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Reviews and perspectives

Personal semantic memory: Insights from neuropsychological research on amnesia

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ABSTRACT

This paper provides insight into the cognitive and neural mechanisms of personal semantic memory, knowledge that is specific and unique to individuals, by reviewing neuropsychological research on stable amnesia secondary to medial temporal lobe damage. The results reveal that personal semantic memory does not depend on a unitary set of cognitive and neural mechanisms. Findings show that autobiographical fact knowledge reflects an experience-near type of personal semantic memory that relies on the medial temporal lobe for retrieval, albeit less so than personal episodic memory. Additional evidence demonstrates that new autobiographical fact learning likely relies on the medial temporal lobe, but the extent to which remains unclear. Other findings show that retrieval of personal traits/roles and new learning of personal traits/roles and thoughts/beliefs are independent of the medial temporal lobe and thus may represent highly conceptual types of personal semantic memory that are stored in the neocortex.

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1. Introduction

Semantic memory can be defined as our repository of knowledge. It consists of culturally shared knowledge about the world, such as vocabulary, facts, and concepts, as well as knowledge about the self and one's life story (Conway, 2005; Tulving, 1972,1983). A majority of research on semantic memory has been concerned with general world knowledge (Binder & Desai, 2011), but in recent years there has been increased interest in personal semantic memory – knowledge that is specific and unique to each individual (Klein & Gangi, 2010; Haslam, Jetten, Haslam, Pugliese, & Tonks, 2011; McAdams, 2013; Prebble, Addis, & Tippet, 2013). This interest stems from recent studies showing that personal knowledge plays a critical role in stabilizing one's sense of self (Rathbone, Moulin, & Conway, 2009), provides the foundation for reflection on major life events (Thompsen, 2009), contributes to cognitive processes involved in prospection such as goal setting (D'Argembeau and Demblon, 2012; D'Argembeau & Mathy, 2011), and may be capitalized on to improve memory in memory-impaired patients (Grilli & Glisky, 2010, 2011, 2013; Marquine, 2009). Despite increased attention, the cognitive and neural bases of personal semantic memory remain underspecified. Therefore, in this paper we review the research on personal semantic memory in patients with stable amnesia secondary to medial temporal lobe (MTL) lesions, with the goal of elucidating the contribution of neuropsychological studies to the cognitive neuroscience of personal semantic memory.

Personal semantic memory consists of a variety of subtypes of knowledge about the self, including personality traits and roles (e.g. I am optimistic; I am a researcher), personal beliefs (e.g. running is enjoyable), and autobiographical facts (e.g. I grew up in California; Conway, 2005, 2009; Klein & Lax, 2010; Martinelli, Sperduti, & Piolino, 2013; Prebble et al., 2013; Renoult, Davidson, Palombo, Moscovitch, & Levine, 2012). While grounded in one's personal memories, personal semantic knowledge represents commonalities abstracted from experience and is devoid of the unique contextual details that characterize episodic memory (Tulving, 1972, 1983). However, different forms of personal semantic knowledge are believed to vary in the extent to which they are concept-based or experience-near (Conway & Pleydell-Pearce, 2000; Martinelli et al., 2013); some autobiographical facts are more experience-near (i.e. associated with spatial-temporal and perceptual details) than traits, roles, and beliefs, which are considered to be highly conceptual and abstract. This distinction has been central to cognitive models of the organization of personal semantic memory (Conway, 2005; Martinelli et al., 2013; Renoult et al., 2012), and also may be relevant to understanding its neural bases.

On the one hand, to the extent that personal semantic memory represents conceptual knowledge, it may rely on similar brain regions as general semantic memory. Thus, the storage and retrieval of personal semantic memory consolidated prior to the onset of amnesia might depend on neocortical brain regions, but not on the MTL (Greenberg & Verfaellie, 2010). There is some neuropsychological evidence to support this notion, as anecdotal findings suggest that amnesic patients often know facts about their identity and life story, implying that personal semantic memory, similar to general semantic memory, may be relatively well preserved in the face of severe amnesia (Cermak & O'Connor, 1983; Damasio, Eslinger, Damasio, Van Hoesen, & Cornell, 1985; Tulving, 1985; Warrington & Duchen, 1992).

On the other hand, to the extent that personal semantic memory remains experience-near, it may share mechanisms with episodic memory. Consistent with this notion, a recent comprehensive meta-analytic review of functional neuroimaging research with healthy adults indicates that the MTL – specifically, the parahippocampus – as well as other neural regions are activated during the retrieval of aspects of personal knowledge, including autobiographical facts (Martinelli et al., 2013). However, functional neuroimaging research is by nature correlational and thus does not speak to the necessity of the MTL to the retrieval of personal knowledge. Therefore, a review of neuropsychological findings in amnesia may provide insight into the contribution of the MTL to the storage and retrieval of personal semantic memory.

Personal semantic memory, although rather stable, typically continues to be updated (i.e. existing personal knowledge is modified or added to) as a function of new experience. How such semantic updating occurs is a topic of theoretical interest. One view holds that the acquisition of semantic knowledge depends on episodic memory (Baddeley, 1988; Squire & Zola, 1998). According to this view, personal knowledge may be learned by extracting commonalities among episodically encoded experiences, and therefore mechanisms mediated by the MTL might be necessary for the acquisition of such knowledge (Kumaran, Summerfield, Hassabis, & Maguire, 2009). However, another view proposes that semantic memory interacts with but is acquired independent of episodic memory (Conway, 2005; Tulving, 1983), and thus, semantic updating can continue in the absence of episodic memory, albeit less efficiently. By this view, to the extent that personal semantic memory is concept-based and thus similar to general semantic memory, slow neocortical learning mechanisms independent of the MTL, possibly associated with implicit memory (Rosenbaum et al., 2005; Glisky, 2004), may support the updating of such knowledge. Furthermore, prior research suggests that neocortical learning mechanisms may be particularly likely to support semantic memory updating when there is a strong pre-existing knowledge structure, such as the self, into which new information can be incorporated (Tse et al., 2011; Kan, Alexander & Verfaellie, 2011). Therefore, some new knowledge may be laid down directly into personal semantic memory. Investigating the effect of amnesia on the updating of the different types of personal semantic memory may elucidate the contribution of episodic memory to new personal semantic learning.

To address the issues highlighted above, we review the neuropsychological research on personal semantic memory in MTL amnesia. To shed light on the mechanisms of storage and retrieval, we review neuropsychological studies examining retrograde or pre-morbid personal semantic memory; to uncover the mechanisms of updating or new learning, we review neuropsychological studies investigating anterograde or post-morbid personal semantic memory. The available evidence is reviewed in relation to three variables. First, we consider the type of personal semantic knowledge and examine separately autobiographical fact knowledge and knowledge of traits, roles, personal thoughts, and beliefs, given that autobiographical facts are thought of as more experience-near and therefore may rely on distinct mechanisms. Second, we consider the impact of extent of lesion: we compare patients with lesions limited to the MTL and patients whose lesion extends beyond the MTL into other cortical regions (i.e. MTL+) to provide insight into the neural bases of personal semantic memory. Third, when possible, we directly compare the magnitude of impairment in retrograde memory for personal facts and retrograde memory for autobiographical events (i.e. episodic memory). Early anecdotal findings suggest that knowledge of autobiographical facts might be better preserved than memory for autobiographical events in amnesia (Cermak & O'Connor, 1983; Damasio et al., 1985; Tulving, 1985), but this question has not been addressed systematically. Anterograde memory for autobiographical facts and anterograde memory for autobiographical events could not be systematically compared as explained in the discussion.

