

Touching the void

***– first and third person perspectives in two cases of autobiographical
amnesia linked to temporal lobe epilepsy***

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Abstract

Temporal lobe epilepsy (TLE) can be associated with a marked impairment of autobiographical memory. This is occasionally its presenting feature. We describe two individuals with severe epilepsy-associated autobiographical memory loss. Both MB and PT were reassured initially that their memory was intact on the basis of standard neuropsychological tests. Both have written detailed accounts of their symptoms. The key neuropsychological features of their cases are the relative normality of performance on standard memory tests, with preservation of semantic memory for impersonal information, in contrast to a profound amnesia for salient autobiographical episodes and an impoverishment of imaginative scene construction. First person accounts from these individuals illustrate the importance of autobiographical memory in sustaining a coherent sense of self, informing interpersonal relationships and supporting future thinking and problem-solving. These cases contribute to the growing evidence for a distinctive pattern of autobiographical memory loss associated with TLE, and indicate that it can take a severe form affecting both personal semantics and episodic recollection. Defining the phase of memory processing most relevant to this form of amnesia, and the roles of physiological and structural pathology, requires further research. The paper's title refers to the introspective 'void' highlighted by both MB and PT in their reports – in PT's words: 'My primary symptom is the void that is my past'.

Keywords: amnesia, autobiographical, epilepsy, temporal lobe, transient epileptic amnesia

Highlights

Temporal lobe epilepsy can cause profound autobiographical amnesia (AbA)

Performance on standard memory tests may be normal

The AbA impacts sense of self, interpersonal relationships and future planning

Epilepsy-related AbA can be mistaken for dissociative or 'psychogenic' amnesia

1 Introduction

'My primary symptom is the void that is my past'

Two accounts can be given of every human disorder. The first evokes the sufferer's experience, describing the 'view from within'. Such 'autopathographies' have become a recognised genre of medical narrative over the past half century, perhaps in response to the increasingly technical and dispassionate nature of contemporary medicine (Hawkins, 1999; Kapur, 1997; Kearney, 2006; O'Brien, 2010). The second form of account, the kind typically found in scientific journals, maps a disorder's clinical features, using terms designed to facilitate diagnosis, treatment and research. Clinicians are well used to translating informal first person accounts into clinical terms in the course of medical care. Once in a while, they deserve to be published in their own right.

The first author was contacted via our epilepsy-memory project website (<http://projects.exeter.ac.uk/time/>) by two patients who had independently come to the conclusion that their profound autobiographical memory loss might be linked to their relatively subtle epilepsy. There was a striking convergence of themes and conclusions in the two accounts. The aim of this paper is to describe these patients' disorders using both first and third person approaches, summarising the key themes of the first-hand accounts and mapping the objective features of their amnesia, before situating their disorders in the wider landscape of autobiographical memory disorders.

The neuropsychological profile of their amnesia - with normal or only mildly abnormal anterograde memory on standard tests but profound autobiographical amnesia in association with temporal lobe epilepsy - is relatively novel but echoes other recent descriptions (Noulhiane et al., 2007; Butler & Zeman, 2008b; Milton et al., 2010; Zeman, Butler, Muhlert, & Milton, 2013; Addis, Moscovitch, & McAndrews, 2007; Tramonì et al., 2011; Hornberger et al., 2010).

2 Materials and Methods

2.1 Participants

Clinical summaries

Case i: PT is a 51 year old senior academic working in the Sciences. Following a successful career at college and graduate school, from which he graduated summa cum laude, he has taught in several University positions, and is currently head of his department. At around the age of 10, he had the first attack of a kind that has continued intermittently throughout his life. He feels hot or clammy, has a sense of fear or dread, remains aware of his surroundings but finds it hard to interpret or react to what he can see and hear and becomes unable to communicate. These episodes last for a minute or two. Observers have reported that his eyes remain open, he has occasionally stumbled or dropped on all fours and has rubbed his stomach with one hand. 'Psychomotor epilepsy' was diagnosed in his early teens and he was treated for a few years with Phenytoin which was effective. The attacks recurred in his early twenties, off treatment, occurring from then on at least once every few months, but he did not recognise their connection with his previous malady. At the age of 44 he had an episode at the wheel in which he came close to losing control of his car. A neurologist diagnosed temporal lobe epilepsy (TLE) and prescribed Oxcarbazepine which PT continues to take, with no further seizures until a single, recent, typical, episode. Following the diagnosis, PT became increasingly aware of a memory problem which he believes had been present at least since his teens, and possibly lifelong, but which

he had so far as possible ignored: a profound amnesia for autobiographical episodes. He also reports that his memories for recent events fade more rapidly than one would expect, so that he becomes unable to recollect their experiential details over days or weeks. He has always had an exceedingly poor memory for what should be very familiar routes. The results of his early EEGs are unavailable. Recent EEGs (2010/11) and structural MRI scans of the brain have been normal. Neuropsychological evaluation at a University medical centre in 2011 was normal with the exception of qualitative difficulty in recalling autobiographical episodes. PT performed normally on standard neuropsychological tests in a second comprehensive evaluation at another centre (University of California, San Francisco (UCSF)) in 2014, generally scoring within normal limits with the exception of measures of autobiographical memory (see Supplementary Material for detailed neuropsychological results).

Case ii: MB is a 78 year old retired IT systems analyst who grew up in the United Kingdom, studying Mathematics at Oxford University, before emigrating to the US in his early twenties, where he worked in the IT industry. He suffered from migraine as a child. In 1981, at the age of 42, he had a brief episode of speech arrest witnessed by his sister. Some weeks later he went on to have a witnessed tonic-clonic seizure without warning, dislocating his shoulder. Brain MRI was normal but an EEG showed evidence of a temporal lobe epileptic focus, which a subsequent recording suggested was right-sided. He was treated with Phenytoin. In 1986 he had a further tonic-clonic seizure preceded by a brief, nondescript, aura. At around the same time he developed a mood disorder, treated with Sertraline. An EEG in 2000 showed 'slow sharp complexes' arising independently from both hemispheres in the fronto-temporal regions, consistent with an 'irritative or paroxysmal disorder'. In 2007, at the age of 69, he became aware, for the first time, of a profound amnesia for autobiographical episodes, affecting at least 30 years of his adult life. Like PT, he also noticed that his memories for recent events were fading more rapidly than he would expect, so that he became unable to recollect their details over days or weeks. His recall for previously familiar routes was impaired. His memory for news events was relatively intact. Despite these pronounced memory symptoms, a formal neuropsychological assessment undertaken at an Alzheimer's Disease Centre concluded that 'cognitive functioning, including general memory, is in the normal range'. In the same year, he noticed a marked reduction in his sense of smell, which has persisted. In 2009 he had a second episode of major mood disorder, and was treated with several psychotropic medications, from which he successfully withdrew in 2012, with the exception of Sertraline which he continues to take. Lamotrigine was substituted for Phenytoin and subsequently discontinued. Between 2010 and 2013 he had six episodes of transient amnesia with disorientation, all on waking from sleep, lasting for around half an hour, without repetitive questioning. An EEG in 2011 showed some non-specific slowing of activity over the left temporal lobe. A further MRI scan of the brain performed in 2010 showed minor white matter changes and global atrophy, both considered age-appropriate. A second assessment at the same Alzheimer's disease Centre in 2011 again gave substantially normal results. MB performed poorly on one of three verbal memory measures in each of these assessments (immediate and delayed (11 minutes) story recall in 2007; short (circa 1 minutes) and long (circa 11 minutes) delay recalls of a word list in 2011), but normally on the remaining measures on each occasion. Assessment at UCSF in 2013 showed a flattened verbal learning curve. Taken together these neuropsychological results suggest a somewhat inconsistent, mild, stable anterograde verbal memory impairment (see Supplementary Material for detailed neuropsychological results). His most recent MRI scan of the brain showed generalized age-appropriate atrophy, with

