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Specific, personally meaningful cues can benefit episodic prospection in medial temporal lobe amnesia

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Objectives. To determine whether severity of episodic prospection impairment in medial temporal lobe (MTL) amnesia is reduced by the types of cues that are used to elicit personal future episodes and, if so, whether episodic memory impairment is similarly affected.

Design. Multiple case study of five individuals with MTL amnesia and healthy control participants.

Methods. Participants were administered two tests of episodic prospection: A commonly used Galton–Crovitz task that uses generic cues (e.g., lemon) and a novel task that includes specific, personally meaningful cues referring to planned or plausible future events (e.g., granddaughter's recital). Narratives were scored for episodic detail using the Autobiographical Interview protocol (Levine *et al.*, 2002), which distinguishes between internal (episodic) details and external (non-episodic) details.

Results. Results showed that specific, personally meaningful cues led to an appreciable reduction of episodic memory and prospection impairment in three of the amnesic cases tested. Clinical benefit from more structured, self-related cues may depend on factors such as extent of MTL damage or general severity of episodic memory and prospection impairment, highlighting the importance of methodological approaches to neuropsychological research that treat each case on an individual basis.

Conclusions. In cases of mild–moderate amnesia, specific, personal cues afford more detailed episodic remembering and prospective imagining than individual cue words.

Practitioner points

- Previous reports of episodic prospection impairment in medial temporal lobe (MTL) amnesia might misrepresent an individual case's true prospective abilities
- Specific cues drawn from a patient's everyday life have greater ecological validity than the more typical generic cues used to elicit episodic prospection and can aid some individuals with MTL amnesia in the ability to imagine future experiences

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- Assessment and rehabilitation tools for MTL amnesic populations should attempt to minimize broad, open-ended questions and instead provide more structured and personally meaningful cues to guide responses
- Further research is needed to determine case-specific characteristics that best predict benefit from specific, personal cues. These might include extent of MTL damage and overall severity of episodic memory and prospection impairment.

The temporal orientation of episodic thought, traditionally focused on memories of past experiences, has undergone a fundamental shift to include prospections of future experiences (Klein, 2013a; Suddendorf, 2006; Suddendorf & Corballis, 2007). This shift in considering memory impairments to also encompass impairments in prospection has lead to a richer understanding of how these deficits impact on the total cognitive picture of the person, their abilities, and their possibilities for recovery.

Impaired episodic prospection – the ability to simulate detailed future personal experiences – was first observed by Tulving (1985), who noted that the amnesic case K.C.'s inability to produce a single detail relating to past experiences extended to possible future experiences (Tulving, 1985). This observation is supported by systematic investigations of future episodic imagining in the case D.B. (Klein, Loftus, & Kihlstrom, 2002), past episodic imagining in K.C. (Rosenbaum, Gilboa, Levine, Winocur, & Moscovitch, 2009; first reported in Rosenbaum *et al.*, 2005), and imagining/scene construction in a group of amnesic cases (Hassabis, Kumaran, Vann, & Maguire, 2007). Although it is possible that these cases might have benefited from more structured or ecologically valid cues, it is relatively unknown whether the level of impairment is a function of the cues used to elicit prospective episodes.

Galton–Crovitz cueing (Crovitz & Schiffman, 1974), in which participants are given a single, generic cue word (e.g., 'lemon') as a starting point for a prospective episode, is typically used to elicit narratives in studies of episodic prospection (e.g., amnesia, Race, Keane, & Verfaellie, 2011; bipolar disorder, King *et al.*, 2011; amnestic mild cognitive impairment, Gamboz *et al.*, 2010; Parkinson's disease, de Vito *et al.*, 2012). This method prevails in popularity for several reasons: It is a long-standing method for cueing autobiographical memories (Galton, 1879; McDermott, Szpunar, & Christ, 2009), and the overlap between episodic memory and prospective imagining makes it an obvious option for cueing prospection. It is also relatively easy to construct and administer, with the same cue words applied uniformly to each participant. Finally, cue words can be matched on variables such as imageability and frequency of use, allowing for better experimental stimulus control.