2. Methods

We identified the articles included in this review through PubMed, Web of Science, and PsychInfo databases with a combination of the following search terms: "self,"

Table 1
Summary of amnesic patient demographic and lesion information, methodology, and results of reviewed articles.

Amnesic patients with MTL lesions

Article	Design	Etiology	Lesion	PS memory	Retrograde	Anterograde	F versus E
Bayley, Hopkins, & Squire, 2006	Group	anoxia; ischemia	Hippocampus (6 total)	Modified AMI	WNL	WNL	– –
Cipolotti et al., 2001	Case: VC	Seizure Disorder	Hippocampus	AMI	Impaired	Impaired	F > E
Eslinger, 1998	Case: PD	Encephalitis	MTL	AMI	Impaired	–	F > E
	Case: MR	Epilepsy	MTL	AMI	Impaired	–	F=E
Fujii, Yamadori, Endo, Suzuki, & Fukatsu, 1999	Case: no initials*	Encephalitis	MTL	AMI	Impaired	–	F=E
Hirano & Noguchi, 1998	Case: YK	Encephalitis	Hippocampus	AMI	WNL	Impaired	F > E
Kapur & Brooks, 1999	Case: BE	Encephalitis	Hippocampus	AMI	WNL	–	–
Kartsounis, Rudge, & Stevens, 1995	Case	CVA	Hippocampus	AMI	Impaired	–	–
Klein et al., 2002	Case: DB	Cardiac Arrest	MTL	Personality Trait Rating	Valid & Reliable	–	–
				AMI	Impaired	–	–
Kopelman, Stanhope, & Kingsley, 1999	Group	Hypoxia (4)	MTL	AMI	Impaired	–	–
Steinvorth, Levine, & Corkin, 2005	Case: HM	Surgical Procedure	MTL	AMI	WNL	Impaired	– –
Schnider, Gutbrod, & Ozdoba, 1995	Case	Lupus	Hippocampus	AMI	Impaired	–	E > F
Tranel & Jones, 2006	Case: 1344	Anoxia	MTL	IAMQ	Impaired	–	–
	Case: 1465	Encephalitis	MTL	IAMQ	WNL	–	–
	Case: 1585	Anoxia	MTL	IAMQ	WNL	–	–
	Case: 1606	Anoxia	MTL	IAMQ	Impaired	–	–
	Case: 1846	Anoxia	MTL	IAMQ	Impaired	–	–
	Case: 2144	Anoxia	MTL	IAMQ	WNL	–	–
Bastin et al., 2004	Case: MR	C.Monoxide Poisoning	MTL+ R > L	AMI	WNL	Impaired	F > E
Bayley, Gold, Hopkins, & Squire, 2005	Case: HC	Ischemia	MTL+	AMI	WNL	–	F=E
	Case: GP	Encephalitis	MTL+	AMI	WNL	–	–
	Case: PH	unclear	MTL+	AMI	Impaired	–	E > F
Buccione, Fadda, Serra, Caltagirone, & Carlesimo, 2008	Case: RS	Encephalitis	MTL+ L > R	Modified AMI	Impaired	–	F > E
	Case: AS	Encephalitis	MTL+ R > L	Modified AMI	Impaired	–	F > E
Calabrese et al., 1996	Case: no initials*	Encephalitis	MTL+	AMI	Impaired	–	F > E
Eslinger, 1998	Case: RS	Stroke	MTL+ L > R	AMI	WNL	Impaired	F=E
	Case: AD	Encephalitis	MTL+ L > R	AMI	WNL	Impaired	F=E
	Case: EK	Encephalitis	MTL+ L > R	AMI	Impaired	Impaired	E > F
Gilboa et al., 2006	Case: KC	Traumatic Brain Injury	MTL+	AMI	Impaired	Impaired	F > E
	Case: AD	Cyst/Surgery	MTL+	AMI	Impaired	Impaired	F > E
Grewal, 2003	Case: no initials	Stroke	MTL+ L > R	AMI	WNL	–	F > E
Haslam, Cook, & Coltheart, 2001	Case: TG	Encephalitis	MTL+	AMI	Impaired	–	F > E
Hepner, Mohamed, Fulham, & Miller, 2007	Case: SG	Stroke	MTL+	AMI	WNL	–	F=E
Kapur et al., 1996	Case: GR*	TBI	MTL+	AMI	WNL	–	F > E
	Case: SP*	TBI	MTL+	AMI	Impaired	–	F > E
Kitchner, Hodges, & McCarthy, 1998	Case: RS	Stroke	MTL+	AMI	Impaired	Impaired	F > E
Kopelman et al., 1999	Group	Encephalitis (9)	MTL+	AMI	Impaired	–	–
Lieberman et al., 2001	Group	Unspecified	MTL (1;$^{\widehat{}}$)	Belief Ratings	–	Preserved	–
McCarthy, Kopelman, & Warrington, 2005	Case: RFR	Encephalitis	MTL+	AMI	Impaired	Impaired	F=E
Oxbury, Oxbury, Renowden, Squier, & Carpenter, 1997	Case: CG	Seizure/Anoxia	MTL+ L > R	AMI (second assessment)	WNL	–	F > E
Reed & Squire, 1998	Case: EP	Encephalitis	MTL+	AMI	Impaired	Impaired	E > F
	Case: GT	Encephalitis	MTL+	AMI	Impaired	Impaired	F=E
Reinvang, Nielsen, Gjerstad, & Bakke, 2000	Case: KE*	Encephalitis	MTL+ R > L	AMI	WNL	–	F > E
Rosenbaum et al., 2008	Case: CB	Encephalitis	MTL+ R > L	AMI	WNL	WNL	F > E
	Case: RG	Encephalitis	MTL+ L > R	AMI	WNL	Impaired	F=E
	Case: DA	Encephalitis	MTL+ R > L	AMI	WNL	Impaired	F > E
Ross & Hodges, 1997	Case: RS	Anoxia	MTL+	AMI	Impaired	Impaired	F=E
Stanhope & Kopelman, 2000	Case: DJ	Encephalitis	MTL+ R > L	AMI	Impaired	WNL	F=E
Steinvorth et al., 2005	Case: WR	Stroke	MTL+ L > R	AMI	WNL	WNL	–

Table 1 (*continued*)

Amnesic patients with MTL lesions							
Article	Design	Etiology	Lesion	PS memory	Retrograde	Anterograde	F versus E
Tanaka, Miyazawa, Hashimoto, Nakano, & Obayashi, 1999	Case: HK*	Encephalitis	MTL+ L > R	Modified AMI	Impaired	–	F > E
Tranel & Jones, 2006	Case: 1647	Encephalitis	MTL+	IAMQ	Impaired	–	–
	Case: 1673	Encephalitis	MTL+	IAMQ	Impaired	–	–
	Case: 0674	Temporal Lobectomy	MTL+ L > R	IAMQ	WNL	–	–
	Case: 0895	Encephalitis	MTL+	IAMQ	WNL	–	–
	Case: 1077	Temporal Lobectomy	MTL+ L > R	IAMQ	WNL	–	–
	Case: 1664	Surgical Procedure	MTL+ R > L	IAMQ	Impaired	–	–
Tsukiura et al., 2003	Case: EC	Encephalitis	MTL+	AMI	Impaired	–	F > E
Tulving, 1993	Case: KC	Traumatic Brain Injury	MTL+	Personality Trait Rating	Valid & Reliable	Valid & Reliable	–
Wilson, Baddeley, & Kapur, 1995	Case: C.	Encephalitis	MTL+	AMI	Impaired	Impaired	F=E

F=autobiographical facts; E=autobiographical events; ; WNL=within normal limits.