slightly more prominent volume loss in the anterior hippocampi, and no evidence for hippocampal sclerosis. He has recently resumed treatment with Lamotrigine.

2.2 Methods

2.2.1 The patient's accounts

We have extracted the principal themes of MB's and PT's accounts of their distinctive pattern of amnesia, and provide illustrative examples of their writings below. The original documents are supplied as Supplementary Material. MB has written several accounts of his amnesia, of varying length: the document available on-line is a wide-ranging memoir of his experience. In contrast, PT used the document reproduced here to record examples of his memory difficulties as these occurred: his writings are therefore closer to the raw experience of his amnesia and less selective than MB's. PT's writings have been edited lightly to preserve anonymity. MB can also be seen giving a summary version of his memoir at <http://millvalleylibrary.net/nakedtruth/marcus-byruck/>.

2.2.2 Neuropsychological assessment (administered October 2012)

The National Adult Reading Test (Nelson HE & Willison J, 1991) was used to obtain a measure of premorbid IQ. The Wechsler Abbreviated Scale of Intelligence (WASI) was used to assess current IQ (Wechsler D, 1999). The Addenbrooke's Cognitive Examination-Revised (ACE-R) (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006) was administered as a widely used screening test of general cognition.

Verbal learning and accelerated long-term forgetting were assessed using a word list from the Rey Auditory verbal Learning Test (RAVLT) (Schmidt M, 1996) which was administered repeatedly (up to a maximum of ten trials) until recall was at a minimum of 80% (12/15 words). Recall was checked after a 40 second distraction period spent counting backwards from 100, and again after 30 minutes and 1 week. The patients' performance was compared to performance in separate groups of age and IQ matched participants ('RAVLT controls': n = 12 and 17 respectively for MB and PT).

Autobiographical memory was assessed using the Modified Autobiographical Memory Test (MAMI) (Butler et al., 2007), which samples semantic and episodic information from each decade of life, using pre-specified topics (ie 'a change of job in your twenties'), and the Autobiographical Interview (AI) (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002), a test designed to elicit and score autobiographical information in as much detail as possible. Careful attention is paid, during scoring of the AI, to the distinction between 'internal' and 'external' details. Internal details are defined as 'those that pertained directly to the main event described by the participant, were specific to time and place, and were considered to reflect episodic re-experiencing' (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). External details include semantic information, repetitions and details of events other than the one chosen for narration. In addition to scoring for internal and external details, memories are rated for specificity of place (/3) and time (/3), perceptual richness (/3), description of emotions and thoughts (/3), integration into a broader time scale (/3) and episodic richness (/6), giving a maximum score of 21 (we chose not to include the 'AMI' score in the ratings to facilitate comparison with the data of Milton et al, 2010). We calculated mean scores across all episodes for the MAMI, which is a constrained task, whereas for the AI we took into account only decades for which a memory could be retrieved. Given the patients' complaints of very markedly depleted recollection of even

highly salient memories, 'Flashbulb memory' was also assessed by asking MB and ST about their recollection of hearing the news of 9/11. Their performance on the MAMI and AI was compared to performance by the age and IQ matched participants reported in Butler et al (Butler et al., 2007) and Milton et al (Milton et al., 2010) respectively. Their recollections of the events of 9/11 were compared to that of their spouses.

In view of the accumulating evidence that memory and imagination share common processes, and of the participants' observation that tasks requiring imagination are challenging for them, we assessed imaginative and future thinking using four of the eight 'imaginary' scenarios from Hassabis et al (Hassabis, Kumaran, Vann, & Maguire, 2007) and the two 'future-thinking' prompts. We followed the protocol described by those authors in all other respects, and compared our patients' performance with the results reported there. We report the 'experiential index', which gives a measure of the 'overall richness of the imagined experience' based on four sub-scores for content, quality (both scored by the rater), perceived vividness and spatial coherence (based on participant ratings), together with the spatial coherence index separately.

As both MB and PT report that their memory for facts is spared, we assessed semantic memory using a New Words Acquisition Test (Milton et al., 2010) which probes knowledge of words which have entered common usage during the last six decades, and a 'Dead or Alive Test' (Manns, Hopkins, & Squire, 2003 adapted from Kapur, Young, Bateman & Kennedy, 1989) designed for use in the United States and which requires participants to indicate whether names are famous or non-famous and, if famous, whether their owners are alive or dead. We compared the patients' performance on the New Words Acquisition Test with the results reported by Milton et al (Milton et al., 2010), and their performance on the Dead or Alive Test with that of their spouses. As IQ and media exposure both influence knowledge of public events (Kapur, Thompson, Kartsounis & Abbott, 1999) we asked MB, PT and their spouses to rate both their level of interest in public events and to what extent they are well informed about these on a five point scale (not at all, a little, moderately, more than most, extremely). MB and his spouse are both educated to degree level and both describe themselves as 'moderately' interested in and well informed about public events; PT and his spouse have 21 and 18 years of education respectively, and while PT describes himself as 'extremely' interested in and well-informed about public events, his spouse is 'moderately' interested in them and 'better informed than most'.

The Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983) was used to assess mood.

2.2.3 Statistics

We used modified t-tests for use with single-case data (Crawford & Garthwaite, 2002) to compare patient and control data.

3 Results

3.1 *The patients' accounts: the view from within*

What has been lost?

