanation might apply to the description task that we used. Our patients resulted unimpaired in narrative construction. Nonetheless, they showed a clear deficit in future thinking.

The impairment in future thinking, which we observed in PD patients, might have been caused by a difficulty in binding known details into a whole story, as observed by Rosenbaum et al. (2009). Rosenbaum et al. reported that amnesic patient K.C. failed not only in imagining the future, but also in recounting well learned stories from the Bible and fairy tales. Our PD patients with an impairment in executive functions might exhibit difficulties in flexible searching details from memory and in binding them in a coherent whole. However, since they did not have memory deficits, they should not have had any problems in retrieving blocks of details and in reporting them, as they were able to see something and fully describe it. The difficulties might have arisen when they had to reshuffle and recombine details from different memories. It is possible that the task could be easily accomplished, when the amount of details is available, physically or in memory, and when participants do not have to break down each single snippet in order to use it for another proposition.

In conclusion, we benefited from the task adopted by Zeman et al. It helped us to isolate some hypotheses in order to interpret the available data more appropriately. We would posit that non-episodic deficits also play a role in eliciting future thinking impairments. In particular, an executive dysfunction might disrupt foresight. However, in the present study this deficit did not devastate the description of a current real-life setting. Therefore, it might underlie future thinking tasks, but not by determining a general impoverishment of verbal reports. A dysexecutive problem might have more plausibly disrupted the flexible searching through different memories, hence the subsequent binding of the various elements into a coherent narrative.

10. Role of the cue in detecting impairments at future thinking: two cases of amnesia

10.1 Introduction

'I barely know where I am. I don't picture myself in the future. I don't know what I'll do when I get home. You need a base to build the future'. In these words M.C., a 27 year-old woman with a selective deficit in episodic memory, expressed her persistent difficulties in future thinking (Andelman et al., 2010, p. 431).

M.C. is the most recent of several published cases of amnesic patients whose ability in future thinking has been experimentally tested. Although the question of whether or not envisaging future events depends on episodic memory has been formally addressed by a number of neuropsychological reports, the theoretical interpretation of the findings is still controversial.

There is a long-standing debate as to whether remembering past experience and imagining events in the future are inextricably intertwined. Furthermore, numerous hypotheses accounting for this postulated link have been proposed. The heterogeneity of the results coming from different studies and sometimes within the paradigm (Hassabis et al., 2007; Zeman et al., submitted) makes the conclusions problematic and uncertain. Such heterogeneity might partially be due to the fact that the amnesic patients themselves present with different patterns of spared and impaired abilities and they can hardly be compared with one another (as Tulving noticed in 1985). This is due in part to the scant information about the lesion sites provided in several of the reported cases (e.g., O.S., Lidz, 1942; D.B., Klein et al., 2002), or to the widespread extension of the lesion in other cases (e.g., K.C., Tulving, 1985; and Hassabis et al.'s patients, 2007), but also to the differences in the

experimental procedures (i.e., types of cue, number of prompts presented to elicit the reports) adopted in the various studies.

Future remains misty, blurred and fragmented for O.S. (Lidz, 1942), K.C. (Tulving, 1985), H.M. (Corkin, personal communication, 01/26/11), GA (Dalla Barba et al., 1997), D.B. (Klein et al., 2002), the group of patients, except for P01, tested by Hassabis and colleagues (2007), H.C. (when tested by Kwan et al., 2010; different findings were observed by Hurley et al., 2011), M.C. (Andelman et al., 2010), eight hippocampal amnesiacs (Kurczek et al., 2010), eight amnesiacs with lesions in the medial temporal lobe (Race et al., 2011), and six of the seven patients (patient P2 performed as well as controls) tested by Zeman et al. (submitted). None of these patients could rely on their past. Their performance on tasks assessing episodic memories paralleled those exhibited in future tasks.

In particular, O.S. could not make future simulations without asking others for suggestions and his reports consistently lacked of temporal continuity (Lidz, 1942). K.C. failed to hold up images of his future, which consequently faded away and left his mind blank in the attempt to answer the question “What will you be doing tomorrow?” (Tulving, 1985). A similar state must have been experienced by H.M., who wittily circumvented Corkin’s question concerning his plans for the future (“What are you going to do tomorrow?”) promptly responding, “Whatever is beneficial” (Corkin, personal communication, 01/26/11). GA exhibited a striking discrepancy between her present situation and her predictions, which were considered unquestionably implausible by the relatives, and, consequently, by the experimenters. She showed this impairment in two different tasks. More precisely, the 60% of her responses were confabulatory to questions concerning her “lived future” (i.e., “What are you going to do in a few minutes/tomorrow/next year?”); and she confabulated 50% of the times when the future constructions were elicited by a single cue-word (Dalla Barba et al., 1997). Future ceased to exist also for D.B.. No less than 50% of his answers regarding his “lived future” were considered in contradiction with his plausible future activities and the 30% were “don’t know”

responses (Klein et al., 2002). Deficits in future thinking were observed also when a neutral single cue-word was provided (Kurczek et al., 2010).

Some patients were found to be impaired at imagining future events, also when they were to adhere to the instruction to depict a common-place scenario, starting from a short description (i.e., *Imagine you are lying on a white sandy beach in a beautiful tropical bay*, Hassabis et al., 2007, Zeman et al., submitted; or *Imagine catching your grandchild getting into trouble twenty years from now*, Race et al., 2011), when required to generate as much detail as possible, when repeatedly prompted to provide a greater amount of snippets (Hassabis et al., 2007), when generally encouraged to continue until they had concluded their reports (Zeman et al., submitted), and when they were given a specific, standardized probe, asking for further elaboration (Race et al., 2011). A mirror pattern in the two temporal directions was reported also by H.C., a 20 years-old woman with developmental amnesia, which hampered her recollection of personal past experiences. She was similarly impaired at constructing future personal events, when elicited by single cue words (Kwan et al., 2010).

These studies presented the intriguing possibility of a tight relationship between the ability to remember past episodes and the ability to imagine future events. The impairments in future thinking were associated to the impairments of episodic memory. Patients unable to remember the past provided vague responses about their personal future and who was prone to generate confabulations pertaining his/her past also confabulated about his/her future (GA and D.B.). An exception is the case of M.C. Whereas her episodic memory deficit affected a circumscribed period of time (i.e., the last two years of her life), her future thinking was compromised for an undefined temporal period. What these findings might entail, as the authors suggested, is that the link between the two processes may not be as strict as it was thought.

Another caveat to the hypothesis that the two time-related functions might be closely interconnected is that a number of amnesiacs show preserved ability to perform constructive tasks.

Hassabis et al. (2007) reported on one patient (P01), with a significant loss of hippocampal volume (48.8% reduction in the left hippocampus and 46.2% reduction in the right hippocampus), whose performance noticeably diverged from the rest of the group. P01, in fact, presented with no deficit in the construction of novel fictitious scenarios. The researchers postulated an association between such surprisingly preserved ability and a residual hippocampal function. This hypothesis was corroborated by a separate fMRI study showing a significant activation in residual right hippocampal tissue, while P01 encoded new semantic information. Thus, it was speculated that the residual hippocampal tissue might be sufficient also to support a successful performance on the construction task. With the aim of further disambiguating this uncertain interpretation of such an atypical case, Squire et al. (2010) tested five amnesic patients. At odds with previous reports, these patients' performances (at the future task prompted by single word cues) fell within, or even above, the control range. Thus, it has been suggested that a selective hippocampal damage that preserves the rest of the past-future core network (Schacter et al., 2007) does not necessarily compromise future thinking. Similarly, an episodic memory deficit which spares all the other cognitive functions might not affect future imagining. The cases of Jon (Maguire et al., 2010), P2 (Zeman et al., submitted) and a group of twenty-one children (Cooper et al., 2011), tested with the task developed by Hassabis et al. (2007), further strengthened this view. Jon, who suffered from a developmental amnesia and from 50% bilateral hippocampal volume loss, performed as well as control participants at future imaging. P2, suffering from a severe anterograde amnesia, could nevertheless imagine detailed future experiences. Similarly, the children, despite a bilateral hippocampal damage, consequent to neonatal hypoxia/ischaemia, were able to construct novel scenarios.

In light of these findings, it seems doubtful that an episodic memory impairment might, in its own right, cause a deficit at future imaging. And this betrays a weaker and more arguable link between the two time-related processes. Squire et al.'s patients (2010) provided supportive evidence that Jon, P01, P2 and the 21 children are not atypical and isolated cases, and that future imagining might be spared in cases of hippocampal amnesia. Thus, at odds with what previous independent reports

stated, amnesia does not always cause parallel impairments in future thinking. Ought this be the case, there must be factors that preserve patients' performances on future tasks, even in case of a severe memory impairment.

The contradictory findings emerging in the different studies have led to discussion about the nature of these factors. Maguire and Hassabis (2011) identified as one of these factors a possible "semantic bias" originated from the different typologies of cues adopted. According to this view, Squire et al.'s participants were wholly successful at future imagining, because they did not mentally picture vivid and articulate events, but rather described events that were more semantic in nature. And, indeed, semantic memory is preserved in a context of hippocampal damage. Maguire and Hassabis (2011) postulated that such a bias might have been encouraged by the use of a single word cue, rather than the full sentence descriptor adopted by Hassabis et al. (2007), which is more likely to cause detailed visualizations. In line with such observation, Hurley and his colleagues (2011) tested again patient H.C., already assessed with future imaging tasks by Kwan et al. (2010), with a different methodological procedure. The two testing protocols (Kwan et al., 2010 versus Hurley et al., 2011) diverged on many features. Kwan et al. (2010) adopted four trials (for each of them H.C. had to construct two events) using single word cues and capped each H.C.'s description at 5 minutes. On the other hand, Hurley et al. (2011) used ten trials (seven with a sentence descriptor cue and three with non-specific cue), gave H.C. free rein in producing whichever additional snippets came to mind, with no time limit, and used a probing protocol to encourage further elaborations the reports (i.e., they required the patient to better describe the ideas, the objects, or the people she had already mentioned). Hurley et al. (2011) did not find any significant difference in future imaging between H.C. and controls, even adopting two different scoring procedures (respectively the scoring procedures proposed by Hassabis et al., 2007 and by Kwan et al., 2010).

In light of these controversial findings, we aimed at ascertaining the contribution of two different types of cue in eliciting more or less detailed reports in two cases of patients with amnesia. The main question was which cue encourages a richer

visualization avoiding semantic biases, so that a full sentence descriptor cue (Hassabis-like) might detect a deficit at future imaging and a single word cue (Squire-like) might not. Therefore, we compared amnesic patients' performances at future imaging elicited by Hassabis-like and Squire-like cues.

10.2 Method

10.2.1 Participants

Two memory-impaired patients participated, M.D and G.C.. They were selected from a larger panel at the IDC (Institute of Diagnosis and Treatment) Hermitage (Capodimonte, Naples).

M.D. was a 68 years-old right handed man with 17 years education. He worked as a lawyer and had no history of psychiatric or neurologic diseases.

On August 14th, 2002 he was admitted to the Intensive Coronary Care Unit because of a cardiac arrest. Subsequently, the physicians detected a ventricular fibrillation and made a diagnosis of Brugada syndrome, which was treated with a implantable cardioverter-defibrillator. Consequently, he developed a severe amnesia, which spared his short term memory. In particular, M.D. was tested on two long-term verbal memory tests. He scored 1.1 on a story recall task Novelli et al., 1986 (cut-off 8) and 4 on a Paired-Associated Learning (Novelli et al., 1986; cut-off 6).A PET study showed an extensive hypometabolism in fronto-temporal areas.

G.C. was a 42 years-old right handed man with 8 years education. He was unemployed, married with a daughter, and had no history of psychiatric or neurological diseases.

On May 15th, 2008 he suffered from a pulmonary embolism, that caused, after a few days, a coma. Subsequently, he presented a very severe amnesia. He scored 0 on the

Story Recall and 0 on the Paired-Associated Learning. Short term memory was totally preserved. A PET study showed an overall slightly reduced cortical distribution, that was more evident in the temporal mesial regions, in the dorsolateral frontal and superior parietal areas and in the superior part of the right and left thalamus.

Five healthy volunteers served as controls for the two patients. Controls averaged 57.2 (\pm 8.78) of age and 11.8 (\pm 6.53) of education.