* focal retrograde amnesic patient;

^ subset of these amnesic patients have damage extending beyond the MTL

"autobiographical memory," "personal semantics," "autobiographical facts," "attitudes," "beliefs," "self-knowledge," and "amnesia," as well as through review of articles cited by the studies identified with these search terms. While isolated thalamic and frontal lesions can also result in forms of amnesia (Kopelman et al., 2003), we restricted this review to articles that investigated amnesic patients with stable memory disorders secondary to acquired MTL lesions. We included studies of patients with global amnesia (as evidenced by anterograde amnesia, which was determined by findings of significantly abnormal performance on standard neuropsychological measures of new learning), and patients with focal retrograde amnesia. However, we did not review updating of (i.e. anterograde) personal semantic memory in patients with focal retrograde amnesia, given that these patients have mild or no anterograde amnesia. Patients included in group-designs were separated into and considered as single-case studies if adequate information regarding individual performance was provided. If data from the same amnesic patient was presented in multiple reports, the paper with the most comprehensive and detailed data set for that patient was selected.

A range of anatomical information was provided by studies included in this review. In few cases where brain imaging was not available, lesion location was inferred based on the patient's neuropsychological profile and etiology of memory disorder. Focal retrograde amnesia has been reported in patients without MTL damage and in some cases without clear evidence of neurological impairment on brain imaging (Kopelman, 2000; Markowitsch & Staniloiu, 2013). The present paper, however, focused on only those focal retrograde amnesic patients with documented MTL damage. Although the contribution of the MTL to focal retrograde amnesia remains a topic of debate (Kapur, 1993; Kopelman, 2000), excluding these amnesic patients did not change the overall findings of this review. Group studies that did not provide sufficient information to determine lesion location for each patient within the group were not included. Based on these inclusion criteria, a total of 79 amnesic patients were reviewed (Table 1).

A majority of the studies included in this review measured autobiographical fact knowledge with the Autobiographical Memory Interview, or a slightly modified version of this measure (AMI; Kopelman, Wilson, & Baddeley, 1989). The AMI is a semi-structured interview designed to assess autobiographical facts and episodic autobiographical memories from childhood, early adulthood, and recent life. In the AMI, questions directed towards autobiographical facts include information about self-relevant people, addresses, accomplishments, and meaningful life changes (e.g. birth of first child). Episodic autobiographical memories also are drawn from these self-relevant categories of information (e.g. "recall an incident from college or your first job"). Amnesic patients given the Iowa Autobiographical Memory Questionnaire (Tranel & Jones, 2006), a measure that assesses retrograde autobiographical fact knowledge and is similar to the AMI, were reviewed as well.

For amnesic patients given the AMI, we calculated z-scores for each time period based on the means and standard deviations from the healthy control group in Kopelman (1989), unless data and statistical comparisons were available from a study-specific control group. Memory for autobiographical facts or autobiographical events was considered impaired if the z-score for any of the time periods for that type of memory was ≤ -2. In a few cases where we were unable to calculate standard scores based on the information provided by the original article and a study-specific control group was not available, we used the cutoff scores from the published AMI (1990) to characterize autobiographical memory as impaired (i.e. "probably abnormal" or "definitely abnormal") or within normal limits (i.e. "intact" or "borderline"). For the patients given the Iowa Autobiographical Memory Questionnaire, z-scores were calculated based on Tranel & Jones' (2006) healthy control group, with a cut-off for impairment of $z=-2$ for any of the time periods.

Whether personal semantic memories were retrograde or anterograde was based on patient background information as well as the timeframe and date of administration of the autobiographical memory measure. If a clear distinction between retrograde and anterograde memory could not be made because of insufficient background information (e.g. not clear how many years post-onset of amnesia a patient was assessed) or the timing of the administration of the autobiographical memory measure precluded a clear division of the two (e.g. a patient three years post-onset of amnesia might be administered the recent time period of the AMI which spans five years), then the memories were conservatively judged to be retrograde in nature unless the authors reported additional information to indicate otherwise.

To investigate whether memory for autobiographical facts might be better preserved than memory for autobiographical events in amnesia, we reviewed the results of amnesic patients for whom retrograde memory for autobiographical facts and retrograde memory for autobiographical events were compared to each other based on the AMI. For each patient, we calculated overall autobiographical fact and autobiographical event scores by averaging the z-scores for each type of memory across the applicable time periods. One type of memory was considered better preserved than the other if the respective z-scores were at least 1 standard deviation apart. This calculation was substituted with study-specific control groups when possible. Studies that used the AMI cutoff scores were not included in this comparison.

3. Results

3.1. Retrograde personal semantic memory

3.1.1. Autobiographical facts

We identified 73 amnesic patients from 54 single cases and 2 group designs that investigated retrograde memory for autobiographical facts. Overall, retrograde autobiographical fact knowledge was within normal limits in 29 patients and impaired in 44 patients. Retrograde memory for autobiographical facts was not well preserved in patients with isolated MTL lesions (total: 12 within normal limits versus 14 impaired). The proportion of normal relative to abnormal cases was not significantly different in amnesic patients with MTL+ lesions (total: 17 within normal limits versus 30 impaired; $x^2=.70$, $p=.40$).

Sufficient information was provided by the original research articles to compare retrograde memory for autobiographical facts and autobiographical events in 36 of the amnesic patients included in this review. Overall, retrograde memory for autobiographical facts was better than retrograde memory for autobiographical events in 20 patients, the reverse was true in 4 patients, and no difference was detected in 12 patients. The proportion of amnesic patients who demonstrated an advantage of retrograde memory for autobiographical facts was greater than what would be expected by

chance ($x^2=42.5$, $p<.0001$). Moreover, the proportion of amnesic patients with isolated MTL lesions who exhibited an advantage of retrograde memory for autobiographical facts was similar to the proportion of MTL+amnesic patients who demonstrated this advantage (3 of 6 cases versus 17 of 30 cases, respectively).

3.1.2. Knowledge of traits and roles and thoughts and beliefs

Only two published case studies were identified that investigated trait knowledge in amnesia: patient K.C. from Tulving (1993) and patient D.B. from Klein, Rozendal, and Cosmides (2002).[1] In both cases, the amnesic patients were reliable in their personality trait judgments and their ratings were consistent with how other people perceived their personalities. The results from these two case studies, therefore, indicate that trait knowledge, at least part of which is presumably pre-morbid in nature, can be preserved in some patients despite amnesia. We did not identify any studies of pre-morbid personal thoughts and beliefs in amnesia through our review of the literature.