Although both MB and PT are able to recall their *curricula vitae*, they report a profound loss of recollection for autobiographical episodes, including major events such as their own weddings, the

births of their own children, family reunions, holidays and serious accidents (among them a car crash), and more minor, but typically recollected events and episodes such as novels read, films watched, recent meals and important conversations. PT writes: 'I cannot even fathom being able to remember what movies I watched one year ago'. MB, who has no prior acquaintance with memory science, devised a test to determine whether he 'really remembered an incident', as against remembering a frequently revisited record of the incident, such as a photograph: he asked himself whether he could recollect any contextual information, for example what happened just before or after the recorded event, or any related feelings. Without exception he was unable to do so for events which were more than a few weeks old. PT, similarly, finds himself unable to recollect the temporal, spatial or sensory details of past events. Both MB and PT find it difficult to date memories that are more than a few weeks old: MB in particular describes a 'reverse telescoping' such that recent events appear much more remote. They both report an almost complete lack of 'spontaneous memories', memories which enter the mind unbidden. Both record that reading written accounts of their lives, such as their diaries, or reviewing family photos is 'pretty much like finding out about someone else's life' - like learning about the biography of a stranger. They differ, however, in one important respect. While PT believes that his episodic memory has always been as it is now, MB is certain - and his wife confirms - that he once remembered events, for example events from his first marriage, which he no longer recalls, suggesting some 'retroactive' element in his condition.

What brings the loss to light?

One of MB's accounts of his memory loss is entitled 'Remember that time when...', as invitations to reminisce tend - naturally enough - to highlight his impairment. PT records similar experiences, but in the list of his 'retrieval failures', which he made prospectively, he notes numerous other situations in which his episodic memory is challenged and found wanting - for example, by students with whom he has had recent conversations or email exchanges, colleagues discussing faculty business, alumni returning to the campus, doctors requesting details of previous symptoms, family members discussing previous exchanges of gifts and shared experiences.

Metaphors for amnesia

Both MB and PT independently describe their experience of autobiographical recollection as akin to probing a void: MB writes 'my memory of much of my past [was] ... black space. That's why I feel lost and hopeless when groping for a memory. I'm trying to explore a void', and elsewhere 'I still get swept away trying to locate a real memory of past times, and hit the black void...'. PT echoes his words: 'my experience of this difficulty is that my past seems like a void', 'my primary symptom is the void that is my past'. PT goes on to provide an evocative simile for his memory problem and his difficulty in appraising this: 'My current analogy for this experience is that it is a bit like standing on the edge of a meadow at dusk. As it is getting darker, people see less and less. I stand there seeing very, very little. Yet others have difficulty too....How do you quantify the void, what you cannot see?'. On the rare occasions when PT has fragmentary images of past experiences, 'it is as though I am looking through incredibly opaque glass that eliminates all details (including colours)'. Both MB and PT also use metaphors to describe their accelerated forgetting of recent events. MB visualises 'my memories as a continuous flow of ships, some sturdy, some less so than others, which ... [head out] ... into the eye of a storm; look up, and they've disappeared ... or they're still there, but fainter... look up again, and they're gone; the horizon's empty; they've disappeared, never to be seen again.'. Elsewhere MB uses

the sinister analogy of a 'memory eraser', which he fears is drawing closer: 'It is as if...an eraser has been following me at a distance, quietly deleting my daily experiences...I have noticed though that the distance I can see in the past – that is the memory I have of it – is getting shorter; the eraser is definitely getting closer ... my biggest fear...'. PT suggests 'it is as if my car's rear view mirror is broken; I can't see much of where I've been. I can see what is right behind me, but beyond that things are just grey'.

What is retained?

Both MB and PT note that their memory for facts, if repeated, and for repeated events, is far superior to their memory for single events. This is particularly striking in PT's case, as his memory for facts was strong enough to allow him to achieve high academic honours and establish an academic career despite a marked impairment of episodic memory from, at least, his teenage years. He describes a learning style which encourages repetition and reinforcement: he likes to consult several sources simultaneously. His continuing ability to learn new factual information, combined with the strategies mentioned below, enables him to function at a high level at work, albeit precariously at times. MB notes that despite the relative sparing of his memory for facts, in the absence of episodic recollection, my 'knowledge of places...is less vivid' and my 'knowledge base is also being somewhat atrophied from not being refreshed'. PT describes some 'fragmentary' visual memories, possible 'snapshots' of past experiences, but is uncertain of the veracity of these.

Reinventing memory science

While PT has spent considerable time reading the academic literature about his condition over the last couple of years, and is thus conversant with the research, MB has not. MB's writings are remarkable for their thoughtful delineation, from first principles, of many of the key distinctions used in contemporary memory science, some of which he later encountered as he began to research his own disorder. He arrives at the distinction between procedural and declarative memory: 'I am like someone who can play the piano ... but cannot evoke the memories of the ... lessons'. He distinguishes 'access' and 'storage' explanations for his episodic amnesia, considering various approaches to distinguishing these including the use of cues and the examination of dreams. He produces a taxonomy of 'second hand memories' which can masquerade as genuinely episodic ones, derived from i) photos, ii) repeated discussions of past events or iii) inference from various kinds of current evidence. He notes that once created these second-hand memories can 'take on a life of their own'. He gives an exemplary description of accelerated long-term forgetting: 'I do make a short-term memory of an event normally, because I can still recall recent events, but as soon as time progresses and my memories are transferred into longer-term memory ... I can no longer retrieve them. They're as lost as the memories of the previous forty years'. He distinguishes his 'personal biography' - which is roughly intact – from his record of individual experiences – which is not. He finds the distinction between episodic and semantic memory particularly resonant, as does PT, as it enables him to capture the essence of his impairment, 'the loss of decades of episodic memories', in contrast to the sparing of the 'semantic ... knowledge extracted from our life experiences'.

The impact of the loss

PT and MB describe the impact of their loss in similar terms. Their accounts touch on six main areas:

i) *Weakened sense of self*: both MB and PT describe a sense of estrangement from their past selves, caused by their inability to recall specific episodes which would exemplify the kinds of people they are and the activities they like to engage in. PT, for example, writes: 'I just don't have the knowledge of my own past, the ... the 'moorings' that others can draw upon to remind them of who they really are. I have working assumptions about who I am, but for the most part I cannot produce evidence from my past to back up those working assumptions'.

ii) *Impaired social relationships*: PT writes that his impairment quite markedly affects the quality of his relationships. 'I feel extremely disconnected from the past', and 'once I leave a place, I virtually never stay in touch or maintain contacts....I suspect that I don't really have a choice in the matter. That is, I can't remember shared experiences'. An amusing corollary is that 'I'm particularly good at 'forgive and forget' or in my case 'forget and forgive'...I don't harbour a grudge, because I don't have painful memories about previous encounters'. MB describes the effects of his impairment in similar terms: 'As a result of losing the common past I shared with friends and family, in some mysterious way a barrier has come down between us...I feel less 'connected' to them, as if somewhat forced to live in a world of my own, as a deaf person might'. Elsewhere MB describes a 'lack of texture, an emptiness' in his relationships.