The healthy individuals were members of different, non-academic, local associations. We did not recruit people under psychoactive pharmacological treatment likely to modify normal memory abilities or people with a history of neurological and psychiatric disorders. No honorarium was offered to participants. Before starting the testing session, they were asked to sign an informed written consent. The study procedures were approved by the local ethical committee and were carried out in accordance with the Declaration of Helsinki.

10.2.2 Materials and experimental procedure

The assessment was conducted in one session. All participants were tested individually following the same procedures; they sat in front of the same experimenter in a peaceful testing environment. Participants were explicitly told that they would be asked to mentally pre-experience 8 autobiographical episodes in response to different cues (4 randomly presented cue words and 4 short verbal descriptors). The cues were displayed, one at a time, on a computer screen and were visible on the computer until the participant completed each description. There was no time limit. Participants described the event until they considered that nothing else might be added. No prompts were provided by the experimenter to the participants when they stopped talking. The reports were digitally recorded to allow later transcriptions.

The performance of the two patients are reported separately, as two single cases.

Squire-like task. The words presented as cues were previously selected from Italian norms (Burani et al., 2001) and matched for familiarity, frequency, imageability, and concreteness. The experimenter required participants to imagine the events in as much detail as possible. Participants were also instructed to generate temporally and contextually specific events and to create novel, rich and feasible future episodes, given their current plans. This procedure followed those of D'Argembeau and van der Linden (2004) and of Addis et al. (2008).

Hassabis-like task. The short verbal descriptors depicted an assortment of common-place scenarios (e.g., “*Imagine you are standing in a open field by the banks of river*” or “*Imagine you are standing on the deck of a ship leaving port on a voyage*”). The short descriptions were randomly assigned across the participants. Once again, participants were required to create novel, contextually specific and plausible scenarios, which had never occurred before, and to describe them in as many details as possible. The procedure and the short verbal cues were adapted from the paradigm formulated by Hassabis et al. (2007).

The experimenter scored the transcriptions, following the procedure devised by Levine et al. (2002). Thus, he had to segment the whole transcriptions into different snippets, to be further categorized as (a) internal details (i.e., episodic information pertaining to the main event, specific to time and place) and (b) external details (general knowledge related to the event).

Subsequently, internal details were distinguished into: (a) event (happenings, individuals present, physical/emotional actions and reactions, weather), (b) place (information about the environment where the event occurred), (c) time (date, season, month, day of the week, time of day), (d) perceptual (sensory information, body position) and (e) emotion (emotional state, thoughts). And external details were classified as: (a) external event (specific details from other incidents, from all of the above categories, external to the main event), (b) semantic (general knowledge or

facts, ongoing events, extended states of being), (c) repetition (unsolicited repetition of details), and (d) other (metacognitive statements, editorializing).

10.3 Results

Case report 1: M.D.

We considered the means of the total number of internal details as scores on future tasks.

Aiming at comparing M.D.'s scores with the control sample on the two tasks (Squire-like vs. Hassabis-like), we adopted two statistical programs developed by John Crawford and his colleagues at the University of Aberdeen (Crawford et al., 2010).

First, we used the program Singlims ES.exe, an upgraded version of the program singlims.exe, which assesses whether an individual patient's performance falls significantly below the range of the controls, estimates the extent to which the patient's performance is abnormal (postulating the proportion of the control population whose performance would be worse than that achieved by the case under study) and provides the confidence limits around such proportion (the test was developed by Crawford and Howell, 1998; Crawford & Garthwaite, 2002; and Crawford et al., 2010).

On the Squire-like test, the difference between M.D.'s score (5.5) and the control sample ($M = 13.1$, $SD = 1.79$) was highly significant, $t = -3.86$, $p < 0.01$. The effect size for the difference between the case and the controls was -4.246 (-7.200 to -1.312) and 0.89% was the estimated percentage of normal population falling below case's score. Using the same program, we also compared M.D.'s performance (scored 4) with that of the control sample ($M = 15$, $SD = 3.9$) on the Hassabis-like test ($t = -2.57$, $p < 0.05$). In this case, the effect size for the difference between the

case and the controls was -2.821 (-4.875 to -0.743) and 3.08% was the estimated percentage of normal population falling below M.D.'s score (see Figure 10.1).

Moreover, with the aim of analysing the difference between M.D.'s performances on the two tasks, we used the upgraded version of the Revised Standardized Difference Test (RSDT ES.exe) (Crawford & Garthwaite, 2005; Garthwaite & Crawford, 2004; and Crawford et al., 2010), that allows a comparison of a single-case difference with the difference observed in the controls. The test revealed no statistically significant difference in M.D.'s scores on the Hassabis-like and Squire-like tasks. A t-test showed no differences also between the normative sample's performances on the two tasks.

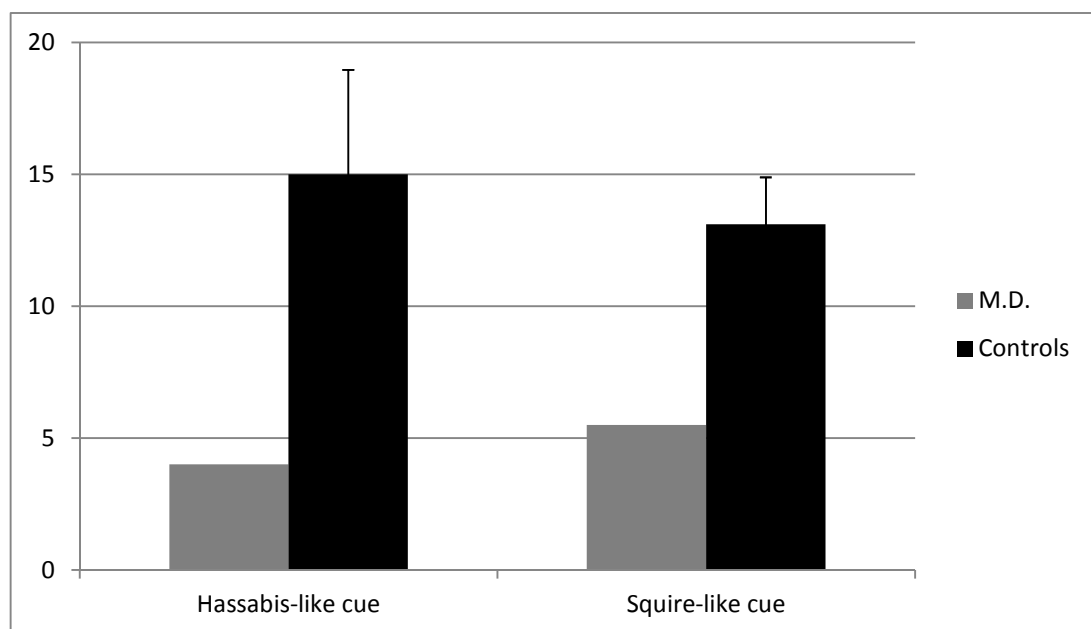


Figure 10.1 - M.D.'s scores compared with the mean of controls' scores on the two tasks (Hassabis-like and Squire-like). Error bars indicate standard deviations.

We also compared, using the Singlims_ES.exe program, the total number of details (internal and external) of M.D.'s and the controls. The differences were significant both in the Hassabis-like task (M.D.: 4.25; Controls: M = 19.35, SD = 4.8, $t = -2.87$, $p < 0.05$), and in the Squire-like task (M.D.: 5.75; Controls: M = 16.15, SD = 2.05, t

= -4.63, $p < 0.005$). M.D.'s total amount of details on the two tasks was not significantly different from that of controls.

Case report 2: G.C.

We adopted the same procedure to analyse G.C.'s performance.

The program Singlims ES.exe revealed an highly significant difference between G.C.'s scores and those of the control sample on the Squire-like task, $t = -3.74$, $p < 0.01$, with an effect size for the difference between G.C. (who scored 5.75) and controls ($M = 13.1$, $SD = 1.79$) of -4,106 (-6,970 to -1,258) and an estimated percentage of normal population falling below G.C.'s score of 0.99%. The difference between G.C.'s score (6.5) and controls' scores ($M = 15$, $SD = 3.9$) on the Hassabis-like task was $t = -1.9$, $p = 0.05$, with an effect size for the difference between the case and controls of -2.179 (-3.850 to -0.464) and an estimated percentage of normal population falling below case's score of 5.87% (see Figure 10.2).

Moreover, the RSDT ED.exe program revealed no differences in G.C.'s scores on the two tasks.

We also compared, using the Singlims ES.exe program, the total number of details (internal and external) of G.C.'s and his controls. The differences were significant both in Hassabis-like task (G.C.: 7.25; Controls: $M = 19.35$, $SD = 4.8$, $t = -2.3$, $p < 0.05$), and in Squire-like task (G.C.: 11; Controls: $M = 16.15$, $SD = 2.05$, $t = -2.29$, $p < 0.05$). G.C.'s total amount of details on the two tasks was not significant different from that of controls.

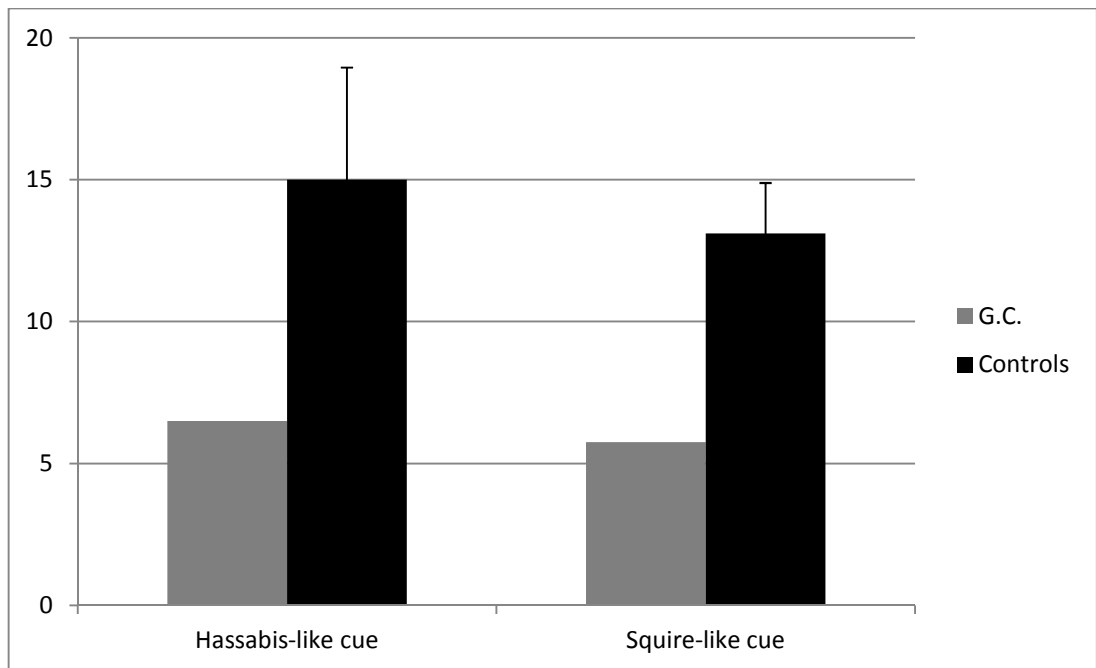


Figure 10.2 - G.C.'s scores compared with the mean of controls' scores on the two tasks (Hassabis-like and Squire-like). Error bars indicate standard deviations.

Spatial Coherence Index. We also assessed the spatial coherence index (adapted from Hassabis et al., 2007), that is “a measure of the contiguousness and spatial integrity of the imagined scene” (Hassabis et al., 2007, p. 1728). After each report, participants were required to rate on a 7-point scale the spatial clarity of the scene (i.e., how clear and integrated the place imagined as scenario of their descriptions was in their mind, and how distinct the objects' arrangement and the individuals' spatial disposition were). Once again we used the program Singlims_ES.exe, to analyse the differences between each patient and the controls at the two task.

Squire-like task. We observed that M.D.'s feedback (3.75) significantly differed from controls feedback ($M = 5.9$, $SD = 0.4$), $t = -4.9$, $p < 0.01$. Similarly, the difference between controls' rating and G.C.'s rating (2.8) was significant ($t = -7.07$, $p < 0.005$).