3.2. Anterograde personal semantic memory

3.2.1. Autobiographical facts

We identified 26 anterograde amnesic patients from 20 single case studies and 1 group study that investigated anterograde memory for autobiographical facts. Anterograde autobiographical fact knowledge was within normal limits in 9 patients and impaired in 17 patients. Anterograde memory for autobiographical facts was more likely to be within normal limits in amnesic patients with lesions restricted to the MTL (6 of 9 cases) than in MTL+ amnesic patients (3 of 17 cases; $x^2=6.25$, $p=.01$).

3.2.2. Knowledge of traits and roles and thoughts and beliefs

In regards to updating of personality trait knowledge, Tulving (1993) reported that K.C.'s current trait knowledge was more consistent with his post-traumatic brain injury personality than his premorbid demeanor. Thus, although additional research is clearly needed, these preliminary results suggest that trait knowledge updating can be resilient to amnesia.

The investigation made by Lieberman, Ochsner, Gilbert, & Schacter, 2001 on attitude change in six MTL/MTL+ amnesic patients (included in a group with six Korsakoff's amnesic patients) was the only study identified to address the status of new learning of personal thoughts and beliefs in amnesia. This study showed that as a group the amnesic patients were as likely as healthy controls to modify their attitudes about their preference for artwork after taking part in a cognitive dissonance reduction experiment. Therefore, the ability to update attitudes, at least under certain conditions, may be intact in amnesia. Although this research report collapsed across MTL amnesic patients and Korsakoff's amnesic patients, the researchers noted no difference in the results between these patient groups. As such, the neural correlates of personal thought and belief updating remain unclear, but these findings suggest that non-MTL mechanisms may be involved in some situations.

[1] Klein and Lax (2010) provide a comprehensive review of personality trait knowledge in patients with memory problems from multiple etiologies. A few of the patients reviewed by Klein and Lax (2010) were not included in this review because of lack of an acquired and stable memory deficit. Rathbone et al. (2009) investigated trait and role knowledge in a case of focal retrograde amnesia subsequent to a head injury. However, no information was provided regarding evidence of a brain lesion. Also see the dissertation by Marquine (2009) for findings on trait knowledge in patients with acquired memory disorders.

4. Discussion

4.1. The storage and retrieval of personal semantic memory: insights from amnesia

4.1.1. Autobiographical facts

The results of 73 amnesic patients showed that retrograde memory for autobiographical facts is commonly impaired in this population, including in patients with brain lesions isolated to the MTL. Therefore, the neuropsychological findings of patients with amnesia elucidate that the storage and retrieval of autobiographical facts depends on the MTL. Furthermore, these results indicate that the activation of MTL regions observed during the retrieval of autobiographical facts in functional neuroimaging research with healthy adults (Martinelli et al., 2013) is not simply a byproduct of renewed encoding of the facts; rather, it is necessary for their retrieval.

These findings are consistent with the notion that autobiographical fact knowledge is an experience-near form of personal semantic memory and thus depends on the MTL for retrieval. Prior research suggests that one's life story may be organized according to meaningful life changes and experiences (Singer, Rexhaj, & Baddeley, 2007; Thomsen, 2009). Therefore, while devoid of the level of specificity characteristic of episodic memory, autobiographical fact knowledge might remain closely associated with life experiences and, as a result, might share mechanisms with episodic memory. Such an explanation implies that the cognitive and neural bases of personal semantic memory are not completely aligned with general semantic memory.

Before accepting this interpretation, an alternative explanation for why the MTL may be involved in the storage and retrieval of autobiographical facts should be considered. Inferring from the standard model of memory consolidation (Squire, 1992), personal semantic memory, similar to general semantic memory, might depend on the MTL only until consolidation is completed in the neocortex. This alternative account provides a less compelling explanation for the results of this review, however, since most of the autobiographical facts assessed in the AMI are drawn from childhood and early adulthood and thus are relatively remote and presumably consolidated in the neocortex. Future research could more systematically address these competing theories of the contribution of the MTL to autobiographical facts by carefully investigating temporal gradients in pre-morbid autobiographical fact knowledge in amnesia.

By comparing retrograde memory for autobiographical facts and autobiographical events we investigated the extent to which the storage and retrieval of these two types of memory are similarly affected by amnesia. Although few studies of amnesia have provided sufficient information to make a direct comparison, the results of this systematic review revealed that retrograde memory for autobiographical facts was better preserved than retrograde memory for autobiographical events in many patients with amnesia secondary to MTL lesions. Therefore, these findings imply that the storage and retrieval of autobiographical facts may not depend on the MTL to the same extent as personal episodic memory. One possibility is that MTL mechanisms are less essential to retrieval because autobiographical facts do not incorporate the same level of spatial-temporal and perceptual specificity as personal episodic memories. Moreover, autobiographical facts may vary in the extent to which they are MTL dependent. Indeed, whereas some autobiographical facts might be closely associated with unique life events (e.g. birth of a child), others might reflect knowledge derived from events that were extended in time (e.g. college years; Conway, 2005). The contribution of the MTL to retrieval of autobiographical facts, therefore, may vary depending on how far removed a fact is from unique life experiences. Future

research could evaluate this latter possibility by systematically investigating the types of pre-morbid autobiographical facts that are preserved or impaired in amnesia.

If autobiographical fact knowledge is less dependent on the MTL for storage and retrieval than autobiographical events, then it may be more reliant on neocortical regions. However, this review found that, in comparison to amnesic patients with isolated MTL damage, amnesic patients with more extensive brain lesions demonstrated a similar advantage of retrograde memory for autobiographical facts relative to autobiographical events and were not more likely to exhibit impaired retrograde memory for autobiographical facts. Nevertheless, it is reasonable to suspect that the anterior/lateral temporal lobe, a brain region implicated in the storage of general semantic knowledge based on neuropsychological research (Greenberg & Verfaellie, 2010), may contribute to the storage and retrieval of autobiographical facts. For instance, neuropsychological research has shown that retrograde memory for autobiographical facts is commonly impaired in patients with semantic dementia (Graham & Hodges, 1997; Hou, Miller, & Kramer, 2005), a condition characterized by disproportionate atrophy of the temporal pole in the early stages of the disease. Furthermore, in mild cases of semantic dementia, retrograde memory for autobiographical facts has been found to be more impaired than memory for autobiographical events (Ivanoiu, Cooper, Shanks, & Venneri, 2006; Maguire, Kumaran, Hassabis, & Kopelman, 2010).

In regards to the MTL+ amnesic patients included in this review, a closer examination of lesion location descriptions from the original articles indicates that amnesic patients with damage extending into the anterior/lateral temporal lobe may be more likely to exhibit impaired retrograde memory for autobiographical facts (MTL+ with anterior/lateral temporal lobe damage: 7 within normal limits/20 impaired; MTL only: 12 within normal limits/14 impaired). Thus, the anterior/lateral temporal lobe may play an important role in retrograde memory of autobiographical facts and therefore may be involved in the storage of personal semantic knowledge in addition to general semantic knowledge. However, this possibility is offered cautiously as most articles in this review did not provide sufficient information to determine the precise location and extent of lesion in the anterior/lateral temporal lobe region.