Galton–Crovitz cueing also has methodological drawbacks. For example, Maguire and Hassabis (2011) suggested that individual cue words can elicit semantic bias and erroneously inflate amnesics' episodic prospection scores, thereby masking potential deficits. They also proposed that cueing with full sentence descriptors is more valid because it encourages rich prospective visualization, which they argue is the foundation of any imagined episode (Hassabis & Maguire, 2007). In contrast, Hurley, Maguire, and Vargha-Khadem (2011) suggested that constructing a detailed representation of a future experience from a single word places high cognitive demands on neuropsychological populations and may, instead, result in overestimating the magnitude of a participant's actual impairment. This could explain how episodic memory in the developmental amnesic case H.C. was impaired when assessed with single Galton–Crovitz cue words (Kwan, Carson, Addis, & Rosenbaum, 2010) but appeared to improve when she was provided with a list of event topics (e.g., high school graduation) from which to choose cues (Rosenbaum *et al.*, 2011).

As with studies of episodic memory, there are variations in the types of cues that have been used by researchers to elicit future events. These differences have led to debate over how best to measure the construct and how interpret discrepant results across studies (Klein, 2013b; Schacter, Addis, Hassabis, Martin, Spreng, & Szpunar, 2012). Nevertheless, systematic research on how such differences may affect performance is only beginning to surface (Rasmussen & Berntsen, 2014).

The main objective of this study is to test whether specific, personally meaningful cues can yield richer episodic prospection in amnesic individuals over typically used single Galton-Crovitz cue words and if so, whether this benefit extends also to their episodic memory. Another objective is to investigate the degree to which each individual amnesic case benefits from cueing, along with the factors that lead to cue-related gains in a given case. Clinical cases are often treated at the group level to increase statistical power and reduce unwanted noise, but averaging may mask important and informative individual differences among clinical cases (Rosenbaum, Gilboa, & Moscovitch, 2014; Schwartz & Dell, 2010). Holdstock *et al.* (2008) illustrated the issues that arise in averaging neuropsychological cases' performance in a study that directly compared two individuals with hippocampal damage. Despite very similar and selective hippocampal lesions, 'Patient A.C.' demonstrated surprisingly intact memory performance and even scored above average on some measures. In contrast, 'Patient P.R.' demonstrated the more typical finding of impaired recollection and highly variable performance on measures of recognition. The authors concluded that even seemingly selective hippocampal damage can have highly variable effects on memory and that additional factors, such as location and extent of hippocampal damage, motivation, and functionality of residual hippocampal tissue and extra-hippocampal tissue, must be taken into consideration. Squire, McDuff, and Frascino (2011) highlight this issue in the context of episodic prospection and assert that differences in the aetiologies and selectivity of hippocampal damage must be considered in predicting differences in prospective abilities among medial temporal lobe (MTL) cases.

Methods

Participants

Amnesic cases

This study features five amnesic cases that represent varied aetiologies and levels of memory impairment. All cases were tested at least two-years post-injury at which point their cognitive recovery was stable. Table 1 summarizes the demographic and neuropsychological profiles of each case. Cases have been previously documented in the literature (see Kwan, Craver, Green, Myerson, & Rosenbaum, 2013; Kwan *et al.*, 2015, for detailed case descriptions) and are summarized briefly below

D.A. is a 59-year-old, right-handed male with 17 years of education who contracted herpes simplex encephalitis, resulting in extensive damage to MTL structures bilaterally. MRI scans confirmed damage to MTL structures, particularly on the right side (Figure 1). Additional volume reductions in the right hemisphere were observed in regions outside of the MTL, including regions of posterior temporal, ventral frontal, occipital, and anterior cingulate cortex, as well as posterior thalamus. D.A.'s volume loss in the left hemisphere was relatively restricted to the MTL region. D.A.'s neuropsychological profile indicates average IQ and intact cognitive function, including preserved semantic memory;

Table 1. Amnesic individuals' demographic and neuropsychological data

								WMS-R/III/IV		Verb Learn			ROCF	
Case	Aetiology	Age	Ed	FSIQ	WCST	LF	BNT	LP/M-I	LP/M-II	AQ	LDFC	R	C	DR
D.A.	Encplts	42/62	17	117	6	8	10	7	1	0	0	0	18	0
D.G.	Anoxia	45/48	16	92	6	6	11	–	–	5	5	7	8	1
L.D.	TLR	59/61	19	111	6	8	0	10	2	3	3	0	3	8
B.L.	Anoxia	25/52	13	92	6	11	–	8	6	8	7	10	2	2
S.N.	Stroke	44/46	12	114	3	8	8	1	2	3	1	1	8	3