Hassabis-like task. M.D.'s self-evaluation (2.5) was significantly lower, if compared with controls ($M = 5.7$, $SD = 0.4$), $t = -7.3$, $p < 0.002$. Likewise, G.C. estimated the spatial coherence of his scenarios (3.8) poorer, in comparison with controls, $t = -4.33$, $p < 0.02$.

We used also RSDT ES.exe to analyse the difference of the single patients' ratings on the two tasks and they did not significantly differ from the difference observed in the control sample.

10.4 Discussion

In the previous two chapters we have discussed the possible components, other than memory, that might play a part in the construction of future scenarios. However, in the present chapter, we focussed our attention on a specific variable which may influence performance on the future thinking tests, i.e., the role of the cue. In Chapter 4, we have already addressed this issue in healthy volunteers. However, we were still interested in assessing the role of the cue in a study with patients.

The fundamental question from which this research stemmed was whether an impairment at imaging future thinking could be detected with a type of cue but not with another one. The effects of cues have only recently been addressed in studies with patients (Hurley et al., 2011). The extent to which a cue can influence patients' performance is still a matter of debate. Therefore, we investigated the difference between the most widely used cues in the literature concerning future thinking, i.e., the single word cue and the short description cue. We decided to take into consideration solely these two structured questionnaires, which elicit future thinking constructions as they have been recently discussed in the literature (Squire, 2011; Meguire & Hassabis, 2011). Indeed, as Squire et al. (2011) have noticed, the informal questionnaire used in the earliest studies investigating future thinking in patients are less accurate and precise at evidencing "a failure to construct well-formed autobiographical narratives" (Squire et al., 2011).

Our patients, presenting with dense amnesia, even with different lesion locations and aetiologies, exhibited a parallel impairment at future imagining on different tasks, reporting fewer event-related details than the control sample. Moreover, the scores obtained on the two future tasks did not significantly differ in either of our patients. M.D. and G.C. differed from controls also in the total amount of the details (external and internal) they produced on each task. Once again, the difference between the two tasks was not significant in either of the patients. However, it has to be taken into account that these two patients were only tested on memory tasks. Therefore, we cannot exclude the involvement of multiple domains, other than memory. In particular, we cannot rule out the possibility of an executive dysfunction, which could have affected the performances of these patients.

Thus, patients' reports were definitely poorer than those generated by controls. And this deficit was detected, to the same extent and at the same manner, by two tasks adopting very different cues.

Taken together, these data offer some contribution to the on-going discussion regarding the possibility that particular cues might cause biases, and, consequently, affect patients' performance at future thinking (Maguire & Hassabis, 2011).

The discussion stemmed from the attempt of disentangling the contradictory results emerging from independent studies on the ability of future thinking of amnesic patients. Beyond Hassabis and his colleagues' study (2007), case reports of patients suffering from a severe amnesia observed analogous impairments at future thinking (Lidz, 1942; Tulving, 1985; Corkin, personal communication, 01/26/11; Dalla Barba et al., 1997; Klein et al., 2002). Hassabis et al. (2007) reported, for the first time, on one patient (P01), who, despite his episodic memory deficit, could imagine fictitious scenarios. These results, that initially appeared to be atypical, have been recently replicated in the single case of Jon (Maguire et al., 2010), P2 (Zeman et al., submitted), in children (Cooper et al., 2010) and in the five patients tested by Squire et al. (2010). The striking contrast arising from the performance of different amnesiacs at creating future scenarios undermines the hypothesis of a close linkage

between episodic memory and future thinking. If, aiming at imagining personal future, individuals are to draw from memory, then people who lost the ability to remember their past should be unable also to depict their future. And this is not unquestionably the case.

However, following different procedures, the same patient can exhibit opposite performances. Patient H.C. was found to be impaired (Kwan et al., 2010) and unimpaired (Hurley et al., 2011) in two independent studies that used different methodologies. The discrepancy between these findings led Hurley and his colleagues to suggest that H.C.'s difficulties in the former research could have been influenced by the specific single word cue (i.e., coffee) adopted by Kwan et al. (2010), which might have greatly constrained the patient, making the task more challenging (although participants were told that the events might have also been unrelated with the cue itself, and that the cue served solely as tool to facilitate the construction task). Kwan et al. (2010) did not rule out this possibility, noticing that also H.C.'s scores in autobiographical memories (probed with the single word cue) were lower than those exhibited in another study using a different methodology (Rosenbaum et al., 2011).

Race et al. (2011) used short descriptions to probe very specific events and, consequently, to minimize accounts of frequently retold events, explaining that “preferred level of processing in autobiographical memory is at a more general level” (p. 10263; see also Conway, 2001) and that amnesiacs with a damage in temporal lobe usually rely on non-specific autobiographical information when reporting past memories (Thaiss & Petrides, 2008). And, indeed, Maguire and Hassabis (2011) objected that a possible reason underlying the lack of impairment observed in Squire et al.'s (2010) patients was attributable to the single word cue used, which is likely to determine semantic biases. Accordingly, Kwan et al. (2010) reported that H.C.'s mother considered many of her daughter's past memories (elicited in the same study with the single cue word) as “stories that had been retold over the years and may have been “semanticized” to some extent” (p. 3184).

In Chapter 8 we reported on patients suffering from Parkinson's disease (PD) who clearly showed a future thinking deficit when the descriptions were prompted with a single word cue and found the task prompted by a full-sentence descriptor easier to accomplish. In this case, the single word cue used was unlikely to determine semantic biases, given that our PD patients revealed severe difficulties in reshuffling details from different memories. Thus, they could have been less prone to fill the gaps of their accounts with semantic memories.

On the contrary, M.D. and G.C. were completely unable to imagine their future with whichever cue we used. Moreover, at the end of each description, we debriefed M.D. and G.C. about their feeling of spatial coherence and contiguity that they might have experienced when depicting the scenarios in their mind. And the feedbacks they provided were undoubtedly less precise than those provided by the control sample, in both tasks. Patients' imagine experiences lacking in spatial unity and taking place in a vague setting. Furthermore, the position and the arrangement of people and objects resulted hazy and indistinct.

It is worth noticing that, once they had stopped talking, we solely gave them a single, standardized prompt, i.e., "Is there anything else you would like to add?", to which usually they answered "No, there is not". This can be due to the fact that amnesic syndromes might have relevant effects on narrative construction, that affect future thinking as well as their portrayals of present experiences (Zeman et al., submitted). The probing protocol used by Hurley et al. (2011) was not as strict as the one we adopted. They did not always use the same general probe (e.g., "can you see anything else in the scene?"). Sometimes, they asked for further description of a concept, of a detail introduced by the participant -"e.g., "can you describe the fishing boat in more detail?" in response to the participant saying "I can see a small fishing boat gently rocking out in the sea"" (Hurley et al., 2011). Although the examiner was not allowed to introduce a new detail, participants were explicitly encouraged to enrich and elaborate their accounts. This procedure might be more likely to encourage semantic descriptions, than the cue itself. A participant does not need to

vividly imagine a “fishing boat” in the future scenario to further describe it, he can simply draw on semantic memory.

Therefore, we suggest that the cue might be not as relevant as the quantity and the quality of prompts provided. The heterogeneity of the statements used by the experimenters to encourage further elaboration might be identified as a plausible source of error. Our data support the idea that when this condition is controlled for, the cues might be more sensitive to detect an impairment.

11. A case of confabulatory behaviour concerning personal future

11.1 Introduction

Confabulation is a memory-related phenomenon, that has been differently referred to as “falsification of memory occurring with clear consciousness” (Berlyne, 1972), “statements or actions that involve unintentional but obvious distortions of memory” (Moscovitch & Melo, 1997), “spontaneous narrative report of events that never happened” (Schacter, Normann & Koutstaal, 1998), or “an honest lying” (Moscovitch, 1989). Patients, who confabulate, produce verbal statements clearly incongruous and inappropriate to their past experiences, background, current context and future plans, without being aware of saying falsehoods (Dalla Barba, 1993). These false beliefs are often related with substantial conviction, and might lead, in certain cases, to act accordingly.

Initially, confabulations were distinguished into momentary and fantastic (Bonhoeffer, 1904; Berlyne, 1972). It was suggested that the former were usually autobiographical events miscombined or displaced in time and were produced in response to a question to overcome the embarrassment due to a faulty memory. The latter were supposed to be completely distinct from momentary confabulations, as they were implausible claims, which appeared without any provocation.

However, today many investigators of confabulations still adopt another conceptual distinction, coined by Kopelman (1987), which differentiated between spontaneous and provoked confabulations. Whereas spontaneous confabulations are rare and bizarre and occur in case of a superimposition of an amnesic syndrome on a frontal dysfunction, provoked confabulations are more common and plausible, and are produced in response to questions which would uncover memory gaps.

All types of confabulation have some common features that has been highlighted by Talland (1965) and Moscovitch (1989). The confabulatory report is based upon a false context and might involve details incongruent even within the false context constructed; confabulations are unintentional, since patients are aware neither of their memory deficits nor of their confabulations; the fact that patients are unaware of confabulating is testified by their acts which typically are compatible with the confabulations' contents. Confabulations have been observed during tasks assessing memory, orientation in time and space and, also, personal future planning (Dalla Barba, 1993). Dalla Barba (1993) observed that once his amnesic patient, MB, who exhibited a confabulatory behaviour, "said that he was looking forward to the end of the testing session because he had to go to the general store to buy some new clothes. On this occasion the patient actually attempted to leave his hospital room, claiming that there was a taxi waiting for him downstairs" (p. 4). Thus, he tried to act upon his confabulation with respect to his future plans, obviously without being aware of the fact that he was confabulating. Another case, reported by Dalla Barba and his colleagues (1997), of a patient suffering from an amnesic-confabulatory syndrome was GA. GA developed her syndrome in consequence of a subarachnoid haemorrhage and ischemia following the rupture of the anterior communicating artery and the consequent vasospasm. She produced confabulations encroaching upon personal past, orientation in time and space and personal future. GA was administered three different tasks: the confabulation battery (Dalla Barba, 1993); a task involving 10 questions about her lived past and 10 questions about her lived future; and a future version of the Crovitz test, using a single-word cue to elicit past and future reports. The confabulatory behaviour was observed across the three tasks. When assessed on the confabulation battery (Dalla Barba, 1993), she presented with 33% of confabulatory responses concerning episodic memory and 40% of confabulatory responses regarding orientation in time and space. GA confabulated 60% of the times in response to questions regarding her lived past and 60% of the times answering questions concerning her lived future. Finally, the 13% of her responses about her personal past, and the 50% of her responses referring to her personal future on the Crovitz test were classified as confabulations. GA confabulated across past, present and future (e.g., in response to the questions "What

did you do yesterday?; Where are you now?; What are you going to do tomorrow?"), but she never produced confabulations in response to question assessing semantic memory. The same pattern was observed in D.B. (Klein et al., 2002). D.B. had sustained a brain damage consequent to an anoxic encephalopathy. He exhibited a severe retrograde and anterograde amnesia. The 30% of his responses to questions concerning lived past and the 50% of his responses to questions concerning lived future was confabulatory. However, once again, he generated confabulations solely when answering questions about his personal past and future. On the contrary, he responded accurately and appropriately when asked questions regarding known past and future. Thus, D.B. showed difficulties at imagining future when asked, "What are you going to do tomorrow?", while he could easily anticipate changes in response to the question, "Can you tell me what you think will be some of the most important issues facing your community in the next ten years?". Szpunar (2010) has noticed that this difference might reflect the specificity of the impairment at thinking about past and future *in a personal manner*. Both GA and D.B. may be thought of as lacking the capacity of being conscious of the subjective time that they experience. This ability has been defined temporal (Dalla Barba, 1997) or auto-noetic (Tulving, 1985) consciousness. The two concepts are closely related. Temporal consciousness (TC) means "to become aware of something as part of a personal past, present or future" (Dalla Barba, 1997, p. 25). This concept stemmed from the consideration that time does not exist in the objects. Things *per se* are not past, present or future. We need an "agent", who recognizes them and attributes a specific meaning, a temporal dimension to them, when we look at them in the present, when we recollect them in past events or when we use these objects to imagine our future (Dalla Barba, 2000). Slightly different is the Tulving's concept of auto-noetic consciousness (AC), which emphasizes the "awareness of one's self existing in a subjective time" rather than that of the "subjective time in which one's self exists" (Szpunar, 2011, p. 410). Whereas both TC and AC are inextricably intertwined with episodic memory, a different type of consciousness accompanies semantic memory. This type of consciousness has been differently defined as knowing consciousness (KC) that is the awareness of "something as a meaning or as an element of impersonal knowledge or information" (Dalla Barba, 1997, p. 25) or as noetic consciousness (NC) that

“allows an organism to be aware of, and to cognitively operate on, objects and events, and relations among objects and events, in the absence of these objects and events” (Tulving, 1985, p. 3). Thus, it might be possible that in both patients, GA and D.B., TC and KC were intact. However, TC, according to Dalla Barba’s model, did not interact, as usual, with less stable modifications in long term memory, but with the more stable ones. The consequence was that “habits or personal semantic information” were “considered in a personal temporal framework” (Dalla Barba, 1997, p. 25) and displaced. The present study reports on another amnesic patient, T.H., who confabulated when remembering past personal episodes. We aim at testing T.H. in three personal conditions (past, future, scene construction) and at assessing his self-evaluation of the phenomenological characteristics of his reports. In particular, we hypothesize that he might confabulate across the three conditions.