In summary, this review of retrograde memory for autobiographical facts in patients with amnesia elucidates that the storage and retrieval of autobiographical facts depends on the MTL. Additional research is needed to uncover the precise contribution of the MTL to autobiographical fact storage and retrieval, but these results indicate that autobiographical facts might represent an experience-near subtype of personal semantic memory and thus share mechanisms with episodic memory. The results also raise the possibility that neocortical regions involved in the storage and retrieval of semantic memory, namely the anterior/lateral temporal lobes, contribute to the storage and retrieval of autobiographical facts as well.

4.1.2. Knowledge of traits/roles and thoughts/beliefs

This review identified only two case studies to investigate retrograde trait and role knowledge in patients with stable amnesia secondary to MTL lesions. The results of these two patient studies suggest that retrograde trait and role knowledge can be preserved in the face of amnesia, and therefore the storage and retrieval of trait and role knowledge may not depend on the MTL. These findings, albeit preliminary, also imply that retrograde trait and role knowledge may be less susceptible to amnesia than autobiographical facts, as both of these patients exhibited impaired personal fact knowledge (K.C. in Gilboa et al., 2006; D. B. in Klein et al., 2002).

Future research is needed to examine more thoroughly the impact of MTL lesion on retrograde trait and role knowledge, and to shed light on other brain regions that might be necessary for the storage and retrieval of trait and role knowledge. A meta-analysis by Martinelli et al. (2013) showed that the medial prefrontal cortex (mPFC) is activated while processing trait words in relation to one's own personality. Furthermore, recent neuropsychological findings showed that patients with mPFC lesions do not demonstrate the typical mnemonic benefit from self-referential processing of trait words (Philippi, Duff, Denburg, Tranel, & Rudrauf, 2012). However, to our knowledge, no published study has investigated the status of retrograde trait and role knowledge in patients with mPFC lesions[2]. Furthermore, although the anterior/lateral temporal lobe is implicated in general semantic memory, and as noted above, possibly personal fact knowledge, recent research suggests that trait self-knowledge may be maintained in patients with mild to moderate semantic dementia (Duval et al., 2012). Prior research has shown that knowledge of one's roles and identity can be impaired in patients with Alzheimer's dementia (Addis & Tippet, 2004), but whether specific cortical regions are critical for the storage and retrieval of trait and role knowledge remains unknown.

The lack of empirical research on the storage and retrieval mechanisms of thoughts and beliefs highlights the need for future studies in this area. Personal thoughts and beliefs are presumed to be similar to traits and roles as they are considered concept-based (Conway, 2005; Martinelli et al., 2013), but future research must investigate the feasibility of this notion. It also will be important to examine the impact of disrupted retrieval of personal thoughts and beliefs on one's sense of self. For instance, it is possible that the retrieval of personal thoughts and beliefs supports the ability to extract meaning from life and to experience a sense of self-continuity.

In summary, the results of this review call attention to the need for future research on the storage and retrieval mechanisms of personal traits, roles, thoughts, and beliefs. Preliminary evidence suggests that trait and role knowledge may be stored and retrieved independently of the MTL, supporting the idea that this subtype of personal semantic memory is concept-based and stored in the neocortex. In contrast, the storage and retrieval mechanisms of personal thoughts and beliefs remain unknown. Therefore, the findings of amnesic patients with MTL lesions, albeit scarce, do not contradict the idea that these forms of personal semantic memory are separable from episodic memory.

4.2. Mechanisms of personal semantic updating: insights from amnesia

4.2.1. Autobiographical fact knowledge

The results of 24 patients reveal that anterograde memory for autobiographical facts is commonly impaired in amnesia. Given that the MTL appears necessary for the storage and retrieval of retrograde autobiographical facts, it is reasonable to assume that it also should be involved in the acquisition of newly acquired autobiographical facts, which presumably are laid down into pre-morbid (i.e. retrograde) personal knowledge. Yet, surprisingly, six of nine patients in the MTL group had normal anterograde memory for autobiographical facts. However, these amnesic patients may not represent most amnesic patients with MTL

[2] Marquine's (2009) dissertation presents the case of a confabulatory patient with ventral medial prefrontal cortex damage who has unreliable and inaccurate trait self-knowledge.

lesions, as all six demonstrated normal retrograde memory for autobiographical facts. Notably, these patients all had lesions restricted to the hippocampus, and yet, a closer examination of patients with hippocampal only lesions shows that retrograde memory for autobiographical facts is commonly impaired in this population (8 within normal limits versus 7 impaired). Nevertheless, future research will need to investigate the role of extra-hippocampal MTL regions in autobiographical fact updating. Indeed, Martinelli et al. (2013) found that the retrieval of autobiographical facts was correlated with activation in the parahippocampus in healthy adults. Furthermore, prior research has shown that a sense of familiarity for new general semantic knowledge can be acquired through extra-hippocampal mechanisms (Verfaellie, Koseff, & Alexander, 2000). Whether this is also the case for personal fact knowledge remains to be investigated.

Prior neuropsychological research on MTL amnesia has not resolved whether episodic memory is a prerequisite for the acquisition of autobiographical fact knowledge or whether some new personal fact learning is supported by slow neocortical mechanisms. In principle, comparing anterograde memory for autobiographical facts and anterograde memory for autobiographical events has the potential to shed light on this issue. However, in practice, the use of the recent time period on the AMI to compare anterograde memory for these two types of memory is problematic, because healthy adults consistently perform at ceiling for both autobiographical facts and autobiographical events. A more fruitful approach to addressing the mechanisms of new personal fact learning may be to investigate the nature of such learning in amnesia, on the premise that neocortical learning lacks the flexibility that results from MTL-mediated relational processing. Indeed, neuropsychological research has shown that the type of knowledge that is acquired post-onset of amnesia can be hyper-specific (Glisky, Schacter, & Tulving, 1986) and isolated from other semantic knowledge (Westmacott & Moscovitch, 2001). As such, future research could investigate whether post-morbid autobiographical facts are less integrated into one's life story and sense of self.

In summary, anterograde memory for autobiographical facts was commonly impaired in amnesia, and thus these results imply that the MTL, although possibly not the hippocampus proper, is necessary for normal autobiographical fact updating; however, the precise contribution of the MTL remains unknown. Furthermore, prior research has not been able to elucidate whether autobiographical fact learning depends on episodic memory or whether semantic memory mechanisms contribute as well.