iii) *Feeling isolated*: Both MB and PT describe a strong emotional reaction to their predicament, of which the most abiding element is their sense of isolation. Both feel that their lack of autobiographical episodic memory has a pervasive effect on their experience, but this is difficult to convey to others as their everyday functioning is so good: 'this disability is bizarre and difficult to explain, and for others to believe. It's proved hard for others to really comprehend and accept it'. PT echoes these words: 'I'm just not sure that most people can understand what it means to have virtually no episodic memory'. He believes that his emotions are swayed more markedly than they otherwise would be by recent events, in the absence of a buffering effect from a memory of more remote ones. MB describes periods of grief, frustration and anger and laments the loss of the 'self-nourishment' that episodic memories provide.

iv) *Insecurity about autobiographical memories*: PT describes the undermining effect of his lack of episodic recollection on his confidence in the veracity of his well-worn stories about past episodes - 'without having episodic memories about them, I'm left wondering about their truthfulness'. His semanticised memories lack authenticity.

v) *Impaired planning and decision making*: While both PT and MB are able to summon imagery to the mind's eye, both suspect that their depleted stock of episodic memories has impaired their ability to plan. MB writes: 'Until I suffered this loss I didn't realise to what extent our lives are informed by the past...Making any kind of informed decisions in the present is much harder when it's not possible to recall what was satisfying in the past'. PT writes that certain kinds of tasks, particularly open-ended ones for which no pre-existing structure will guide the solution, defeat him: 'I just felt like I'd hit an impasse. I got that 'butterflies' feeling in the pit of my stomach that you get when something just utterly and completely vexes you...'

vi) *Concerns about progression*: MB was concerned initially that he might be suffering from dementia. He remains concerned, despite stable bedside testing, that the period over which he can retain memories is shrinking and that this may increasingly 'imprison him in the present'. For PT, given the

gradual dawning of his realisation that his autobiographical memory was poor and always had been, such concerns were more muted.

Coping strategies

Both MB and PT report embarrassment and difficulty in social situations which call for recollection. MB writes: 'Though I can appear to be part of such a conversation, I can't really contribute anything to it. I don't have the faintest thread that would lead me back to the experience being discussed ... I notice myself intentionally avoiding those ... conversations or, if caught, I notice now that I sidestep them ... or try to contribute to the conversation in some other way. I try to guide the conversation away from that area or conversationally pass the ball to others.'. Both MB and PT report that at times when they don't wish to acknowledge or discuss their problem, they will try to 'fake it' - not always successfully. PT writes at length of his coping strategies: 'I honestly find myself constantly thinking about how to engineer my environment to compensate for my faulty memory'. These methods range from a reliance on routine, liberal use of notes, frequent prompts from his secretary, encouragement of colleagues to keep him updated, flashcards filled out by his students to electronic alarms, and a searchable email archive. These strategies come close to creating a fully-fledged artificial memory which, it turns out, both MB and PT have envisaged.

Prosthetic memory

Both MB and PT feel some compulsion to document their lives by artificial means, recreating, in a sense, the autobiographical memory they lack. PT took up the hobby of photography to do so. MB describes a more elaborate project, an attempt to 'reconstruct' his life, involving the digital collation of memorabilia, documents, genealogical information, CVs, appointment books, diaries, journals, videos, audio tapes and 'hundreds of photographs'. While these make it possible to 'review' episodes from the past that neither MB nor PT can recall, the effort is in a way frustrating, as the review lacks the normal 'warmth' of recollection. Both MB and PT report that they can capture some of that warmth with the help of highly evocative, emotional stimuli which fail to trigger specific recollections but nevertheless convey them into a 'generic past'. In MB's case familiar poems, in particular, have this quality of 'resonance and poignancy'. For PT music has a similar effect, and he listens especially to music with a 'strong element of 'high school-ness' which allows him to enjoy a kind of 'emotional re-experiencing [of] that era...When you're otherwise hard-pressed to remember episodes from large chunks of your life, that's no small thing. I have music that reminds me of college and childhood as well.'

A final resource deserves a mention. Both MB and PT have always regarded their wives' episodic memories as exceptional. They have come to recognise that this partly reflects their own difficulties in this domain. Nevertheless, each relies heavily on his partner's ability to recollect his own and his family's past.

3.2 Neuropsychological results:

3.2.1 IQ and ACE-R

In keeping with their educational and professional attainments, estimated IQs were 122 (MB) and 124 (PT). Full scale IQs, assessed using the WASI, were 127 and 124. MB scored 30/30 on the MMSE,

96/100 on the ACE, including 26/26 on the measures of memory, with 10/10 for delayed recall. PT's corresponding scores were 30/30, 97/100, 24/26 and 9/10. These scores are well within normal limits.

3.2.2 Long term forgetting (RAVLT)

On the RAVLT, MB and PT reached the criterion of 80% correct recall in 4 trials, recalling 12/15 (80%) and 13/15 (87%) words respectively after a filled delay of 40 seconds. There were no significant differences between MB and the age and IQ matched RAVLT controls or between PT and the controls in the number of trials required to reach criterion, or on their scores at the final learning trial, after 40s, 30 minutes or 1 week. Both forgot more information between 30 minutes and 1 week than average (z scores – 0.53 and – 1.43 for MB and PT respectively) but neither value reached significance (see Supplementary Material).

3.2.3 Autobiographical memory: Modified Autobiographical Memory Interview (Figure 1 and Supplementary Material)

MB's episodic memory scores were significantly lower than those of the MAMI controls ($p < 0.001$) and, in fact, than those of TEA patients ($p < 0.01$). His autobiographical semantic scores were also significantly lower than those of the controls ($p < 0.001$).

PT was impaired by comparison with MAMI controls on the episodic ($p < 0.001$) but not the semantic element of the MAMI, with relative sparing of the first two and the current decades of life.

3.2.4 Autobiographical memory: Autobiographical interview (Figure 2 and Supplementary Material)

All memories were scored by the first author and a second, highly experienced, rater. Inter-rater reliability was high as evinced by correlations of 1.0 for internal details and 0.94 for ratings.