Our goal is to assess whether confabulations only encompass past and future conditions or whether they also extend to a condition requiring the ability to construct a scene which is non temporal in nature. We predict that Dalla Barba’s findings will be replicated, hence we will observe confabulations encompassing both the past and the future. Moreover, if there is an impairment of the temporal consciousness causing confabulations, we might expect to observe lower “feeling of experiencing” indexes in T.H., when compared to controls.

We aim at further exploring the findings of a previous study that we conducted on healthy people (see Chapter 6) on this confabulatory patient, hypothesizing that, since non temporal events have been shown to be indistinguishable from future events, if a patient confabulates in future events, he should confabulates also in non temporal events.

11.2 Method

11.2.1 Participants

The patient T.H. and five matched controls participated to this study.

The patient T.H. was 68 years old, with 16 years of education. He was diagnosed with a subarachnoid haemorrhage, due to the rupture of the anterior communication artery, and hydrocephalus.

TH was recruited at the Blackheath Brain Injury Rehabilitation Centre, in London. He was administered three neuropsychological tests, the Addenbrooke's Cognitive Examination Revised (ACE-R) (Mioshi et al., 2006), a battery for dementia screening; the Hayling and Brixton tests (Burgess & Shallice, 1997), which measure executive functions; and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) (Randolph et al., 1998), that detects and characterizes dementia. He scored 60/100 on the ACE-R (cut-off < 82 gives 84% sensitivity and 100% specificity for dementia); he was *impaired* (scaled score of 1) on the Hayling test and exhibited a *poor* performance (scaled score of 3) on the Brixton test; and showed an overall *extremely low* score on the RBANS (in particular, he presented with an *extremely low* level of functioning in immediate (53) and delayed memory; a *low average* level of functioning in the visuo-spatial/constructional subtest and in language; and a *borderline* level in the attentional sub-task). At the end of the Hayling and Brixton tests, it was observed that he was "*cooperative during testing, yet was confused and disorientated and perseverated on a number of fixed false beliefs*".

T.H. was presented with the confabulation battery (Dalla Barba, 1993). He produced a 50% of confabulations in response to questions concerning his episodic memory; a 40% of incorrect responses regarding the orientation in time and a 20% of incorrect responses referring to the orientation in space. Furthermore, he confabulated in a

number of situations, in response to specific questions and spontaneously, referring to episodic memory and future thinking. For instance, to the question “What did you do yesterday?”, he falsely answered that he went to visit his grandchildren. Moreover, at the end of an experimental session, he said that he could not come to the hospital the day after, since he had planned a trip with his wife. And this was not true.

The healthy individuals were members of different, non-academic, local associations. We did not recruit people under psychoactive pharmacological treatment likely to modify normal memory abilities or people with a history of neurological and psychiatric disorders. No honorarium was offered to participants. Before starting the testing session, they were asked to sign an informed written consent. The study procedures were approved by the local ethical committee and were carried out in accordance with the Declaration of Helsinki.

11.2.2 Materials and experimental procedure

Each testing was implemented in a single session. Participants were assessed individually and sat in front of the experimenter in a quiet testing room.

First, they were instructed that they had to retrieve or imagine specific events (which were to take place at a specific time and in a specific place) that happened to them in the past or that might happen to them in the future, in response to a cue word or to a short description of a scenario. For the future task and for the construction of the scenario, they were explicitly required not to retrieve memories of past events or any part of them, but rather to imagine episodes that could potentially happen to them in the future given their current plans and goals. In addition, they were given the following example: “If I ask you to imagine any event that might happen to you during the next two years, which involves the word «holiday », you should try to imagine a particular conversation, a particular meal or a particular moment of your potential holiday, that could last from a few minutes up to an hour. The holiday as a

whole is not going to be considered a specific event”. Once they were briefed to describe the remembered/imagined event in as much detail as possible, including aspects referring to the setting of the events, the happening, the people and the objects present, any emotion, colour, smell, taste, sound and to try to experience the event as vividly as possible.

Then, participants were provided with the experimental battery. Aiming at prompting the past and future events, two sets of eight words, matched for familiarity, frequency, imageability, and concreteness, were selected from Italian norms (Burani et al., 2001). Within each list, the words were randomly assigned to the two temporal directions. Then, each participant was given one of these two sets. They were told that the cue word served to facilitate the event construction (4 past autobiographical memories and 4 future events), so it was to consider solely as a tool. They were allowed to describe an event unrelated to the cue word. This procedure followed those of D’Argembeau and van der Linden (2004) and of Addis et al. (2008).

In order to prompt the construction of scenarios, we used four sentences depicting a common-place scenarios (e.g., “Imagine you are standing in a open field by the banks of river”; “Imagine you are standing on the deck of a ship leaving port on a voyage”; “Imagine sitting in a pub having a drink”; “Imagine standing in the impressive main hall of a busy museum”). Participants were asked to richly create 4 new experiences, plausible, which had never happened before, and again to describe them in as many details as possible. The events were to be contextually specific. This procedure and the short verbal cues were adapted from the paradigm devised by Hassabis et al. (2007).

The cues were displayed, one at a time, on the computer screen. Once an event had been recalled or imagined, it was described by each participant. There was no time limit for each cue. Participants were allowed to keep on recounting the event until they thought that nothing else could be added. Recollections and simulations were digitally recorded to enable later transcriptions and subsequent scoring of participants’ responses.

Following the description of each event, participants were asked to rate the phenomenological characteristics of the mental representations they had formed on a 7-point scale. They had to estimate how many visual details they “saw” in their representation (no one/a lot); how many sounds, smells, tastes they “felt” (no one/a lot); how distinct was the setting where the representation took place (vague/clear); how clear was the spatial arrangement of people and objects (vague/clear); how strong was the feeling of experiencing the event (no feeling/strong feeling); how often they had experienced in the past the same or a very similar event (never/very often).

At the end of the study, we asked a general question concerning participants’ living future (e.g., “What do you think you will be doing in the future?”).

11.3 Results

Participants’ answers were scored as “correct” or as “confabulations”. In line with Dalla Barba et al. (1997), we considered as correct a response that was congruent with information, given by a relative, regarding the past, the present activities and the feasible future of the participants. For what concerns the future, we marked as “confabulatory” an answer that showed “a marked discrepancy or a real contradiction with what a predicted future action might be, in view of the present situation” (Dalla Barba, 1997). To this end, with T.H.’s consent, we asked his wife to listen to his recollections and then to answer a YES/NO question (i.e., for the past “as far as you know, did this event really happen in the past?” or for the future and for the scene construction “might this event really be likely to happen?”) for each of them. So if T.H.’s wife thought that the information given in the recollection was consistent with information referring to his past, his present and his plausible future plans, then she was to sign YES. Otherwise, she was to sign NO and was required to indicate the reason why she thought that the event was unlikely, implausible or unconvincing.

The results are shown in Table 11.1.

| | Past | | Future | | Scene Construction | |
|-------------|---------|--------|---------|--------|--------------------|--------|
| | Correct | Confab | Correct | Confab | Correct | Confab |
| T.H. | 75 | 25 | 50 | 50 | 50 | 50 |
| C | 100 | 0 | 100 | 0 | 100 | 0 |

Table 11.1 - T.H.'s and normal sample's (C) percentage of correct responses (Correct) and confabulations (Confab) in the three tasks concerning past, future, scene construction.

Furthermore, T.H. confabulated in response to the last question, asking for his plans for the future. He answered that he would go back home to Ireland for good, do the treatment by himself and own, and take care of, some horses and greyhounds. However, he lived in London, not Ireland, so would not go back to Ireland. His life, his house were in London and possibly he would have some involvement with horses and greyhounds through friends, but would not own or be too heavily involved, given his brain injury. He solely could help out to some degree.

Subjective ratings. The phenomenological characteristics of the mental representations were classified in four categories, according to Hassabis et al. (2007): sensorial details (given by the mean rate of the vividness of visual details, sounds, smells, tastes), spatial index score (obtained by the mean rate of the clarity of the setting and spatial arrangement of people and objects), feeling of experiencing the event and novelty of the event (i.e., how often they have experienced the episode in the past, see Chapter 5). The differences between T.H. and controls were analysed with the program Singlims_ES.exe (developed by Crawford and Howell, 1998; Crawford & Garthwaite, 2002; and Crawford et al., 2010). When compared to controls, T.H.'s subjective ratings of sensorial details ($t = -3.16, p < 0.02$), spatial index ($t = -2.55, p < 0.05$) and feeling of experiencing ($t = -4.42, p < 0.01$) the event

were significantly poorer solely for past events. He rated 3.18 the vividness of sensorial details (Controls: M = 6.27, SD = 0.89); 3.66 the clarity of the setting and of the spatial arrangements of the entity present (Controls: M = 6.4; SD = 0.98); and 1.75 the feeling of experiencing the event (Controls: M = 6.35; SD = 0.95). Moreover, T.H. experienced very differently the vividness of sensorial details in past events (3.18; Controls: M = 6.27, SD = 0.89) and in future events (5.12; Controls: M = 5.22; SD = 0.52), $t = 6.14$, $p < 0.005$. Also, solely for T.H., the perceived spatial clarity of the setting and spatial arrangements varied between past (3.66; Controls: M = 6.4; SD = 0.98) and future events (5.58; Controls: 5.8; SD = 1.03; $t = 2.36$, $p < 0.05$). Finally, T.H.'s feeling of experiencing mental representations significantly differed in past (1.75; Controls: M = 6.35; SD = 0.95) and future (4.75; Controls: M = 6.45; SD = 1.70) episodes, compared to controls, $t = 2.77$, $p < 0.05$ (see table 11.2). The phenomenological characteristics of T.H.'s confabulatory reports did not significantly differ from those of T.H.'s correct reports in any of the three conditions.

| Rating | T.H. | | Controls | |
|--------------------------------|------|--------|--------------|-------------|
| | Past | Future | Past | Future |
| Sensorial Details | 3.18 | 5.12 | 6.27(± 0.89) | 5.22(±0.52) |
| Spatial Index | 3.66 | 5.58 | 6.4(±0.98) | 5.8(±1.03) |
| Feeling of Experiencing | 1.75 | 4.75 | 6.35(±0.95) | 6.45(±1.70) |

Table 11.2 – T.H.'s and Controls' subjective mean rating (± standard deviation for controls) referring to the *sensorial details, the spatial index and the feeling of re-experiencing and pre-experiencing past and future events.*

11.4 Discussion

This chapter reports on the case of T.H., who, following the rupture of the anterior communication artery and a consequent subarachnoid haemorrhage, was suffering from an amnesic-confabulatory syndrome. TH was required to remember some past events and to generate future episodes in response to single-cue words. In addition, he was required to construct non-temporal scenarios, prompted with full-sentence

descriptors (Hassabis et al., 2007). Finally, he was asked a question concerning his lived future.

With respect to our first hypothesis, Dalla Barba's findings have been replicated, as expected. The 25% of his responses on the past task were confabulatory. And he confabulated in half of his reports on the future task. Also the answer at the question regarding his lived future was confabulatory.

With respect to our second hypothesis, we observed that T.H also confabulated on the construction task.