4.2.2. Knowledge of traits/roles and thoughts/beliefs

There is limited neuropsychological research on the acquisition of novel personal traits, roles, thoughts, and beliefs in patients with stable amnesia secondary to MTL lesions. Tulving (1993) investigated whether amnesic patient K.C.'s knowledge of his personality had been modified to accommodate his post-injury demeanor, and Lieberman et al. (2001) investigated the impact of amnesia on the updating of personal beliefs towards art in a group study that included patients with MTL lesions. Preliminary evidence from these studies shows that these forms of personal semantic memory can be updated in the face of amnesia, implying that new semantic learning of highly conceptual personal knowledge, such as traits, roles, thoughts, and beliefs, might occur in the absence of episodic memory. Indeed, subsequent research with healthy adults supported this notion (Sherman & Klein, 1994). These results cast doubt on the idea that episodic memory is a prerequisite for semantic memory, and instead are in line with the notion that semantic memory interacts with but is independent of episodic memory. As mentioned, whether autobiographical fact learning depends on episodic memory is unclear.

4.3. Limitations

The results of this review speak to the necessity of the MTL to autobiographical fact knowledge but do not imply that only the MTL is important for this form of personal semantic memory. Relying on MRI for lesion demarcation has its limitations, and we cannot rule out the possibility that some patients in the MTL-only group had subtle damage to neural pathways extending beyond the MTL that was not appreciated on imaging. Furthermore, a meta-analysis of functional neuroimaging evidence by Martinelli et al. (2013) suggests that the MTL is part of a core network of brain regions involved in the storage and retrieval of autobiographical facts, including the thalamus, medial and ventrolateral prefrontal cortex, anterior and posterior cingulate cortex, and lateral and superior temporal lobe. Therefore, future studies of patients with lesions to other parts of this neural network may shed light on how these brain regions work in concert with the MTL to mediate autobiographical fact knowledge.

Also, the results of this review are based on the assumption that autobiographical memory measures, like the AMI, provide separable indices of episodic memory and personal semantic memory. However, these autobiographical memory measures are not process pure; episodic memory queries may be answered with semanticized stories, and in non-amnesic individuals episodic memory may facilitate the retrieval of personal semantic knowledge. As an alternative approach to a content-based analysis of personal memory, more attention could be directed towards the type of consciousness elicited by the retrieval of personal memory (Klein, 2013). For instance, Tulving's (1985) influential model proposes that semantic memory is known without being relived (i.e. noetic consciousness), whereas episodic memory requires conscious recollection of past experience (i.e. autonoetic consciousness). Thus, future research might provide insight into the cognitive and neural bases of personal semantic memory by investigating the type of consciousness that accompanies the retrieval of personal memory in amnesia.

4.4. Concluding remarks: personal semantic memory and self-referential thinking

Prior research has shown that personal semantic memory contributes to numerous cognitive processes that involve self-referential thinking, including reflecting on one's past life, imagining a personal future, and maintaining self-identity. The results of this review support the notion that personal semantic memory does not rely on a unitary set of cognitive and neural mechanisms (Klein & Gangi, 2010; Klein & Lax, 2010); therefore, how personal semantic memory contributes to self-referential thinking may depend on the type of personal knowledge that is involved. Indeed, autobiographical facts, whose retrieval depends on the MTL and perhaps the neocortex, may support self-referential thinking that is experience-near but devoid of detailed perceptual and spatial specificity. In contrast, knowledge of one's traits, roles, thoughts, and beliefs may support self-referential thinking that is highly conceptual and independent of the MTL. These results may have implications for understanding the role of personal semantic memory in a variety of cognitive constructs, including prospection (D'Argembeau & Demblon, 2012), autobiographical memory (Conway, 2005), self-identity and self-continuity (Prebble et al. 2013), as well as for elucidating the utility of self-referential cognitive rehabilitation strategies (Grilli & Glisky, 2013).

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References*

Addis, D. R., & Tippet, L. (2004). Memory of myself: autobiographical memory and identity in Alzheimer's disease. *Memory*, *12*(1), 56–74.

Baddeley, A. D. (1988). Cognitive psychology and human memory. *Trends in Neurosciences*, *11*, 176–181.

(*) Bastin, C., Van der Linden, M., Charnallet, A., Denby, C., Montaldi, D., Roberts, N., et al. (2004). Dissociation between recall and recognition memory performance in an amnesic patient with hippocampal damage following carbon monoxide poisoning. *Neurocase: The Neural Basis of Cognition*, *10*(4), 330–344.

(*) Bayley, P. J., Gold, J. J., Hopkins, R. O., & Squire, L. R. (2005). The neuroanatomy of remote memory. *Neuron*, *46*, 799–810.

(*) Bayley, P. J., Hopkins, R. O., & Squire, L. R. (2006). The fate of old memories after medial temporal lobe damage. *The Journal of Neuroscience*, *26*(51), 13311–13317.

Binder, J. R., & Desai, R. H. (2011). The neurobiology of semantic memory. *Trends in Cognitive Sciences*, *15*(11), 527–536.

(*) Buccione, I., Fadda, L., Serra, L., Caltagirone, C., & Carlesimo, G. A. (2008). Retrograde episodic and semantic memory impairment correlates with side of temporal lobe damage. *Journal of the International Neuropsychological Society*, *14*, 1083–1094.

(*) Calabrese, P., Markowitsch, H. J., Durwen, H. F., Widlitzek, H., Haupts, M., Holinka, B., et al. (1996). Right temporofrontal cortex as critical locus for the ecphory of old episodic memories. *Journal of Neurology, Neurosurgery, & Psychiatry*, *61*, 304–310.

Cermak, L. S., & O'Connor, M. (1983). The anterograde and retrograde retrieval ability of a patient with amnesia due to encephalitis. *Neuropsychologia*, *21*(3), 213–234.

(*) Cipolotti, L., Shallice, T., Chan, D., Fox, N., Scahill, R., Harrison, G., et al. (2001). Long-term retrograde amnesia…the crucial roles of the hippocampus. *Neuropsychologia*, *39*, 151–172.

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, *53*, 594–628.

Conway, M. A. (2009). Episodic memories. *Neuropsychologia*, *47*, 2305–2313.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*(2), 261–288.

Damasio, A. R., Eslinger, P. J., Damasio, H., Van Hoesen, G. W., & Cornell, S. (1985). Multimodal amnesic syndrome following bilateral temporal and basal forebrain damage. *Archives of Neurology*, *42*, 252–259.

Duval, C., Desgranges, B., de La Sayette, V., Belliard, S., Eustache, F., & Piolino, P. (2012). What happens to personal identity when semantic knowledge degrades? A study of the self and autobiographical memory in semantic dementia. *Neuropsychologia*, *50*, 254–265.

D'Argembeau, A., & Demblon, J. (2012). On the representational systems underlying prospection: evidence from the event-cueing paradigm. *Cognition*, *125*, 160–167.

D'Argembeau, A., & Mathy, A. (2011). Tracking the construction of episodic future thoughts. *Journal of Experimental Psychology: General*, *140*(2), 258–271.

(*) Eslinger, P. (1998). Autobiographical memory after temporal lobe lesions. *Neurocase: The Neural Basis of Cognition*, *4*(6), 481–495.

(*) Fujii, T., Yamadori, A., Endo, K., Suzuki, K., & Fukatsu, R. (1999). Disproportionate retrograde amnesia in a patient with herpes simplex encephalitis. *Cortex*, *35*, 599–614.

(*) Gilboa, A., Winocur, G., Rosenbaum, R. S., Poreh, A., Gao, F., Black, S. E., et al. (2006). Hippocampal contributions to recollection in retrograde and anterograde amnesia. *Hippocampus*, *16*, 966–980.