MB: MB's mean score for total internal details for all decades prior to the current (17.25) is significantly below the mean score of healthy control participants (mean 58.0, sd 7.9, $p < 0.001$) and somewhat, but not significantly lower than the mean score of patients with TEA (mean 30.8 internal details, sd 13.2, $p = 0.170$, control data from Milton et al, 2010). His score for the current decade, relating to an event that had occurred about two weeks before (54), is intermediate between the mean score in the healthy control group (79.58, sd 22.09) and the TEA group mean (41.43 sd 11.45), but not significantly different from either. This was the only memory which, he felt, transported him back to the context of the event so that he could 'remember what it was like to be there'. However, one year after this event, he had no recollection whatsoever of its occurrence. This pattern of results is reflected in the rating scores: for decades prior to the current, MB's mean score (8.5) is significantly lower than the score obtained by control participants (mean control rating 17.9, sd 0.97, $p < 0.001$) and somewhat, but not significantly lower than the mean score of patients with TEA (mean TEA patient rating 12.7, sd 3.15, $p = 0.220$). For the current decade, MB's rating of 16 is lower than the control value (mean 20.83, sd 0.39, $p < 0.001$) and close to the TEA group mean (16.29, sd 2.998).

PT: PT's mean score for total internal details for all decades prior to the current (15.5) is well below the mean scores of healthy control participants ($p < 0.001$) and somewhat, but not significantly, lower than the scores of patients with TEA ($p = 0.142$). His score for the current decade (46), relating to an event that had occurred one week before, is intermediate between the healthy control group and the

TEA group means, but not significantly different from either. As was the case for MB, this was the only memory which clearly transported him back to the context of the event so that he could 'remember what it was like to be there'. One year later his score for this event was very similar to his mean scores for remote events. This pattern of results is again reflected in the ratings scores, with a significantly lower mean rating for decades prior to the current (8) than in controls ($p < 0.001$) but not in patients with TEA. For the current decade, his rating of 15 is lower than the control value ($p < 0.001$) and close to the TEA group mean.

3.2.5 Flashbulb memory

Both participants were asked if they could remember when they first heard the news of the 9/11 attack on the Twin Towers in 2001. They both recollected the essential facts of the attack. PT had no clear recollection of hearing this news, but believed that he was at home when a news announcement cut into the programming. He could not recall who else was in the house at the time or any other events from the day. MB had no recollection whatsoever of hearing the news for the first time. Both spouses, in contrast, had detailed recollections of the circumstances in which they first heard the news, their company at the time, their thoughts and feelings and the actions that the news caused them to take.

3.2.6 Imagination (Figure 3)

PT's mean experiential index, 24.6/60, is significantly below the control mean reported by Hassabis et al (2007) of 45.1/60 (sd 4.02, $p < 0.001$), and similar to the reported mean of 27.5/60 (sd 13.12) for amnesic subjects. MB found the imagination and future thinking task difficult and unpleasant, but achieved a score (22.2) similar to PT's mean score, in the single scenario he attempted. PT's mean spatial coherence index (-5), which was identical to the score for MB's single completed scenario, is, similarly, significantly lower than the control mean of 3.68 (sd 1.3, $p < 0.001$) but not significantly different from the patient mean of 0.1 (sd 3.21).

3.2.7 New words

MB scored 76/84 (0.90) on the new word definition recall test, 37/42 (0.88) on the new word definition recognition test; PT scored 72/84 (0.86) and 40/42 (0.95) respectively. IQ matched control means from Milton et al 2010 were 0.73 and 0.88. Thus MB and PT performed above control means on this test.

3.2.8 Dead or alive

On this demanding test, MB and PT outperformed their spouses, correctly identifying names as famous/not famous in 245/252 (97.2%) and 235/252 (93.2%) cases vs 213/252 (84.5%) and 231/252 (91.6%) in their spouses. The corresponding values for correct 'Dead or Alive' judgements (for those names correctly identified as famous) were 106/120 (88%) and 83/109 (76%) vs 63/103 (61%) and 78/111 (70%).

3.2.9 HADS

PT scored 3/28 on the anxiety scale of the HADS, 0/28 on the depression scale, both well within normal limits. MB scored 12/28 on the anxiety scale, which is in the abnormal range (> 10), 9/28 on the depression scale which is in the borderline range (10-12), in keeping with his history of mood disorder.

4 Discussion

4.1 Main findings

MB and PT give eloquent descriptions of an unusual form of memory loss, which partially spares memory for recent events, and permits effective functioning in intellectually demanding roles, yet leads to loss of recall over extended intervals and devastates remote autobiographical recollection. A similar pattern of impairment has been described recently in other patients with temporal lobe epilepsy, especially patients with Transient Epileptic Amnesia (Addis, Moscovitch, and McAndrews 2007; Butler and Zeman 2008; Hornberger, Mohamed, Miller, Watson, Thayer, and Hodges 2010; Milton et al. 2010; Noulhiane, Piolino, Hasboun, Clemenceau, Baulac, and Samson 2007; Tramonì et al. 2011; Zeman, Butler, Muhlert, and Milton 2013). Here we consider in turn the pattern of memory impairment, its impact and its interpretation in the light of the existing literature.

4.2 *The pattern of memory impairment*

Both MB and PT were initially reassured, on the basis of standard tests of recall and recognition, that their memories were essentially normal. This does not of course prove that their anterograde memories are entirely or consistently normal, and more demanding tests might have revealed shortcomings: indeed it is clear from their autobiographical memory scores that over extended intervals their anterograde memory is severely impaired. Nevertheless, no marked memory impairment was apparent using widely accepted measures, and both MD and PT were dismayed by the discrepancy between their subjective impression that their memories were defective and the apparently normal results of objective testing. In contrast to the normal results of standard tests, both MB and PT perform very poorly, as would be expected from their testimony, on measures of autobiographical memory. Neither shows a clearly abnormal forgetting rate on the RAVLT over 1 week: more extended testing would be of interest. In contrast to the impoverishment of their autobiographical memory, both MB and PT report a relatively normal memory for facts, and PT in particular has noticed a considerable benefit from repetition. This is borne out by their performance on measures of semantic memory. The memory profile is thus one of substantially normal performance on standard anterograde memory tests, in the presence of a marked autobiographical amnesia, with suggestive evidence of accelerated long-term forgetting from their subjective accounts, but well preserved semantic memory. Both also complain of topographical memory impairment though this has not been formally assessed. MB, but not PT, believes that his autobiographical memory was once normal, and that he has lost a multitude of remote memories which were once vivid. In both MB and PT there is some evidence for an associated impairment of future thinking and imagination.