Notes. Age, age in years at injury/age in years at testing; Ed, education in years; Encplts, encephalitis; FSIQ, Full Scale IQ, based on Wechsler Adult Intelligence Scale – Revised for D.A. and D.G., Wechsler Abbreviated Scale of Intelligence–III for L.D. and S.N., and Wechsler Abbreviated Scale of Intelligence–IV for B.L.; WCST, Wisconsin Cart Sort Test, number of completed categories/6.
The following measures are reported in scaled scores: LF, letter fluency; BNT, Boston Naming Test; WMS-R/III/IV, Wechsler Memory Scale Revised/III/IV, LP/M-I, LP/M-II, Logical Passages/Memory I and II; Verb Learn., Verbal learning based on California Verbal Learning Test-II for D.A., D.G., and B.L., Hopkins Verbal Learning Test – Revised for L.D., Kaplan Baycrest Neurocognitive Assessment, Word List Learning for S.N., AQ, acquisition; LDFR, long delay free recall; R, recognition; ROCF, Rey Osterrieth Complex Figure, C, copy, DR, delayed recall.

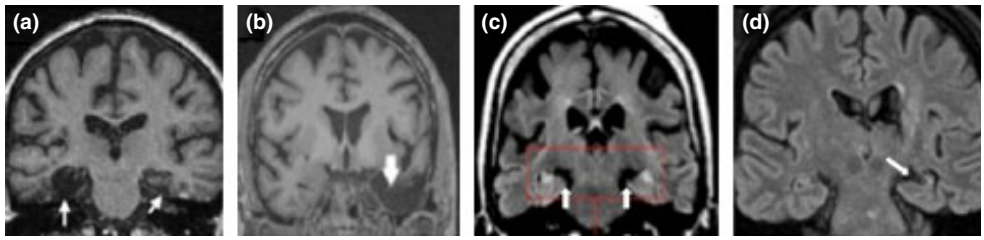

Figure 1. Coronal T1 MRI slices of damage for (a) D.A., (b) L.D., (c) B.L., and (d) S.N. Images are presented according to radiological convention (right hemisphere is presented on left side of image). D.G. could not be scanned because of an implantable cardioverter defibrillator.

however, within the episodic memory domain, he has a moderate retrograde amnesia that is temporally graded (with better remote than recent memory), which is likely an overestimate due to his unique ability to compensate for his memory deficits (Rosenbaum *et al.*, 2008; Ryan, Moses, Barense, & Rosenbaum, 2013), and a significant anterograde amnesia (Table 1).

D.G. is a 47-year-old, right-handed man with 16 years of education who suffered cardiac arrest and related anoxia. He had an implantable cardioverter–defibrillator inserted following the cardiac arrest, which prevented him from undergoing MRI examination. Consistent with other amnesic profiles, D.G. demonstrates a neuropsychological pattern that is characteristic of hippocampal/MTL damage. Within the episodic domain, D.G. has a temporally graded retrograde amnesia and anterograde amnesia for personal experiences, whereas semantic memory, other domains of cognitive function, and overall IQ remain intact (Table 1).

L.D. is a 61-year-old right-handed man with 19 years of education and with a history of complex partial seizures. Initial MRI revealed a left hippocampal lesion, and subsequent MRI revealed a growth in the left parahippocampal region. In 2011, L.D. underwent a left

temporal lobectomy and amygdalohippocampectomy to treat refractory temporal lobe epilepsy. Resection of the left middle temporal gyrus, hippocampus, uncus, and amygdala successfully ameliorated his seizures but exacerbated his memory impairment (Figure 1). After surgical resection, L.D.'s episodic memory further deteriorated relative to pre-surgical functioning, particularly for verbal material. L.D.'s episodic memory impairment appears to be selective with a stable pattern of average overall intellectual function, with the exception of low semantic fluency (Table 1).

B.L. is a 52-year-old, right-handed man with 13 years of education who suffered cardiac arrest and a subsequent anoxic episode as a result of electrocution. MRI shows clear bilateral lesions in the hippocampus and hyperintensities consistent with hippocampal sclerosis. B.L.'s hippocampal lesions appear to be limited to the dentate gyrus with relative sparing of the CA1 and CA3 subfields and the surrounding parahippocampal cortices (Figure 1). B.L. has borderline-low average memory for verbal material and stark memory impairment for non-verbal material. B.L. demonstrates average intellectual function, but deficits in motor speed and dexterity, and executive functions including difficulties in planning, mental flexibility, and self-monitoring. Other cognitive abilities appear to be within normal limits (Table 1).