With respect to our third hypothesis, T.H.'s subjective ratings of sensorial details, spatial index and feeling of experiencing the event was poorer for past events, when compared to the control sample. In particular, the perceived feeling of experiencing the events was always lower than that of controls. This was evident on the past task, where the difference between T.H. and controls was significant. However, also in the other two tasks he scored lower than controls although the difference was not significant. He rated 4.75 his feeling of experiencing the events in the future (Controls: 6.45; SD = 1.70) and 3 his feeling of experiencing the constructed scene (Controls: 6.6; SD = 2.70). Furthermore, T.H.'s ratings of the phenomenological characteristics of past events were lower than his ratings of future events. On the contrary, no differences were reported within the control sample between past and future ratings.

Furthermore, it is worth noting that T.H. scored poorly on a number of neuropsychological tests. In addition, he was disorientated in time and space and generated a number of "fixed false beliefs".

In this study we aimed at better exploring the relation between future thinking and the subjective time.

The examples of confabulators have been often reported in support of the constructive simulation hypothesis (Schacter and Addis, 2007a). MB, GA and D.B.'s performances in the future reflect their performances in the past. This confabulatory behaviour that extends in all the temporal dimensions uncovers, according to some researchers (see Schacter et al., 2008), parallel difficulties in remembering past and imagining future. And the reason of such difficulties has been ascribed to the possibility that future thinking relies on personal past. Thus, when a patient is impaired at retrieving past episodes, he might experience serious problems also in constructing his future. "There appears to be a close relationship between the ability to remember the personal past and the ability to imagine the personal future: in the absence of the former, the latter is severely compromised (see also, Tulving, 1985)" (Klein et al., 2002, p. 372). "Both past and future event tasks require the retrieval of information from memory, thus engaging common memory networks" (Schacter et al., 2008, p. 45). However, this interpretation might be fallacious and misleading. Why should one rely on his episodic memory to construct an episodic future thought? If one wants to imagine an episode that he has never experienced in the past, or if one does not remember any of his personal past events, why cannot he rely on his semantic memory and construct a plausible scenario? For instance, a person can imagine to go to the savannah and look at a giraffe eating acacia shoots, even if he cannot rely on his past experience. So why do not amnesiacs rely on their semantic memory to describe a plausible future scenario? Studies on confabulators offer a precious insight, that might help to answer these questions. They suggest a different interpretation of the relation between past and future thinking. It might be possible, for instance, that personal future is not compromised in absence of personal past. Personal future and personal past might be related in the sense that each of them embodies the manifestation of particular mechanisms, which underlie both remembering and foreseeing. One of these mechanisms is represented by the auto-noetic consciousness (AC). AC enables "mental time travel in the personal subjective way that is the hallmark of retrieval from episodic memory" (Wheeler et al., 1997, p. 331). It allows to become conscious of the subjective experience extending from the past to the future. Thus, it enables also mental time travel in the personal subjective way that is the hallmark of the construction of scenes projected in

the future. The act of imagining a future personal episode might be thought as a function of AC. K.C., the famous amnesic patient described by Tulving (1985), had preserved his noetic consciousness (NC), whereas his AC was seriously compromised. And indeed he could imagine neither his past nor his future. D.B. (Klein et al., 2002) is another case of amnesic patient, who also confabulated when required to think about his past and his future in a personal way, i.e., when the task required to use AC. On the contrary, he was unimpaired in tasks involving NC.

“Simply thinking that something may happen in the future, without mentally preexperiencing a specific episode, is a function of noetic consciousness” (Szpunar, 2010, p. 145). Thus, as Szpunar (2010) has already noticed, since his NC worked properly and AC was compromised, he could think of past and future solely in an impersonal manner. Subjective temporality is considered a fundamental pre-requisite to travel back and forward in personal time. According to Dalla Barba’s model (1997), temporal consciousness (TC) usually interacts with the more recent, and consequently less stable and weaker, modifications of the long-term memory system, with the aim of remembering the past, of being orientated in the current time-place and elaborating future plans. In some patients, like K.C., TC was impaired, so it could not work properly. In other patients, like GA, TC has been retained, but it does not accomplish its task of operating “a sort of fine grain search in the long-term storage system and use less stable modifications in order to set up a personal temporal workspace” (Dalla Barba, 1997, p. 25). In this condition, TC interacts with more stable modifications of long-term memory and consequently it uses information frequently told and retold over the years and “semanticized” to some extent. When required to plan their lived future, confabulators of this type are prone to answer with habits that they used to adopt in their life. Therefore, our patient, T.H., lived in Ireland many years before our experimental interview and used to take care of a number of animals, like horses. When asked about his plans in the next future, he proposed a very unlikely scenario, ignoring his current medical, social and practical conditions. He did not take into account to have a house in London and to need constant assistance, and he answered that he would go back home to Ireland, do the treatment by himself, and take care of some horses and greyhounds. Moreover, he

seemed to adhere without doubt to his confabulatory descriptions. Accordingly, there was no difference between the perceived phenomenological characteristics of his confabulatory and his non-confabulatory reports. However, the feeling of re-experiencing and pre-experiencing his mental representation was less strong when compared to controls.

This is in line with what suggested by Klein et al. (2002): “semantic memory also makes possible a form of mental time travel, albeit one that does not entail awareness of the temporal dimension of one’s own experience. Specifically, individuals who possess semantic memory are capable of knowing about, but not re-experiencing, previous states of the world and drawing on that generic knowledge to construct possible scenarios of the future” (p. 369-370). And it might be possible that an impairment of TC is reflected also by a weak subjective feeling of mentally experiencing past events.

Furthermore, our results show that imagined future events are impossible to tell apart, with respect to the percentage of confabulations produced, from non temporal events. Therefore, we replicated with a confabulatory patient the results that we obtained on healthy people (see Chapter 6). In Chapter 6, we hypothesized that participants envisage future scenarios even when they are asked to imagine experiences not explicitly temporal in nature. This might apply also for T.H.. It may be the case, in fact, that cueing T.H. “to imagine an event that might happen to him in the next two years, which involves the word holiday” or “to imagine that he is standing in an open field by the banks of river” does not make any difference in terms of mental time travel in future, i.e., the inclusion of a time period in the cue sentence does not seem crucial to trigger prospection. It may occur that, as far as a person is engaged in imagining doing something plausible, he spontaneously projects into his personal future. Therefore, TC might be involved not only when remembering the past and when imagining the future, but also when constructing non temporal scenarios.

However, we cannot rule out also a different interpretation of the present data. Moscovitch (1995) has noticed that tasks involving episodic memory place a high cognitive demand, especially on executive functions, requiring temporal experience and narrative constructions. Consequently, they might involve strategic retrieval processes. In particular, future thinking tasks have been shown to involve even a greater neural activity than the episodic memory tasks (Okuda et al., 2003; Addis et al., 2007). Okuda et al. (2003) have revealed that frontal lobes are activated when normal participants foresaw. In particular, specific frontal polar regions are more active when participants think and reports their future prospects. Recently, Anderson et al. (in press) have suggested that future thinking might be considered more effortful than past memory. Executive functions underlie both processes by monitoring and combining the different details. But, whereas past episodes require “a search for a unique combination of information; in contrast, a future event can be formed from any combination of an infinite array of information within autobiographical memory” (p. 2). T.H. showed poor performances in many cognitive domains, in particular in tests assessing executive functions. These difficulties might have also contributed to his impaired performance.

12. Final Discussion

“All the world’s a stage”, wrote Shakespeare. Suddendorf and Corballis (2007) noted that this applies to the mental world as well. Information and material stored in long-term memory can be mentally manipulated and re-combined to form infinite and elaborated simulations of possible upcoming episodes. However, our mind does not work like a video-camera and we do not have at our disposal full-fledged scenes to be performed as in a movie (“The past, like the future, can only be imagined”, de Hériz, 2006, p.21). Episodes are constructed by drawing from different snippets and by reshuffling them to shape a coherent whole. Therefore, future thinking is far from being an encapsulated cognitive function. It, instead, impinges upon a constellation of constituent abilities. For this reason, it is a costly process, likely to be disrupted at different stages, hence in several diseases, which might be characterised by an impairment of one or more of its crucial components. Indeed, the mental construction of future experiences requires the activation of much of cortical mass and, consequently, it can be impaired by “*any* kind of cortical brain damage” (Berryhill et al., 2010, p. 1391). The ability of forecasting necessitates a greater neural activity than that underlying past recollections (Okuda et al., 2003; Addis et al., 2007). When healthy participants think and report their future prospects, specific frontal polar regions are more active (Okuda et al., 2003). Furthermore, the activity of the right frontopolar cortex (BA 10) positively correlate with the amount of details uttered (Addis & Schacter, 2008). Also Anderson et al. (in press) noted that future thinking might be regarded as more effortful and expansive than past memory. For instance, future thinking is thought to place a considerable demand on executive functions, which underlie both processes by monitoring and combining various elements. However, whereas past episodes require “a search for a unique combination of information; in contrast, a future event can be formed from any combination of an infinite array of information within autobiographical memory” (Anderson et al., in press, p. 2). “Like human language, it [future thinking] is open-ended and generative, so there is no end to the number of potential future scenarios one might envisage” (Suddendorf and Corballis, 2007, p. 302).

The abilities of foreseeing unique episodes and of acting accordingly provide us with an essential selective advantage. The adaptation to the future is facilitated by the versatility in facing novel situations and the flexibility to elaborate and use strategic plans to achieve personal devised goals (Suddendorf and Corballis, 2007).

The matter is intriguing and has led to a growing surge of literature during the last years, insomuch as Schacter and Addis (2007c) argued that “the future of thinking about the future appears to be now” (p. 33). The present thesis stemmed from the need of breaking down the whole process into its basic components, aiming at deeply investigating this sort of “life simulator” (Brüne & Brüne-Cohrs, 2007). To this end, this research encompassed a number of experiments both on healthy volunteers and on different groups of patients.

After presenting the concept of future thinking and reviewed the relevant literature in Chapters 2 and 3, the thesis proceeds with the attempt to select an appropriate cue to prompt future episodes (Chapter 4).

The types of cue hitherto adopted in the literature have been highly heterogeneous. And this is a key point, which had never been experimentally addressed before, to consider in the interpretation of the results. Some researchers had already noted that indeed different cues might lead to different outcomes, as it was observed in the case of H.C., who was found to be impaired at future thinking when tested with Kwan et al.’s (2010) procedure and unimpaired when assessed with Hurley et al.’s (2011) paradigm. Thus, it was suggested that some cues might be more sensitive to detect difficulties forecasting, while others might encourage more semantic descriptions. However, there is a rather heated debate as to which cue is more likely to minimize the dependence on semantic memory. In some studies, cues indicating a context were adopted to enhance the dependence on semantic memory (Hassabis et al., 2007) and to make the future task less challenging for patients with brain injury (Hurley et al., 2011). In others, researchers did the opposite, using cues representing a context to avoid participants to report “frequently retrieved event information” (Race et al., 2011, p. 10263) and ascribing semantic biases to descriptions prompted by generic

object-cues, which did not encourage the construction of vivid scenarios, but the production of accounts more semantic in nature (see the discussion between Maguire and Hassabis, 2011 and Squire et al., 2011). Our findings showed that when the cue represented a setting, healthy participants uttered more internal-episodic and less external-semantic snippets, by comparison with a more generic cue characterizing an object. Thus, throughout the thesis we have mainly used object-cues or variations of them, to elicit future thinking. This, according to Conway's model (2001), loads on both strategic searching and scene construction, hence allowing to detect an impairment at more steps of forecasting.

In the study reported in Chapter 5, it was hypothesized that, given that future thinking is a more effortful and costly process than remembering (Anderson et al., in press), on some occasions, participants might provide past personal episodes that have already occurred, instead of truly constructing novel scenarios. This hypothesis was investigated by assessing participants on near future (few weeks) and distant future (few years) events. In fact, given that this could represent a possible caveat in our research, we were interested into experimentally ascertaining whether our concern was founded. We observed, in the delayed recognition tasks of both the relevant experiments, that some of the personal future events produced were acknowledged as being already occurred in the past or as being very similar to past events. Participants were more likely to be relying upon personal memories when simulating near future scenarios than distant future scenarios. Thus, we thought that it could be more appropriate for the ensuing experiments to test participants on distant future events (i.e., "*Imagine an episode that might happen to you next year*") rather than on near ones, to reduce the possibility that they simply reproduce past personal memories, instead of truly imagining future prospects.