4.3 *The impact of the memory impairment*

Episodic memory enables us to adapt to a world that is both stable and changeful. Autobiographical memory in particular, helps i) to shape our knowledge and sense of ourselves, ii) to mediate interpersonal relationships, and iii) to supply knowledge of the past that allows us to envision and plan for the future (Kihlstrom, 2009; Routledge, Sedikides, W, Wildschut, & Juhl, 2013; Pillemer DB & Kuwabara KJ, 2012; D'Argembeau A, 2012). The accounts by MB and PT illustrate each of these functions.

i) They describe a disconcerting impoverishment of recollection that makes facts about their own pasts feel equivalent to facts about a stranger's past. This, in turn, reduces their confidence in their self-knowledge, reflecting the loss of what William James described as the 'warmth and intimacy' that characterises those memories '“appropriated” by the thinker as his own'(James, 1890). If 'episodic memory is normally infused with 'consciousness of the self as the one who experienced the event and possesses the memory' (Moscovitch M, 2012), it is understandable that such a severe depletion of episodic memory should impoverish the experience of the self, just as MB and PT describe. Loss of the ability to reminisce deprives them of the psychological benefits of 'nostalgia'(Routledge, Sedikides, W, Wildschut, & Juhl, 2013), most notably its capacity to 'imbue life with purpose and meaning'.

ii) Their accounts point to an especially critical role for episodic autobiographical memory in tracking changes in the social world. Both report that they are embarrassed in social situations which involve shared acts of recollection, and feel isolated by their inability to participate fully in these. PT describes a resulting loss of motivation to maintain long-term social relationships outside his immediate family.

iii) They both describe a reduction in their capacity for imaginative thinking about the future, and open-ended problem solving. Their markedly impaired performance on measures of imagination and future thinking is in keeping with their accounts. These observations echo the growing evidence that recollection of the past and contemplation of the future are closely interlinked at both cognitive and neural levels(Hassabis, Kumaran, Vann, & Maguire, 2007; Addis, Wong, & Schacter, 2007), and that amnesia impairs the ability to plan and problem solve effectively(Sheldon, McAndrews, & Moscovitch, 2011). It is of interest that imagination and future thinking should be impaired in individuals whose memory impairment only becomes apparent at extended intervals.

4.4 *The interpretation of the memory impairment*

The pattern of memory impairment in these patients and others like them raises several questions of interpretation which we discuss below in turn.

4.4.1 *What is the neuropsychological basis of the deficit?*

There are two main competing explanations for the pattern of memory impairment described here, involving relatively well preserved anterograde memory on standard memory tests, with fading of memories over longer intervals and depletion of the autobiographical store. The most natural explanation is in terms of a disturbance of processes of consolidation that operate over these intervals, combined, possibly, with a retroactive 'erasure of previously well-established memories, particularly suggested by MB's account. Candidate targets for the disruption of later phases of consolidation include later phases of LTP or LTD involving glutamatergic transmission, the processes of 'replay' which are thought to support consolidation, and a range of additional factors which contribute to determining the long term fate of memories including atypical protein kinase C isoform M-zeta (PKMZeta), a protein with a key role in long-term potentiation and the maintenance of long-term memory, and neurogenesis(Hardt, Nader, & Nadel, 2013; Redondo & Morris, 2011). The loss of previously well-established memories could result either from direct damage to the engrams themselves or from interference with processes of reconsolidation.

However, there are at least two alternative explanations. The first, methodological, alternative suggests that the pattern of impairment in these cases does not reflect a distinctive pathology of

memory, but rather a damaged memory system which we are assessing with poorly matched tasks: specifically, the measures of anterograde and retrograde memory used in the majority of studies of autobiographical memory fail to compare like with like (Kopelman MD, 2004). The tests we use to probe memory at longer intervals (such as the AI) are certainly very different to those with which we normally examine it at shorter, standard, ones (such as paragraph and word list learning): if the retrograde tests are more difficult, it could be that the apparent dissociation of anterograde and autobiographical memory is an illusion. Work showing that patients with temporal lobe epilepsy have particularly severe difficulty, even at relatively short delays, in retrieving ‘perceptual’ as opposed to ‘story’ details, highlights the possibility that standard measures, such as word lists, may fail to tap anterograde capacities that are highly relevant to autobiographical memory (St-Laurent, Moscovitch, Jadd & MCAndrews, 2014).

The second alternative explanation takes account of evidence that standard laboratory tests of episodic memory activate substantially different neural networks to those activated by autobiographical tasks (Gilboa, 2004; McDermott, Szpunar & Christ, 2009). In keeping with this observation, standard anterograde measures fail to distinguish individuals with ‘highly superior, autobiographical memory performance’ (LePort et al., 2012). Thus the relative normality of standard measures in our patients may reflect the insensitivity of these measures to autobiographical memory impairment for both methodological and neurobiological reasons.

Two lines of evidence render a solely methodological explanation unlikely. First, there are now several examples of patients with impeccable performance on anterograde tests at standard intervals who nonetheless show marked accelerated long term forgetting and autobiographical memory loss (Butler & Zeman, 2008a; Jansari, Davis, McGibbon, Firminger, & Kapur, 2010; Tramoni et al., 2011; Witt et al., 2015). Tramoni’s study, in particular, addressed the question of differential difficulty by ensuring that anterograde and retrograde tests were matched for difficulty. In the absence of any evidence for ceiling effects on the standard tests, the dissociation between performance at standard and at longer intervals in these patients, using tests matched for difficulty, suggests a disruption of ‘later’ processes, or, at the very least, a disruption of memory which only becomes apparent at long delays. Future studies of this issue could attempt to compare ‘like with like’ systematically, by, for example, testing memory for words at long intervals using remember-know judgements, and by assessing autobiographical memory at short and long retention intervals. Second, some authors (Muhlert, Milton, Butler, Kapur, & Zeman, 2010; Hoefijzers, Dewar, Della, Zeman, & Butler, 2013) have found that while in healthy subjects memory at 30 minutes predicts performance at 1 week, this correlation is lost in patients like those reported here. This again points to a role for events occurring some time after memory acquisition. The relative sparing of recent memories seen in MB and PT assessed using the AI is in keeping with this suggestion. However, it would be of great interest to use approaches like those of St-Laurent et al (St-Laurent, Moscovitch, Jadd & MCAndrews, 2014), focussing on recollection of perceptual details, to examine newly formed memories in MB and PT at short delays.

While differential difficulty of anterograde and retrograde memory measures is unlikely to be the sole explanation for the pattern of impairment considered here, it is not clear that any behavioural test can absolutely exclude the possibility that the memories formed in such patients are fragile from the start, yet sufficiently resilient to maintain memory function at short delays. Distinguishing this possibility from a disruption of later memory processes requires a better understanding of the underlying biology of this form of memory disorder.