S.N. is a 46-year-old man with 12 years of education who suffered a left thalamic haemorrhage (likely secondary to acute hypertension). MRI revealed bilateral damage to the dorsolateral thalamus (with greater damage on the left) and left pons, and smaller lesions in the right pons, right putamen, and left occipital lobe medial to the occipital horn. Examination of MTL regions revealed a localized left hippocampal lesion. S.N. appears to have intact perirhinal, entorhinal, and parahippocampal cortices as well as intact fornices and mammillary bodies (Figure 1). S.N. has intact retrograde memory for personal semantic information and a severe, selective impairment in episodic memory (in particular, encoding of verbal information). He exhibits high average overall intellectual functioning but demonstrates additional impairments in verbal fluency and inhibitory control (Table 1).

Controls

Control data for episodic prospection based on Galton–Crovitz cueing were taken from Addis, Wong, and Schacter's (2008) healthy older adult sample (n = 16, six male, age = 72.313 years, SD = 5.003). The older controls for baseline memory and prospection likely underestimate baseline impairment in our amnesic cases given known age-related decline in episodic memory and prospection (Addis *et al.*, 2008) and should yield a conservative estimate of the amnesics' impairment.

We tested a separate sample of older adults using specific, personally meaningful cues (n = 30, 16 male; mean age = 68.233, SD = 6.027). Participants gave informed, written consent and received monetary compensation for their time in accordance with the Human Research Ethics Committees of the university and hospital testing sites.

Procedure

Galton–Crovitz cueing

Episodic prospection data for the amnesic cases and controls were collected and reported in previous studies (Addis *et al.*, 2008; Kwan *et al.*, 2013, respectively); a brief description of the task procedure is included here for ease of comparison.

A Galton–Crovitz cueing paradigm in which cue words are used to elicit narratives of personal events was administered to participants (Crovitz & Schiffman, 1974; see Addis *et al.*, 2008 for detailed task description). Participants were asked to remember past personal events (up to 5 years ago) and to imagine future personal events (up to 5 years into the future). The task unfolded as follows: On each trial, participants were presented with a single cue word on a computer screen along with a time condition (past or future). Participants were instructed to use the cue to help generate a personal event that occurred in the past or that could occur in the future, depending on the time condition. We explained that the cue was a tool to help generate an event and that the event itself need not be related to the cue. For past trials, participants were asked to recall specific, personally experienced events in as much detail as possible. For future trials, participants were asked to imagine in as much detail as possible specific novel events that they might personally experience in the future. Each trial lasted five minutes, with the cue word and time frame appearing in full view for the duration of the trial. The experimenter gave one general probe (i.e., 'Is there anything (else) you can remember/imagine?') when approximately 30s of silence had elapsed, but did not give any specific probing. Sessions were recorded using a digital audio recorder and then transcribed.

Specific, personal cueing

Approximately 1 year after completing the Galton–Crovitz cueing, each amnesic case returned to provide narratives in response to specific, personally meaningful cues. None of the participants could recall the contents of the first test session, or even of having participated previously. A group of healthy, demographically matched controls was also tested. Before beginning the task, amnesic and control participants first identified six past personal events (up to 5 years ago) and six planned or plausible future personal events (up to 5 years in the future). Examples of events included specific appointments, anniversaries, and outings which participants identified the event with a brief tag (e.g., '40th wedding anniversary'). They did not elaborate on the event. All participants were permitted to draw from personal calendars for examples of future events. If participants encountered difficulty providing an event, the experimenter probed with the following questions: 'Might there be any events with family or friends that took place/may take place in <insert delay>?' and 'Is there something you possibly did/could see yourself doing in <insert delay>?' As expected, the amnesic cases had greater difficulty than controls in generating topics. In the case of S.N., his mother provided several possible future events when he was unable to provide cues.

While cues from participants are less controlled than if they had been experimenter-generated, such cues are more ecologically valid. We determined this to be a worthwhile trade-off given the clinical and theoretical importance of the ability to imagine real personal experiences. Once the cues were given, all aids were removed and participants had to freely construct the imagined experience without assistance. Participants identified only neutral or positively valenced future events to minimize the possibility of inducing anticipatory anxiety or distress. The experimental task then followed exactly the same procedure as the Galton–Crovitz condition.