After these two studies, we were interested at better defining what differentiates future thinking from the related concept of imaging complex scenes. The specific contribution of three essential features of future thinking was therefore explored in Chapter 6: familiarity of setting, self-relevance, and self-projection in time. Our main purpose was to understand whether future thinking differed from imagined future

events involving familiar others and from imagined a-temporal events, and whether the familiarity of setting might be a crucial modulator of the characteristics of future thought. In two experiments it was observed that constructions of future events occurring in familiar settings are perceived as more vivid, are related to a stronger feeling of pre-experiencing and are characterized by a greater amount of episodic details, by comparison with the images of future events occurring in unfamiliar settings. On the contrary, future autobiographical episodes were found to be entirely indistinguishable from a-temporal personal events. There were no differences, indeed, between the subjective rating on sensorial details (perceived vividness), spatial clarity of context and feeling of experiencing indexes, and between the number of episodic details in the two conditions. Thus, we suggested that future and a-temporal events, as long as they are plausible, are mentally represented in a similar way.

These first three studies had the goal of investigating at depth the concept of future thinking and the possible caveats one is likely to encounter when assessing participants on future thinking.

Then, our further purpose was that of dissecting the cognitive architecture of foresight. In particular, we aimed at evaluating the parts played by two cognitive functions: episodic memory, which is thought to lie at the very core of future thought and executive control, which is considered a key component of future thinking (Brüne & Brüne-Cohrs, 2007). In addressing this issue, we greatly benefited from assessing people with different types of disorders.

Many authors (see e.g., Suddendorf & Corballis, 2007) have suggested that episodic memory helps to pre-experience future episodes, given that it is the type of memory that we used to re-experience the past. Hegdè (2007) convincingly objected that this implies an unnecessarily limitation, because “if it was strictly true, it would mean that one would be able to foresee only those events that one has episodic memory of” (p. 324). Furthermore, the author extends the formulation of the close relationship between episodic memory and future thinking to its logical limits, proposing a

conundrum. “To the extent that one can only foresee those future events that one has experienced in the past, and to the extent that events never repeat themselves exactly, one can never apply the memory of any past event to a future situation” (p. 324).

Therefore, the relationship between remembering the past and imagining the future appears to be more subtle than it has been postulated in various studies (see Szpunar, 2010). We can imagine events never experienced before. In order to imagine to eat tiger shark sushi at the Chiharu Japanese Restaurant in Singapore, we do not need to have done it before. Information about the details of specific events already occurred is not necessarily needed. We can easily generalize and extrapolate information from our general knowledge, adding arbitrary particularities. “Without the ability to extrapolate from generalities, the amount of particularities the brain would have to store would be subject to a combinatorial explosion. For every prediction of a future event, the memory of a corresponding past event would be needed. Conversely, what one can predict about the future will be limited by one’s episodic memory” (Hegdè, 2007, p. 324). This sharp observation implies that different types of memory might cooperate with each other and with other cognitive domains to aid forecasting.

Thus, we first analysed the actual dependence of the ability of future thinking on episodic memory.

In Chapter 7 the capacity of foreseeing personal future in a group of patients diagnosed with aMCI, hence presenting a selective and isolated impairment of episodic memory, was assessed. Our findings revealed that these patients produced fewer episodic details and a greater amount of semantic details than controls. Thus, the existence of a close linkage between remembering the past and imagining the future was highlighted.

We were also interested in investigating whether or not difficulties in future thinking might be observed also in the absence of episodic memory deficit. Indeed, in Chapter 8, we reported that patients with Parkinson’s Disease, who did not exhibit impairments in memory, were nonetheless impaired in the construction of future

scenarios. In particular, seven patients, who reached the poorest scores on the future thinking task (generating less episodic details), achieved a significantly lower mean score on the Frontal Assessment Battery compared to the rest of the group. Furthermore, these patients expressed their own incapability to take distance from their memories in favour of the imagination of completely novel scenarios. This chapter documented a clear dissociation between spared episodic memory and the impaired ability of forecasting, suggesting that future thinking deficits do not represent a specific feature of amnesia and that executive functions might also essentially contribute to the construction of future scenarios.

In Chapter 9, we adopted the task developed by Zeman et al. (submitted) to better interpret the data that we obtained in Chapter 8. In particular, this Chapter helped us to rule out the hypothesis that an executive functions deficit might have determined a general impoverishment of verbal reports of our patients with Parkinson's Disease. Two samples of these patients (one executive and one non-executive) were tested, indeed, on a Description Task, requiring to describe a current real-life setting. The total amount of specific details produced was equivalent between the three groups, executive, non-executive and controls. Therefore, we concluded that the failure in the future task performance noted in the previous chapter was more plausibly due to a disruption of the flexible searching through different memories and to the subsequent binding of the various elements into a coherent narrative, caused by a dysexecutive problem.

In Chapter 10, we focussed our attention on the role of the cue. However, we did not address this issue by testing healthy volunteers, as in Chapter 4, but in two patients presenting with dense amnesia. We aimed at evaluating the extent to which a cue can influence patients' performance, contrasting the most widely used cues in the literature concerning future thinking, i.e., the single word cue and the short description cue. It was observed that patients' reports were definitely poorer than those generated by controls. The deficit was detected, to the same extent and at the same manner, by the two tasks adopting very different cues. We suggested that the cue might not be as relevant as the quantity and the quality of prompts provided, to

encourage the patient to further elaborate his report. Our data supported the idea that when this condition is controlled for, the cues might be more sensitive to detect an impairment.

The last issue we addressed in the present dissertation was the relation between future thinking and the subjective time. We did it in Chapter 11, which reported on the case of T.H. suffering from an amnesic-confabulatory syndrome. We observed that the 25% of his responses on the past task were confabulatory. Furthermore, he confabulated in half of his reports on the future task and on the construction task. The answer to the question regarding his lived future was also confabulatory. We suggested that his difficulties imagining the future were plausibly due to an incapability of T.H. to be aware of the temporal dimension of his experience.

In conclusion, we greatly benefited from the studies that we run with healthy volunteers. They helped us to investigate at depth some relevant issues concerning the human ability to imagine personal future. Moreover, studies on patients offered an insight to further explore, and hence offer different interpretations about the relations between future thinking and other cognitive functions, like memory, executive functions and subjective time.

In Woody Allen's movie, "Midnight in Paris" (2011), Gil expresses to the artist Man Ray his astonishment at being catapulted back and forth in time. Man Ray finds entirely normal the idea of living in more temporal dimensions at the same time and Gil replies, "It's easy for you! You're a surrealist. But I'm a normal guy!". Thus, unless we are surrealists, the ability of mentally travelling forward in time is extremely fascinating and complex and requires a widespread range of cognitive processes.

13. References

Addis DR, Wong AT, and Schacter DL. Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, 45(7): 1363-1377, 2007.

Addis DR and Schacter DL. Constructive episodic simulation: temporal distance and detail of past and future events modulate hippocampal engagement. *Hippocampus*, 18: 227-237, 2008.

Addis DR, Wong AT, and Schacter DL. Age-related changes in the episodic simulation of future events. *Psychological Science*, 19(1): 33-41, 2008.

Addis DR, Sacchetti DC, Ally BA, Budson AE, and Schacter DL. Episodic simulation of future events is impaired in mild Alzheimer's disease. *Neuropsychologia*, 47(12): 2660-2671, 2009.

Addis DR, Pan L, Vu MA, Laiser N, and Schacter DL. Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia*, 47: 2222-2238, 2009.

Addis DR, Musicaro R, Pan L, and Schacter DL. Episodic simulation of past and future events in older adults: evidence from an experimental recombination task. *Psychology and Aging*, 25: 369-376, 2010.

American Psychiatric Association. *Diagnostic and statistical manual of mental disorders DSMVI* (4th ed.). Washington, DC: American Psychiatric Association, 1994.

Andelman F, Hoofien D, Goldberg I, Aizenstein O, and Neufeld MY. Bilateral hippocampal lesion and a selective impairment of the ability for mental time travel. *Neurocase*, 16: 426-435, 2010.

Anderson RJ, Dewhurst SA, and Nash RA. Shared cognitive processes underlying past and future thinking: the impact of imagery and concurrent task demands on event specificity. *Journal of Experimental Psychology: Learning, Memory and Cognition*, in press.

Atance CM and O'Neill DK. Episodic future thinking. *Trends in Cognitive Sciences*, 5(12): 533-539, 2001.

Bar M. The proactive brain: using analogies and associations to generate predictions. *Trends of Cognitive Sciences*, 11(7): 280-289, 2007.

Bartlett FC. *Remembering: a study in experimental and social psychology*. Cambridge: Cambridge University Press, 1932.

Bergson H. *Matter and Memory*. London George Allen & Co., LTD, 1913.

Berlyne N. Confabulation. *British Journal of Psychiatry*, 120: 31-39, 1972.

Berryhill ME, Picasso L, Arnold R, Drowos D, and Olson IR. Similarities and differences between parietal and frontal patients in autobiographical and constructed experience tasks. *Neuropsychologia*, 48: 1385-1393, 2010.

Bonhoeffer K. Der korsakowsche symptomenkoplex in seinen beziehungen zu den verschiedenen krankheitsformen. *Allgemeine Zeitung Psychiatrie*, 61: 744-752, 1904.

Bosboom JL, Stoffers D, and Wolters E. Cognitive dysfunction and dementia in Parkinson's disease. *Journal of Neural Transmission*, 111: 1303-1315, 2004

Brüne M and Brüne-Cohrs U. The cost of mental time travel. *Behavioural and Brain Sciences*, 30(3): 317-318, 2007.

Buckner RL and Carroll DC. Self-projection and the brain. *Trends in Cognitive Sciences*, 11(2): 49-57, 2007.

Buckner RL, Andrews Hanna JR, and Schacter DL. The brain's default network: Anatomy. Function and relevance to disease. *Annals of the New York Academy of Sciences*, 1124: 1-38, 2008.

Burani C, Barca L, and Arduino LS. Una base di dati sui valori di età di acquisizione, frequenza, familiarità, immaginabilità, concretezza, e altre variabili lessicali e sublessicali per 626 nomi dell'Italiano. *Giornale Italiano di Psicologia*, 4: 839-856, 2001.

Burgess PW and Shallice T. *The Hayling and Brixton Tests*. Thames Valley Test Company, Bury St. Edmunds, U.K., 1997.

Cabeza R and St Jacques P. Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences*, 11: 219-227, 2007.

Carlesimo GA, Caltagirone C, Fadda L, Marfia G, Gainotti G e il Gruppo per la standardizzazione della batteria per il Deterioramento Mentale. Batteria per la valutazione del Deterioramento Mentale (parte III): analisi dei profili qualitativi di compromissione cognitiva. *Archivio di Psicologia, Neurologia e Psichiatria*, 4: 489-502, 1995.

Carlesimo GA, Caltagirone C, and Gainotti G. The Mental Deterioration Battery: normative data, diagnostic reliability and qualitative analyses of cognitive impairment. The Group for the Standardization of the Mental Deterioration Battery. *European Neurology*, 36: 378-384, 1996.

Chertkow H and Bub D. Semantic memory loss in dementia of Alzheimer's type: What do various measures measure? *Brain*, 113: 397–417, 1990.

Cohen NJ and Eichenbaum H. *Memory, amnesia, and the hippocampal system*. Cambridge: MIT. 1993.

Conway MA. Sensory perceptual episodic memory and its context: autobiographical memory. *Philosophical Transactions of The Royal Society B*, 356: 1375-1384, 2001.

Conway MA and Pleydell-Pearce CW. The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107: 261–288, 2000.

Cooper JM, Vargha-Khadem F, Gadian DG, and Maguire EA. The effect of hippocampal damage in children on recalling the past and imagining new experiences. *Neuropsychologia*, 49(7): 1843-1850, 2011.

Corkin S. What's new with the amnesic patient H.M.? *Nature Reviews Neuroscience*, 3: 153-160, 2002.

Crawford JR and Howell DC. Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist*, 12: 482-486, 1998.

Crawford JR and Garthwaite PH. Investigation of the single case in neuropsychology: confidence limits on the abnormality of test scores and test score differences. *Neuropsychologia*, 40(8): 1196–1208, 2002.

Crawford JR and Garthwaite PH. Evaluation of criteria for classical dissociations in single-case studies by Monte Carlo simulation. *Neuropsychology*, 19(5): 664–678, 2005.