4.4.2 What is the underlying aetiology of the deficit?

The pattern of memory impairment described here has been reported almost exclusively among patients with epilepsy, yet many of these patients - like MB and PT - have been seizure-free, or having only very infrequent seizures, at the time of study. Some but not all studies have identified correlations between seizure frequency (Jokeit, Daamen, Zang, Janszky, & Ebner, 2001; Mameniskiene, Jatuzis, Kaubrys, & Budrys, 2006; Wilkinson et al., 2012; Narayanan et al., 2012), or the frequency of interictal epileptiform activity (Mameniskiene, Jatuzis, Kaubrys, & Budrys, 2006; Fitzgerald, Thayer, Mohamed, & Miller, 2013), and memory loss over long intervals. Anecdotal reports from patients and limited published evidence suggests that memory is sometimes improved by treatment (Goldstein, Patel, Aspinall, & Lishman, 1992; O'Connor, Sieggreen, Ahern, Schomer, & Mesulam, 1997; Tombini et al., 2005; Midorikawa & Kawamura, 2007; Razavi, Barrash, & Paradiso, 2010), but one careful, recent, single case study found no improvement on treatment (Jansari, Davis, McGibbon, Firminger, & Kapur, 2010). Taken in the round, this evidence suggests that both epileptiform activity and some structural or neurochemical correlate of epilepsy in the MTLs or their connections are likely to be relevant to the pattern of memory loss we have observed. It may be significant that both MB and PT have continuing, albeit rare, ictal events, which may be a pointer to more frequent subclinical events with a disruptive effect on memory. MB, indeed, satisfies diagnostic criteria for Transient Epileptic Amnesia which has been associated with the pattern of memory loss described in this paper (Zeman, Boniface, & Hodges, 1998; Butler et al., 2007; Zeman, Butler, Muhlert, & Milton, 2013). Further examination of the relationship of EEG changes to memory impairment, of the impact of treatment on memory function, including memory at extended delays, and of the fine-grained neuroanatomy of the MTLs and their connections in patients with these forms of memory impairment should all help to shed light on this question.

While mood disturbance has been prominent in MB's case, this is not true of PT, and has not been notable in other reported cases: mood disorder is therefore unlikely to be the root cause. In discussion of MB's, PT's and similar cases, 'dissociative', 'functional' or 'psychogenic' amnesia has sometimes been proposed as the most probable diagnosis. A number of considerations make this an unlikely explanation for these cases as a class and for MB and PT's cases in particular. Markowitsch and Staniloiu (Markowitsch & Staniloiu, 2013) have suggested that six criteria support a diagnosis of 'functional retrograde amnesia': i) selective retrograde amnesia; ii) loss of personal identity; iii) absence of a physical or medical cause for amnesia; iv) relationship of the onset to psychological trauma or stress; v) prior history of psychological trauma or mood disorder; vi) belle indifference. Only one of these (i) applies to PT's case and only two (i and v) to MB's. Moreover, the marked dissociation between preserved semantic and impaired episodic recollection is not a common feature in dissociative amnesia, and indeed the impairment of *semantic* memory for one's personal past is a hallmark of dissociative amnesia, while impairment of episodic recall is the striking feature of the cases described here. Finally cases like those of MB and PT conform to a distinctive pattern which we compare below to other causes of 'disproportionate' autobiographical amnesia (AbA).

We also consider two other possible explanations of MB's and ST's amnesia to be unlikely. Many patients with this pattern of AbA are taking effective doses of anticonvulsant medication. However, the pattern has been reported in patients who are not receiving medication (Jansari, Davis, McGibbon, Firminger, & Kapur, 2010), the doses required are generally low and many patients report an improvement in their memory when treatment begins (see above). An explanation in terms of drug

side effects therefore appears unlikely also. Finally, one could give a sceptical interpretation of MB and PT's symptoms in terms of an excessively high expectation of autobiographical memory, or, correspondingly, an abnormally low threshold for symptoms of memory dysfunction. However, the objective impairment of their performance on measures of autobiographical memory argues strongly against this view.

4.4.3 What is spared?

The key distinction between the knowledge spared and knowledge lost in MB and PT is between factual or semantic memory (spared) and contextual or episodic memory (impaired). Both report preservation of factual, context free knowledge. Both report a massive loss of memory for the contextual details of past events, whether temporal, spatial or sensory. For both repetition is greatly beneficial to later recall, with a sharper than usual contrast between recollection of unique and repeated events.

In these respects MB and PT resemble patients with developmental amnesia, in whom perinatal damage to the MTL is associated with episodic amnesia coupled with well-preserved semantic memory (De Haan M., Mishkin, Baldeweg, & Vargha-Khadem, 2006; Picard et al., 2013). MB and PT differ from these patients in that their episodic recall for very recent events, of the past few hours or days, is relatively rich. The question of whether the memory impairment seen in MB and PT differs in kind or in degree from that seen in developmental amnesia echoes the question posed above about the best characterisation of their memory impairment, whether as a disorder of acquisition or of consolidation.

4.5 The neurology of autobiographical amnesia

The pattern of memory impairment in the cases of MB and PT, with relatively preserved anterograde memory at standard intervals, suggestive evidence of accelerated long-term forgetting and pronounced autobiographical amnesia is distinctive. How does it compare to other forms of 'disproportionate' autobiographical amnesia described in the literature due to acquired neurological disorder? Given the complexity of the processes involved in autobiographical memory (Svoboda, McKinnon, & Levine, 2006; St Jacques, 2012), it is to be expected that autobiographical amnesia can result from a range of pathologies. At least five forms of this phenomenon have been described, in addition to the type exemplified by the cases of MB and PT.

i) *Diffuse pathology*: Evans et al (Evans JJ, Breen EK, Antoun N, & Hodges JR, 1996; Evans JJ, Graham KS, Pratt KH, & Hodges JR, 2003) reported a patient, JM, with severe retrograde memory loss for autobiographical events following recovery from cerebral vasculitis. Her case is remarkable for well-preserved anterograde memory on standard tests, on measures of ALF, *and* on measures of post-accident autobiographical memory, although she has not been assessed using the exacting AI. Bifrontal, left parietal and left temporal lobe changes were noted on MRI and SPECT scans. The authors interpret the 'focal' autobiographical amnesia demonstrated in this case in terms of 'damage to either lower level features of memories, or, perhaps more likely, the pathways that are required to connect those mnemonic fragments into an event' caused by the multifocal pathology evident on imaging. This damage, remarkably, must have spared critical structures in the memory system required to acquire, consolidate, store and retrieve *new* autobiographical memories.