Glisky, E. L. (2004). Disorders of memory. In: J. Ponsford (Ed.), *Cognitive and behavioral rehabilitation: From neurobiology to clinical practice* (pp. 100–128). New York, NY: Guilford Press.

Glisky, E. L., Schacter, D. L., & Tulving, E. (1986). Learning and retention of computer-related vocabulary in memory-impaired patients: method of vanishing cues. *Journal of Clinical and Experimental Psychology*, *8*(3), 292–312.

Graham, K. S., & Hodges, J. R. (1997). Differentiating the roles of the hippocampal complex and the neocortex in long-term memory storage: evidence from the study of semantic dementia and alzheimer's disease. *Neuropsychology*, *11*(1), 77–89.

Greenberg, D. L., & Verfaellie, M. (2010). Interdependence of episodic and semantic memory: evidence from neuropsychology. *Journal of the International Neuropsychological Society*, *16*, 748–753.

(*) Grewal, R. P. (2003). Severe amnesia following a unilateral temporal lobe stroke. *Journal of Clinical Neuroscience*, *10*(1), 102–104.

Grilli, M. D., & Glisky, E. L. (2010). Self-Imagining enhances recognition memory in memory-impaired individuals with neurological damage. *Neuropsychology*, *24*(6), 698–710.

Grilli, M. D., & Glisky, E. L. (2011). The self-imagination effect: Benefits of a self-referential encoding strategy on cued recall in memory-impaired individuals with neurological damage. *Journal of the International Neuropsychological Society*, *17*(5), 929–933.

Grilli, M. D., & Glisky, E. L. (2013). Imagining a better memory: self-imagination in memory- impaired patients. *Clinical Psychological Science*, *1*(1), 93–99.

(*) Haslam, C., Cook, M., & Coltheart, M. (2001). 'I know your name but not your face': explaining modality-based differences in access to biographical knowledge in a patient with retrograde amnesia. *Neurocase: The Neural Basis of Cognition*, *7*, 189–199.

Haslam, C., Jetten, J., Haslam, S. A., Pugliese, C., & Tonks, J. (2011). 'I remember therefore I am, and I am therefore I remember': exploring the contributions of episodic and semantic self-knowledge to strength of identity. *British Journal of Psychology*, *102*, 184–203.

(*) Hepner, I. J., Mohamed, A., Fulham, M. J., & Miller, L. A. (2007). Topgraphical, autobiographical, and semantic memory in a patient with bilateral mesial temporal and retrosplenial infarction. *Neurocase: The Neural Basis of Cognition*, *13*(2), 97–114.

(*) Hirano, M., & Noguchi, K. (1998). Dissociation between specific personal episodes and other aspects of remote memory in a patient with hippocampal amnesia. *Perceptual and Motor Skills*, *87*, 99–107.

Hou, C. E., Miller, B. L., & Kramer, J. H. (2005). Patterns of autobiographical memory loss in dementia. *International Journal of Geriatric Psychiatry*, *20*, 809–815.

Ivanoiu, A., Cooper, J. M., Shanks, M. F., & Venneri, A. (2006). Patterns of impairment in autobiographical memory in the degenerative dementias constrain models of memory. *Neuropsychologia*, *44*, 1936–1955.

Kan, I. P., Alexander, M. P., & Verfaellie, M. (2011). Contribution of prior semantic knowledge to new episodic learning in amnesia. *Journal of Cognitive Neuroscience*, *21*(5), 938–944.

Kapur, N. (1993). Focal retrograde amnesia in neurological disease: A critical review. *Cortex*, *29*(2), 217–234.

(*) Kapur, N., & Brooks, D. J. (1999). Temporally-specific retrograde amnesia in two cases of discrete bilateral hippocampal pathology. *Hippocampus*, *9*, 247–254.

(*) Kapur, N., Scholey, K., Moore, E., Barker, S., Brice, J., Thompson, S., et al. (1996). Long-term retention deficits in two cases of disproportionate retrograde amnesia. *Journal of Cognitive Neuroscience*, *8*(5), 416–434.

(*) Kartsounis, L. D., Rudge, P., & Stevens, J. M. (1995). Bilateral lesions of CA1 and CA2 fields of the hippocampus are sufficient to cause a severe amnesic syndrome in humans. *Journal of Neurology, Neurosurgery, and Psychiatry*, *59*, 95–98.

(*) Kitchner, E. G., Hodges, J. R., & McCarthy, R. (1998). Acquisition of post-morbid vocabulary and semantic facts in the absence of episodic memory. *Brain*, *121*, 1313–1327.

Klein, S. B. (2013). Making the case that episodic recollection is attributable to operations occurring at retrieval rather than to content stored in a dedicated subsystem of long-term memory. *Frontiers in Behavioral Neuroscience*, *7*(3), 1–14.

Klein, S. B., & Gangi, C. E. (2010). The multiplicity of self: neuropsychological evidence and its implications for the self as a construct in psychological research. *Annals of the New York Academy of Sciences*, *1191*, 1–15.

Klein, S. B., & Lax, M. L. (2010). The unanticipated resilience of trait self-knowledge in the face of neuraldamage. *Memory*, *18*(8), 918–948.

(*) Klein, S. B., Rozendal, K., & Cosmides, L. (2002). A social-cognitive neuroscience analysis of the self. *Social Cognition*, *20*(2), 105–135.

Kopelman, M. D. (1989). Remote and autobiographical memory, temporal context memory and frontal atrophy in Korsakoff and Alzheimer patients. *Neuropsychologia*, *27*(4), 437–460.

Kopelman, M. D. (2000). Focal retrograde amnesia and the attribution of causality: an exceptionally critical review. *Cognitive Neuropsychology*, *17*(7), 585–621.

Kopelman, M. D., Lasserson, D., Kingsley, D. R., Bello, F., Rush, C., Stanhope, N., et al. (2003). Retrograde amnesia and the volume of critical brain structures. *Hippocampus*, *13*, 879–891.

(*) Kopelman, M. D., Stanhope, N., & Kingsley, D. (1999). Retrograde amnesia in patients with diencephalic, temporal lobe, or frontal lesions. *Neuropsychologia*, *37*, 939–958.

Kopelman, M. D., Wilson, B. A., & Baddeley, A. D. (1989). The autobiographical memory interview: a new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology*, *11*(5), 724–744.

Kumaran, D., Summerfield, J. J., Hassabis, D., & Maguire, E. A. (2009). Tracking the emergence of conceptual knowledge during human decision making. *Neuron*, *63*(6), 889–901.

(*) Lieberman, M. D., Ochsner, K. N., Gilbert, D. T., & Schacter, D. L. (2001). Do amnesics exhibit cognitive dissonance reduction? the role of explicit memory and attention on attitude change. *Psychological Science*, *12*(2), 135–140.

Maguire, E. A., Kumaran, D., Hassabis, D., & Kopelman, M. D. (2010). Autobiographical memory in semantic dementia: a longitudinal fMRI study. *Neuropsychologia*, *48*, 123–136.