Crawford JR, Garthwaite PH, and Porter S. Point and interval estimates of effect sizes for the case-controls design in neuropsychology: Rationale, methods, implementations, and proposed reporting standards. *Cognitive Neuropsychology*, 27: 245-260, 2010.

D'Argembeau A and Van der Linden M. Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: influence of valence and temporal distance. *Consciousness and Cognition*, 13: 844-858, 2004.

D'Argembeau A and Van der Linden M. Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, 15: 342-350, 2006.

D'Argembeau A, Raffard S, and Van der Linden M. Remembering the past and imagining the future in schizophrenia. *Journal of Abnormal Psychology*, 117: 247-251, 2008.

D'Argembeau A, Renaud O, and Van der Linden M. Frequency, characteristics, and functions of future-oriented thoughts in daily life. *Applied Cognitive Psychology*, 25: 96–103, 2009.

D'Argembeau A, Stawarczyk D, Majerus S, Collette F, Van der Linden M, Feyers D, Maquet P, and Salmon E. The neural basis of personal goal processing when envisioning future events. *Journal of Cognitive Neuroscience*, 22: 1701-1713, 2010.

D'Argembeau A and Mathy A. Tracking the construction of episodic future thoughts. *Journal of Experimental Psychology: General*, 140: 258–271, 2011.

Dalgleish T, Williams JMG, Golden AJ, Perkins N, Barrett LF, Barnard PJ, Au Yeung C, Murphy V, Elward R, Tchanturia K, and Watkins E. Reduced specificity of autobiographical memory and depression: the role of executive control. *Journal of Experimental Psychology: General*, 136(1): 23–42, 2007.

Dalla Barba G. Confabulation: knowledge and recollective experience. *Cognitive Neuropsychology*, 10: 1-20, 1993.

Dalla Barba G, Cappelletti JY, Signorini M, and Denes G. Confabulation: remembering “another” past, planning “another” future. *Neurocase*, 3: 425-436, 1997.

Dalla Barba G. Memory, consciousness and the brain. *Brain and Cognition*, 42: 20-22, 2000.

Della Sala S, Laiacona M, Spinnler H, and Ubezio C. A cancellation test: its reliability in assessing attentional deficits in Alzheimer's disease. *Psychological Medicine*, 22: 885-901, 1992.

Della Sala S, Laiacona M, Spinnler H, and Trivelli C. Autobiographical recollection and frontal damage. *Neuropsychologia*, 31(8): 823-839, 1993.

De Hériz E. *Bugia*. Dalai Editore, 2006.

de Vito S and Della Sala S. Predicting the future. *Cortex*, 47(8): 1018-1022, 2011.

de Vito S, Gamboz N, and Brandimonte MA. What does differentiate episodic future thinking from complex scene imagery? *Consciousness and Cognition*, under revision.

de Vito S, Gamboz N, Brandimonte MA, Barone P, Amboni M, and Della Sala S. Future thinking in Parkinson's Disease: an executive function? *Neuropsychologia*, under revision.

Driscoll I, Hamilton DA, Petropoulos H, Yeo RA, Brooks WM, Baumgartner RN, and Sutherland RJ. The aging hippocampus: cognitive, biochemical and structural findings. *Cerebral Cortex*, 13: 1344-1351, 2003.

Dubois B, Slachevsky A, Litvan I, and Pillon B. The FAB: A frontal assessment battery at bedside. *Neurology*, 55: 1621-1626, 2000.

Dudai Y. Predicting not to predict too much: How the cellular machinery of memory anticipates the uncertain future. *Philosophical Transactions of The Royal Society B*, 364: 1255-1262, 2009.

Dudai Y and Carruthers M. The janus face of Mnemosyne. *Nature*, 434: 567, 2005.

Emre M, Aarsland D, Brown R, Burn DJ, Duyckaerts C, Mizuno Y, Broe GA, Cummings J, Dickson DW, Gauthier S, Goldman J, Goetz C, Korczyn A, Lees A, Levy R, Litvan I, McKeith I, Olanow W, Poewe W, Quinn N, Sampaio C, Tolosa E, and Dubois B. Clinical diagnostic criteria for dementia associated with Parkinson's disease. *Movement disorders*, 22: 1689-1707, 2007.

Folstein MF, Folstein SE, and McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12: 189-198, 1975.

Friedman W. *About time*. Cambridge, MA: MIT Press, 1990.

Gaesser B, Sacchetti D, Addis DR, and Schacter DL. Characterizing age-related changes in remembering the past and imagining the future. *Psychology and Aging*, 26(1): 80-84, 2011.

Gamboz N, Brandimonte MA, and de Vito S. The role of past in the simulation of autobiographical future episodes. *Experimental Psychology*, 57: 419-428, 2010.

Gamboz N, de Vito S, Brandimonte MA, Pappalardo S, Galeone F, Iavarone A, and Della Sala S. Episodic future thinking in amnesic mild cognitive impairment. *Neuropsychologia*, 48(7): 2091-2097, 2010.

Gardiner JM, Java RI, and Richardson-Klavehn A. How level of processing really influences awareness in recognition memory. *Canadian Journal of Experimental Psychology*, 50: 114-122, 1996.

Garthwaite PH and Crawford JR. The distribution of the difference between two *t*-variates. *Biometrika*, 91: 987-994, 2004.

Gauthier S, Reisberg B, Zaudig M, Petersen RC, Ritchie K, Broich K, Belleville S, Brodaty H, Bennett D, Chertkow H, Cummings JL, de Leon M, Feldman H, Ganguli M, Hampel H, Scheltens P, Tierney MC, Whitehouse P, Winblad B and on behalf of the participants of the International Psychogeriatric Association Expert Conference on mild cognitive impairment. Mild cognitive impairment. *Lancet*, 367: 1262–1270, 2006.

Gibb WR and Lees AJ. The relevance of the Lewy body to the pathogenesis of idiopathic Parkinson's disease. *Journal of Neurology, Neurosurgery & Psychiatry*, 51: 745-752, 1998.

Gilbert DT and Wilson T. Prospection: Experiencing the future. *Science*, 317: 1351-1354, 2007.

Giovanello KS, Schnyer DM, and Verfaellie M. A critical role for the anterior hippocampus in relational memory: evidence from an fMRI study comparing associative and item recognition. *Hippocampus*, 14: 5-8, 2004.

Goddard L, Dritschel B, and Burton A. The role of autobiographical memory in social problem-solving and depression. *Journal of Abnormal Psychology*, 105: 609–616, 1996.

Goff LM and Roediger HL III. Imagination inflation for action events: Repeated imagining lead to illusory recollection. *Memory and Cognition*, 26: 20–33, 1998.

Gold JJ and Squire LR. Quantifying medial temporal lobe damage in memory impaired patients. *Hippocampus*, 15: 79-85, 2005.

Haith MM. The development of future thinking as essential for the emergence of skill in planning. In Mahwah NJ (Eds.). *The developmental psychology of planning: why, how and when do we plan*. L.Erlbaum Associates, 25-42, 1997.

Hassabis D, Kumaran D, and Maguire AM. Using imagination to understand the neural basis of episodic memory. *The Journal of Neuroscience*, 27: 14365-14374, 2007.

Hassabis D, Kumaran D, Vann SD, and Maguire EA. Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America*, 104(5): 1726-1731, 2007.

Hassabis D and Maguire EA. Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, 11: 299–306, 2007.

Hassabis D and Maguire EA. The construction system of the brain. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364: 1263-1271, 2009.

Hegdè J. Mental time travel sickness and a Bayesian remedy. *Behavioural and Brain Sciences*, 30(3): 323-324, 2007.

Hodges JR and Patterson K. Is semantic memory consistently impaired early in the course of Alzheimer's disease? Neuroanatomical and diagnostic implications. *Neuropsychologia*, 33: 441-459, 1995.

Hoehn MM and Yahr MD. Parkinsonism: onset, progression and mortality. *Neurology*, 17: 427-442, 1967.

Hoshi Y, Oda I, Wada Y, Ito Y, Yamashita Y, Oda M, Ohta K, Yamada Y, and Tamura M. Visuospatial imagery is a fruitful strategy for the digit span backward task: a study with near-infrared optical tomography. *Cognitive Brain Research*, 9: 339-342, 2000.

Hou CE, Bruce L, Kramer M, and Kramer H. Patterns of autobiographical memory loss in dementia. *International Journal of Geriatric Psychiatry*, 20: 809-815, 2005.

Hurley NC, Maguire EA, and Vargha-Khadem F. Patient HC with developmental amnesia can construct future scenarios. *Neuropsychologia*, 49(13): 3620-3628, 2011.

Hyman IE and Pentland J. The role of mental imagery in the creation of false childhood memories. *Journal of Memory and Language*, 35: 101-117, 1996.

Iavarone A, Ronga B, Pellegrino L, Loré E, Vitaliano S, Galeone F, and Carlomagno S. The Frontal Assessment Battery (FAB). Normative data from an Italian sample and performances of patients with Alzheimer's disease and frontotemporal dementia. *Functional Neurology*, 19: 191-195, 2004.

Ingvar DH. "Hyperfrontal" distribution of the cerebral grey matter flow in resting wakefulness; on the functional anatomy of the conscious state. *Acta Neurologica Scandinavica*, 60: 12-25, 1979.

Ivanoiu A, Cooper JM, Shanks MF, and Venneri A. Patterns of impairment in autobiographical memory in the degenerative dementias constrain models of memory. *Neuropsychologia*, 44: 1936-1955, 2006.

Jack CR, Jr, Petersen MO, O'Brien PC, Smith GE, Ivnik RJ, Boeve BF, Tangalos EG, and Kokmen E. Rates of hippocampal atrophy correlate with change in clinical status in aging and AD. *Neurology*, 55: 484-489, 2000.

Johansson M, Stenberg G, Lindgren M, and Rose'n I. Memory for perceived and imagined pictures. An event-related potential study. *Neuropsychologia*, 40: 986-1002, 2002.

Johnson MK, Foley MA, Suengas AG, and Raye CL. Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General*, 117: 371–376, 1988.

Kant I. *Anthropology From a Pragmatic Point of View*. Trans. Victor Lyle Dowdell. Carbondale, Illinois: Southern University Press Paperback edition, 1996 (originally published 1798).

Killiany RJ, Hyman BT, Gomez-Isla T, Moss MB, Kikinis R, Jolesz F, Tanzi R, and Jones K. MRI measures of entorhinal cortex vs hippocampus in preclinical AD. *Neurology*, 58: 1188–1196, 2002.

Klein SB, Loftus J, and Kihlstrom JF. Memory and temporal experience: The effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition*, 20(5): 353-379, 2002.

Kopelman MD. Two types of confabulation. *Journal of Neurology, Neurosurgery, & Psychiatry*, 50: 1482-1487, 1987.

Kopelman MD. Frontal dysfunction and memory deficits in the alcoholic Korsakoff syndrome and Alzheimer-type dementia, *Brain*, 114(1): 117-137, 1991.

Kopelman MD, Wilson BA, and Baddeley AD (1989). The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology*, 11: 724–744, 1989.

Kopelman MD, Wilson BA, and Baddeley AD. *The autobiographical memory interview*. Bury St. Edmunds: Thames Valley Test, 1990.

Kurczek JC, Duff MC, Jensen U, Adolphs R, Cohen NJ, and Tranel D. Hippocampal amnesia impairs the generation of mental representations across all time periods. *In Society for neuroscience annual meeting*. November 13–17, San Diego, CA., abstract n. 600.8, 2010.

Kwan D, Carson N, Addis DR, and Rosenbaum RS. Deficits in past remembering extend to future imagining in a case of developmental amnesia. *Neuropsychologia*, 48: 3179-3186, 2010.

Levine B, Svoboda E, Hay JF, Winocur G, and Moscovitch M. Aging and autobiographical memory: dissociating episodic from semantic retrieval. *Psychology and Aging*, 17: 677-689, 2002.

Leyhe T, Müllera S, Miliana M, Eschweiler GW, and Saura R. Impairment of episodic and semantic autobiographical memory in patients with mild cognitive impairment and early Alzheimer's disease. *Neuropsychologia*, 47: 2464-2469, 2009.

Lidz T. The amnestic syndrome. *Archives of Neurology and Psychiatry*, 47(4): 588-605, 1942.

Luria AR. *The Working Brain*. Allen Lane The Penguin Press, 1973.

Maguire EA. Neuroimaging studies of autobiographical event memory. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 356: 1441-1451, 2001.