ii) *Right temporofrontal pathology*: Levine et al (Levine B et al., 1998; Levine, Svoboda, Turner, Mandic, & Mackey, 2009) described a patient, ML, with marked autobiographical memory loss for events preceding a severe traumatic brain injury which damaged the region of the right uncinate fasciculus which connects the inferior frontal with the temporal lobe. This damage was associated with reduced activation of the right frontal pole, using PET, and of midline frontal and posterior regions, using fMRI, in episodic retrieval tasks. Like JM, ML performed normally on standard tests of anterograde memory, but unlike JM there was evidence of an impairment of recollective or 'autonoetic' awareness of post-injury events: ML had, to some degree, lost the ability to re-experience the entirety of his past, both pre- and post-injury. Piolino et al (Piolino et al., 2005) describe a complex case of disproportionate retrograde amnesia in which PET imaging also showed evidence of right inferior frontal hypometabolism. A group study of retrograde amnesia likewise implicated the frontal lobes (Kopelman et al., 2003).

iii) *Pathology in visual cortices*: Rubin (Rubin & Greenberg, 1998) has drawn attention to a distinctive form of predominantly retrograde autobiographical amnesia associated with visual memory impairment due to damage to posterior cortical regions (with the implication that performance on standard memory tests will *not* be normal in this subgroup of patients). This phenomenon is thought to reflect the key role of visual memory in most autobiographical memories.

iv) *Severely deficient autobiographical memory syndrome* (Palombo, Alain, Soderlund, Khuu, & Levine, 2015): the syndrome, which may be related to the previous category, was recently described in three individuals with a marked, lifelong impairment of autobiographical recollection, with otherwise normal cognition and day to day functioning, excepting an impairment of visual recall. Functional imaging studies (fMRI, EEG) revealed alterations in biomarkers linked to autobiographical recollection, in particular reduction of activation on fMRI in key midline regions (left medial prefrontal cortex and right precuneus) during autobiographical recollection and reduced event related potentials to correct recognition in left parietal sites at around 500 msec. Right hippocampal volumes were smaller in patients than comparison participants.

v) *'Functional' amnesia*: 'functional' or 'psychogenic' amnesia is often characterised by a predominant retrograde amnesia, sometimes including loss of personal identity, in combination with well-preserved anterograde memory (Markowitsch & Staniloiu, 2013; Kopelman, 2002; Kritchevsky, Chang, & Squire, 2004). It is frequently associated with a past history of psychiatric or psychological disorder and triggered by the occurrence of disturbing life events which may not at first be evident. It is, thus, an important differential diagnosis in any patient with a disproportionate retrograde amnesia. There may be some common ground between the neurobiology of functional amnesia and other forms of autobiographical amnesia.

The form of autobiographical amnesia described in this paper belongs to a sixth type, which has been increasingly well documented over the past decade:

vi) *Temporal lobe epilepsy*: remote memory loss has now been described among patients with chronic refractory epilepsy (Viskontas, McAndrews, & Moscovitch, 2000; Addis, Moscovitch, & McAndrews, 2007; Lah, Lee, Grayson, & Miller, 2006), following temporal lobectomy (Lah, Grayson, Lee, & Miller, 2004; Noulhiane et al., 2007), in adult-onset drug sensitive TLE (Tramoni et al., 2011), as the presenting feature of TLE in combination with subtle seizures (Jansari, Davis, McGibbon, Firminger, & Kapur, 2010) and as a prodromal phenomenon, preceding the clinical onset of epilepsy (Hornberger et al., 2010). It

is particularly common in TEA, occurring in 2/3 of patients (Butler et al., 2007). It can occur among patients with normal or near normal anterograde memory on standard tests, but is often, though not always, associated with accelerated long-term forgetting. A similar case was recently described as a result of exposure to treatment with high dose intrathecal baclofen (Zeman et al., 2016). Potential explanations for amnesia in patients with TLE include poor encoding of experiences as a result of concurrent seizure activity, poor consolidation due to ALF, and loss of access to or erasure of existing retained memories. The impairment of 'recall of highly specific contextual information such as perceptual details, thoughts and emotions, and fine-grained temporal relations... those detailed elements that support vivid recollection of past experiences' (McAndrews MP, 2012), as described so clearly by MB and PT, is characteristic. The details of the relationship between autobiographical amnesia and anterograde memory impairment in patients with TLE remains 'an open question' (McAndrews MP, 2012). Answering this question will require further research using searching tests of anterograde memory over standard delays, tests of ALF and measures of anterograde memory which mirror those used to test retrograde memory, making it possible to 'compare like with like' (Kopelman MD, 2004). In interpreting the results obtained using these measures, however, it will be important to remember that co-occurring deficits may not be causally linked.

4.6 Contrasts and limitations

While the cases of MB and PT have several similarities, there are also informative differences between them. PT believes that his autobiographical and topographical memory have always been poor, in keeping with his longstanding TLE. He cannot remember a time when he had access to rich episodic memories for events occurring more than 1-2 months previously. MB, by contrast, reports that his autobiographical memory was normal until an unexplained deterioration nine years ago, 26 years after the onset of his epilepsy. His wife corroborates this account. Thus, whereas PT's autobiographical memory impairment can be explained by an anterograde memory impairment of some kind, including ALF, MB's impairment is likely to be due, at least in part, to a 'retroactive' process, involving erasure of or loss of access to established memories or some combination of these factors.

We acknowledge several limitations to the current study. While both patients were reassured following thorough standard neuropsychological assessment that they showed no evidence of memory impairment, it is possible that more exacting tests of anterograde memory might have been more revealing, for example measures of forced choice recognition, pattern separation, associative memory or the perceptual richness of recently formed memories. Similarly, the sampling of public knowledge in this study was limited, and it is possible that more detailed tests, for example probing contextual details such as, mode and date of death in the Dead or Alive Test, might have revealed deficits that were not apparent on the limited range of tests used here.

4.7 Conclusions

This paper has described the objective features in two cases of epilepsy-associated memory loss in parallel with the experience of the two individuals concerned, as documented in their accounts. The key features are the relative normality of performance on standard memory tests, and preservation of semantic memory, in contrast to a profound amnesia for salient autobiographical episodes, suggestive evidence of ALF, and an impairment of imagination. The first person accounts illustrate the importance of autobiographical memory in sustaining a coherent sense of self, informing

interpersonal relationships and supporting imaginative thought. Establishing the relative contributions of impairment of early and later stages of memory processing to this pattern of amnesia, and the roles of physiological and structural pathology, requires further research. Adding one further metaphor to those in the writings of MB and ST, it is as if the soil of their memory systems has been thinned: rich, experiential memories can briefly take root there, but lack the tenacity required to withstand the winds of time.

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Figures

Figure 1: Modified Autobiographical Memory Interview: mean semantic and episodic score/decade; error bars show standard deviations (control and TEA data from Butler et al., 2007).

Figure 2: Autobiographical Interview: mean internal detail scores for previous decades, internal details score for current decade; error bars show standard deviations (control and TEA data from Milton et al., 2010).

Figure 3: Experiential index and spatial coherence scores; error bars show standard deviations (mean control and amnesic data from Hassabis et al., 2007).

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