Markowitsch, H. J., & Staniloiu, A. (2013). The impairment of recollection in functional amnesic states. *Cortex*, 1494–1510.

Marquine, M. J. (2009). Self-knowledge and self-referential processing in memory disorders: implications for neuropsychological rehabilitation. *Dissertation Abstracts International: Section B: The Sciences and Engineering*, *69*, 4432.

Martinelli, P., Sperduti, M., & Piolino, P. (2013). Neural substrates of the self-memory system: new insights from a meta-analysis. *Human Brain Mapping*, *34*(7), 1515–1529.

* Denotes articles included in the review.

McAdams, D. P. (2013). The psychological self as actor, agent, and author. *Perspectives on Psychological Science*, *8*(3), 272–295.
(*) McCarthy, R. A., Kopelman, M. D., & Warrington, E. K. (2005). Remembering and forgetting of semantic knowledge in amnesia: a 16-year follow-up investigation of RFR. *Neuropsychologia*, *43*, 356–372.
(*) Oxbury, S., Oxbury, J., Renowden, S., Squier, W., & Carpenter, K. (1997). Severe amnesia: an unusual late complication after temporal lobectomy. *Neuropsychologia*, *35*(7), 975–988.
Philippi, C. L., Duff, M. C., Denburg, N. L., Tranel, D., & Rudrauf, D. (2012). Medial PFC damage abolishes the self-reference effect. *Journal of Cognitive Neuroscience*, *24*(2), 475–481.
Prebble, S. C., Addis, D. R., & Tippet, L. J. (2013). Autobiographical memory and sense of self. *Psychological Bulletin*, *139*(4), 815–840.
Rathbone, C. J., Moulin, C. J. A., & Conway, M. A. (2009). Autobiographical memory and amnesia: using conceptual knowledge to ground the self. *Neuroscase: The Neural Basis of Cognition*, *15*(5), 405–418.
(*) Reed, J. M., & Squire, L. R. (1998). Retrograde amnesia for facts and events: findings from four new cases. *The Journal of Neuroscience*, *18*(10), 3943–3954.
(*) Reinvang, I., Nielsen, C. S., Gjerstad, L., & Bakke, S. J. (2000). Isolated retrograde amnesia: evidence for preservation of implicit memory. An event-related potential investigation. *Neurocase: The Neural Basis of Cognition*, *6*(5), 423–433.
Renoult, L., Davidson, P. S. R., Palombo, D. J., Moscovitch, M., & Levine, B. (2012). Personal semantics: at the crossroads of semantic and episodic memory. *Trends in Cognitive Sciences*, *16*(11), 550–558.
Rosenbaum, R. S., Kohler, S., Schacter, D. L., Moscovitch, M., Westmacott, R., Black, S. E., et al. (2005). The case of K.C.: contributions of a memory-impaired person to memory theory. *Neuropsychologia*, *43*, 989–1021.
(*) Rosenbaum, R. S., Moscovitch, M., Foster, J. K., Schnyer, D. M., Gao, F., Kovacevic, N., et al. (2008). Patterns of autobiographical memory loss in medial-temporal lobe amnesic patients. *Journal of Cognitive Neuroscience*, *20*(8), 1490–1506.
(*) Ross, S. J. M., & Hodges, J. R. (1997). Preservation of famous person knowledge in a patient with severe post anoxic amnesia. *Cortex*, *33*, 733–742.
(*) Schnider, A., Gutbrod, K., & Ozdoba, C. (1995). Very severe amnesia with acute onset after hippocampal damage due to systemic lupus erythematosus. *Journal of Neurology, Neurosurgery, & Psychiatry*, *59*(6), 644–646.
Sherman, J. W., & Klein, S. B. (1994). Development and representation of personality impressions. *Journal of Personality and Social Psychology*, *67*(6), 972–983.
Singer, J., Rexhaj, B., & Baddeley, J. (2007). Older, wiser, and happier? comparing 'older adults and college students' self-defining memories. *Memory*, *15*(8), 886–898.
Squire, L. R. (1992). Memory and the hippocampus: a synthesis from findings with rats, monkeys, and humans. *Psychological Review*, *99*, 195–231.
Squire, L. R., & Zola, S. M. (1998). Episodic memory, semantic memory, and amnesia. *Hippocampus*, *8*, 205–211.
(*) Stanhope, N., & Kopelman, M. D. (2000). Art and memory: a 7-year follow-up of herpes encephalitis in a professional artist. *Neurocase: The Neural Basis of Cognition*, *6*(2), 99–110.
(*) Steinvorth, S., Levine, B., & Corkin, S. (2005). Medial temporal lobe structures are needed to re-experience remote autobiographical memories: evidence from H. M. and W.R. *Neuropsychologia*, *43*, 479–496.
(*) Tanaka, Y., Miyazawa, Y., Hashimoto, R., Nakano, I., & Obayashi, T. (1999). Postencephalitic focal retrograde amnesia after bilateral anterior temporal lobe damage. *Neurology*, *53*, 344–350.
Thomsen, D. K. (2009). There is more to life stories than memories. *Memory*, *17*(4), 445–457.
(*) Tranel, D., & Jones, R. D. (2006). Knowing 'what' and knowing 'when'. *Journal of Clinical and Experimental Neuropsychology*, *28*(1), 43–66.
Tse, D., Takeuchi, T., Kakeyama, M., Kajii, Y., Okuno, H., Tohyama, C., et al. (2011). Schema-dependent gene activation and memory encoding in neocortex. *Science*, *333*, 891–895.
(*) Tsukiura, T., Ohtake, H., Fujii, T., Miura, R., Ogawa, T., & Yamadori, A. (2003). Preserved ability to recognize keywords related to remote events in the absence of retrieval of relevant knowledge: a case of postencephalitic amnesia. *Brain and Cognition*, *51*, 1–11.
Tulving, E. (1972). Episodic and semantic memory. In: E. Tulving, & W. Donaldson (Eds.), *Organization of memory* (pp. 381–403). New York: Academic Press.
Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.
Tulving, E. (1985). Memory and consciousness. *Canadian Journal of Psychology*, *26*, 1–12.
(*) Tulving, E. (1993). Self-knowledge of an amnesic individual is represented abstractly. In: T. K. Srull, & R. S. Wyer (Eds.), *Advances in social cognition*, Vol. *5* (pp. 147–156). Hillsdale, NJ: Erlbaum.
Verfaellie, M., Koseff, P., & Alexander, M. P. (2000). Acquisition of novel semantic information in amnesia: effects of lesion location. *Neuropsychologia*, *38*, 484–492.
Warrington, E. K., & Duchen, L. W. (1992). A re-appraisal of a case of persistent global amnesia following right temporal lobectomy: a clinico-pathological study. *Neuropsychologia*, *30*(5), 437–450.
Westmacott, R., & Moscovitch, M. (2001). Names and words without meaning: incidental postmorbid semantic learning in a person with extensive bilateral medial temporal damage. *Neuropsychology*, *15*(4), 586–596.
(*) Wilson, B. A., Baddeley, A. D., & Kapur, N. (1995). Dense amnesia in a professional musician following herpes simplex virus encephalitis. *Journal of Clinical and Experimental Neuropsychology*, *17*(5), 668–681.