Maguire EA, Vargha-Khadem F, and Hassabis D. Imagining fictitious and future experiences: Evidence from developmental amnesia. *Neuropsychologia*, 48: 3187-3192, 2010.

Maguire EA and Hassabis D. Role of the hippocampus in imagination and future thinking. *Proceedings of the National Academy of Sciences*, 108(11): 39, 2011.

Mammarella N. The role of spaced repetitions in imagination inflation. *European Journal of Cognitive Psychology*, 19: 882-897, 2007.

Mazzoni G and Memon A. Imagination can create false autobiographical memories. *Psychological Science*, 14: 186-188, 2003.

McDaniel MA, Lyle KB, Butler KM, and Dornburg CC. Age-related differences in reality monitoring of action memories. *Psychology and Aging*, 23: 646-656, 2008.

Measso G, Cavarzeran F, Zappalà G, Lebowitz BD, Crook TK, Pirozzolo FJ, Amaducci LA, MAssari D, and Grigoletto F. The Mini Mental State Examination: Normative study of an Italian random sample. *Developmental Neuropsychology*, 9: 77-85, 1993.

Mioshi E, Dawson K, Mitchell J, Arnold R, and Hodges JR. The Addenbrooke's Cognitive Examination Revised (ACE-R): a brief cognitive test battery for dementia screening. *International Journal of Geriatric Psychiatry*, 21: 1078-1085, 2006.

Morewedge CK, Gilbert DT, and Wilson TD. The least likely of times: How remembering the past biases forecasts of the future. *Psychological Science*, 16: 626-630, 2005.

Moscovitch M. Confabulation and the frontal systems: strategic versus associative retrieval in neuropsychological theories of memory. In HL Roediger & FI Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (pp. 133-160). Hillsdale NJ : Lawrence Erlbaum Associates, 1989.

Moscovitch M. Confabulation. In DL Schacter (Ed.), *Memory distortion: How minds, brains, and societies reconstruct the past* (226-251). Cambridge, MA: Harvard University Press, 1995.

Moscovitch M and Melo B. Strategic retrieval and the frontal lobes: evidence from confabulation and amnesia. *Neuropsychologia*, 35: 1017-1034, 1997.

Moulton ST and Kosslyn SM. Imagining predictions: mental imagery as mental emulation. *Philosophical Transactions of the Royal Society B*, 364: 1273-1280, 2009.

Murphy KJ, Troyer AK, Levine B, and Moscovitch M. Episodic, but not semantic, autobiographical memory is reduced in amnesic mild cognitive impairment. *Neuropsychologia*, 46: 3116-3123, 2008.

Nestor PJ, Graham KS, Bozeat S, Simons JS, and Hodges JR. Memory consolidation and the hippocampus: Further evidence from studies of autobiographical memory in semantic dementia and frontal variant frontotemporal dementia. *Neuropsychologia*, 40: 633–654, 2002.

Novelli G, Papagno C, Capitani E, Laiacona M, Cappa SF, and Vallar G. Tre test clinici di memoria verbale a lungo termine. Taratura su soggetti normali. *Archivio di Psicologia, Neurologia e Psichiatria*, 47(2): 278-296, 1986.

Nyberg L, Kim ASN, Habib R, Levine B, and Tulving E. Consciousness of subjective time in the brain. *Proceedings of the National Academy of Sciences of the United States of America*, 107(51): 22356-22359, 2010.

Okuda J, Fujii T, Ohtake H, Tsukiura T, Tanji K, Suzuki K, Kawashima R, Fukuda H, Itoh M, and Yamadori A. Thinking of the future and the past: The roles of the frontal pole and the medial temporal lobes. *Neuroimage*, 19(4): 1369-1380, 2003.

Petersen RC, Doody R, Kurz A, Mohs RC, Morris JC, Rabins PV, Ritchie K, Rossor M, Thal L, and Winblad B. Current concepts in mild cognitive impairment. *Archives of Neurology*, 58: 1985-1992, 2001.

Petersen RC, Smith GE, Waring SC, Ivnik RJ, Tangalos EG, and Kokmen E. Mild cognitive impairment: Clinical characterization and outcome. *Archives of Neurology*, 56: 303–308, 1999.

Petersen RC and Negash S. Mild cognitive impairment: An overview. *CNS Spectrums*, 13: 45–53, 2008.

Piolino P, Desgranges B, Benali K, and Eustache F. Episodic and semantic remote autobiographical memory in ageing. *Memory*, 10: 239–257, 2002.

Prabhakaran V, Smith JAL, Desmond JE, Glover GH, and Gabrieli JDE. Neural substrates of fluid reasoning: an fMRI study of neocortical activation during

performance of the Raven's progressive matrices test. *Cognitive Psychology*, 33: 43-63, 1997.

Race E, Keane M, and Verfaellie M. Medial temporal lobe damage causes deficits in episodic memory and episodic future thinking not attributable to deficits in narrative constructions. *Journal of Neuroscience*, 31(28): 10262-10269, 2011.

Randolph C, Tierney MC, Mohr E, and Chase TN. The repeatable battery for the assessment of neuropsychological status (RBANS): preliminary clinical validity. *Journal of Clinical and Experimental Neuropsychology*, 20(3): 310-319, 1998.

Rosen VM and Engle RW. The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, 126: 211-227, 1997.

Rosenbaum RS, Stuss DT, Levine B, and Tulving E. Theory of mind is independent of episodic memory. *Science*, 318: 1257, 2007.

Rosenbaum RS, Gilboa A, Levine B, Winocur G, and Moscovitch M. Amnesia as an impairment of detail generation and binding: Evidence from personal, fictional, and semantic narratives in K.C.. *Neuropsychologia*, 47(11): 2181-2187, 2009.

Rosenbaum RS, Carson N, Abraham N, Bowles B, Kwan D, Köhler S, Svoboda E, Levine B, and Richards B. Impaired event memory and recollection in a case of developmental amnesia. *Neurocase*, 17(5): 394-409, 2011.

Rowe J, Stephan KE, Friston K, Frackowiak R, Lees A, and Passingham R. Attention to action in Parkinson's disease: impaired effective connectivity among frontal cortical regions. *Brain*, 125: 276-289, 2002.

Samarasekera SR, Vincent A, Welch JL, Jackson M, Nichols P, and Griffiths TD. Course and outcome of acute limbic encephalitis with negative voltage-gated potassium channel antibodies. *Journal of Neurology, Neurosurgery and Psychiatry*, 78(4): 391-394, 2007.

Schacter DL, Norman K, and Koutstaal W. The cognitive neuroscience of constructive memory. *Annual Review of Psychology*, 49: 289-318, 1998.

Schacter DL and Addis DR. The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of The Royal Society B*, 362(1481): 773-778, 2007a.

Schacter DL and Addis DR. The ghosts of past and future. *Nature*, 445(4): 27, 2007b.

Schacter DL and Addis DR. On the constructive episodic simulation of past and future events, *Behavioural and Brain Sciences*, 30(3): 331-332, 2007c.

Schacter DL, Addis DR, and Buckner RL. Remembering the past to imagine the future: the prospective brain. *Nature Review Neuroscience*, 8: 657-661, 2007.

Schacter DL, Addis DR, and Buckner RL. Episodic simulation of future events. Concepts, data, and applications. *Annals of the New York Academy of Sciences*, 1124: 39-60, 2008.

Schacter DL and Addis DR. On the nature of medial temporal lobe contributions to the constructive simulation of future events. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364: 1245-1253, 2009.

Snowden JS, Griffiths HL, and Neary D. Semantic episodic memory interactions in semantic dementia: Implications for retrograde memory function. *Cognitive Neuropsychology*, 13: 1101-1137, 1996.

Spreng RN, and Levine B. The temporal distribution of past and future autobiographical events across the lifespan. *Memory and Cognition*, 34: 1644-1651, 2006.

Squire LR, van der Host AS, McDuff SGR, Frascino JC, Hopkins RO, and Mauldin KN. Role of the hippocampus in remembering the past and imagining the future. *Proceedings of the National Academy of Sciences of the United States of America*, 107(44): 19044-19048, 2010.

Squire LR, McDuffb SG, and Frascino JC. Reply to Maguire and Hassabis: autobiographical memory and future imagining. *Proceedings of the National Academy of Sciences*, 108(11): 40, 2011.

Suddendorf T and Corballis MC. Mental time travel and the evolution of the human mind. *Genetic, Social & General Psychology Monographs*, 123(2): 133-167, 1997.

Suddendorf T. Foresight and evolution of the human mind. *Science*, 312(5776): 1006-1007, 2006.

Suddendorf T and Corballis MC. The evolution of foresight: What is mental time travel, and is it unique to humans? *Behavioural and Brain Sciences*, 30(3): 299-351, 2007.

Suddendorf T, Addis DR, and Corballis MC. Mental time travel and the shaping of the human mind. *Philosophical Transactions of The Royal Society B*, 364: 1317-1324, 2009.

Suddendorf T. Episodic memory versus episodic foresight: similarities and differences. *Wiley Interdisciplinary Reviews Cognitive Science*, 1: 99-107, 2010.

Summerfield JJ, Hassabis D, and Maguire EA. Differential engagement of brain regions within a 'core' network during scene construction. *Neuropsychologia*, 48(5): 1501-1509, 2010.

Szpunar KK, Chan JC, and McDermott KB. Contextual processing in episodic future thought. *Cerebral Cortex*, 19: 1539-1548, 2009.

Szpunar KK. Episodic future thought : an emerging concept. *Perspectives on Psychological Science*, 5(2): 142-162, 2010.

Szpunar KK. On subjective time. *Cortex*, 47(3): 409-411, 2011.

Szpunar KK, Watson JM, and McDermott KB. Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences*, 104: 642-647, 2007.

Szpunar KK and McDermott KB. Episodic future thought and its relation to remembering: Evidence from ratings of subjective experience. *Consciousness and Cognition*, 17: 330-334, 2008.

Talland GA. *Deranged memory* . New York: Academic Press, 1965.

Thaiss L and Petrides M. Autobiographical memory of the recent past following frontal cortex or temporal lobe excisions. *European Journal of Neuroscience*, 28: 829-840, 2008.

Thomas AK, Bulevich JB, and Loftus EF. Exploring the role of repetition and elaboration in the imagination inflation effect. *Memory and Cognition*, 31: 630-640, 2003.

Tolman EC, Ritchie BF, and Kalish D. Studies in spatial learning. I. Orientation and the short-cut. *Journal of Experimental Psychology*, 36: 13-24, 1946.

Trope Y and Liberman N. Temporal construal. *Psychological Review*, 110: 403-421, 2003.

Tulving E. Episodic and semantic memory. In Tulving E, and Donaldson W (Eds.). *Organization of memory*. New York: Academic Press, 381-403, 1972.

Tulving E. Memory and consciousness. *Canadian Psychology*, 26(1): 1-12, 1985.

Tulving E. Episodic memory: From mind to brain. *Annual Review of Psychology*, 53: 1-25, 2002.

Wheeler MA, Stuss DT, and Tulving E. Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. *Psychological Bulletin*, 121(3): 331-354, 1997.

Williams JMG, Ellis NC, Tyers C, Healy H, Rose G, and MacLeod AK. The specificity of autobiographical memory and imageability of the future. *Memory and Cognition*, 24(1): 116-125, 1996.

Zeman AZJ, Beschin N, Dewar MT, and Della Sala S. Imagining the present: amnesia may impair descriptions of the present as well as of the future and the past. *Cortex*, submitted.

Appendix A

The modified version of the MCQ questionnaire (see D'Argembeau & van der Linden, 2004).

| | | | | | | | |
|---|--------|---|---|---|---|------------|---|
| Visual details: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | No one | | | | | A lot | |
| Sounds: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | No one | | | | | A lot | |
| Smells/Tastes: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | No one | | | | | A lot | |
| Clarity of location: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Vague | | | | | Clear | |
| Clarity of spatial arrangement of objects: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Vague | | | | | Clear | |
| Clarity of spatial arrangement of people: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Vague | | | | | Clear | |
| Clarity of temporal connotation of the event: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Vague | | | | | Clear | |
| Clarity of the event overall: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Vague | | | | | Clear | |
| Feeling of experiencing the event: | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | No one | | | | | Strong | |
| How often do you have experienced in the past the same or a very similar event? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Never | | | | | Very often | |