Scoring

Narratives were transcribed and scored using the Autobiographical Interview, a scoring protocol designed to assess the episodic detail of participants' remembered

autobiographical events (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). The protocol has since been adapted to assess episodic detail in participants' episodic prospections (Addis *et al.*, 2008; Gamboz *et al.*, 2010). Raters were trained to meet reliability standards and were blind to group (amnesic, control). For each event, narratives were segmented and categorized as either internal (referring to specific episodic information about the central event) or external (non-episodic details provided by participants that are tangential or unrelated to the central event, semantic information, repetitions, or metacognitive statements/editorializing). We then tallied and averaged details from both internal and external categories, producing a separate overall index for each detail type, for future event narratives and for autobiographical memory narratives.

Results

We applied a descriptive, estimates-based approach that is commonly used in Neuropsychology to quantify the degree of impairment in each case (see Cumming, 2013, statistical guidelines for research integrity). This approach circumvents the frequent statistical limitations of patient studies that typically feature small sample sizes or rare populations. An estimates-based approach is sensitive to variability among cases and allows discussion of each amnesic individual in clinically meaningful terms of impairment severity. To this end, we calculated participants' *z*-scores corresponding to the number of internal details and external details generated by each case in response to each cueing condition relative to respective control groups. We then interpreted scores using a standardized psychometric conversion table based on the Wide Range Achievement Test – Third Edition, Administration Manual (WRAT-III, Wilkinson, 1993) that gives quantitative (estimated percentile rankings) and qualitative (diagnostic labels) estimates of impairment. Using this standardized table, we operationalized clinically significant change as a performance increase by at least one diagnostic level on a standardized psychometric conversion table, viewed as reflecting clinically meaningful improvement.

Episodic prospection

Figure 2 shows the performance of each amnesic case's performance on episodic prospection in response to specific, personal cues relative to Galton–Crovitz cues. As can be seen, the five amnesic cases showed varying degrees of benefit from personal cueing. Episodic prospection impairment in three of the five amnesic cases (L.D., B.L., and S.N.) was alleviated by personal cues, such that they generated a greater number of internal details when given personal cues compared to the number generated in response to generic cue words. This was particularly striking for S.N., who benefited despite being unable to supply the prospective cue. The number of internal details generated by D.A. and D.G. was lower than that of controls for each cue type and did not differ in response to personal cues.

In contrast, specific cueing had widely variable effects on external detail generation, with no clear pattern in external detail generation as a result of personal cueing. These findings are summarized in Table 2, which includes *z*-scores, estimated percentiles, and diagnostic labels corresponding to the number of internal and external details of future events that was generated by each amnesic case.

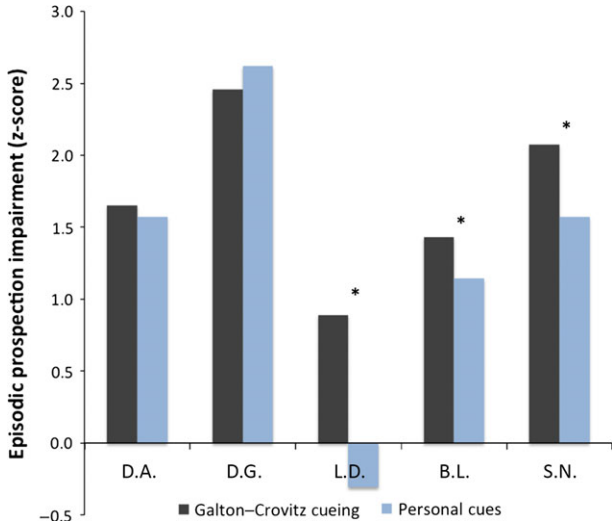

Figure 2. Episodic prospection using Galton–Crovitz and Personal cueing. *Z*-scores indicating degree of impaired episodic prospection in each amnesic case response to Galton–Crovitz cue words and specific, personal cues. *Z*-scores are reversed so that higher numbers indicate greater impairment. Asterisks denote clinically significant improvement, defined as improvement across diagnostic labels of function in a standardized psychometric conversion table.

Table 2. Episodic prospection with Galton–Crovitz cues and specific, personal cues

	Galton–Crovitz cue words			Personal specific cues		
Case	*Z*-score	‰ Rank	Descriptive label	*Z*-score	‰ Rank	Descriptive label
Internal details						
D.A.	−1.653	4th–5th	Borderline	−1.574	5th–6th	Borderline
D.G.	−2.459	0.7th–0.8th	Impaired	−2.622	0.4th–0.5th	Impaired
L.D.	−0.891	18th–19th	Low average	0.308	61st–63rd	Average*
B.L.	−1.432	7th–8th	Borderline	−1.144	12th–13th	Low average*
S.N.	−2.074	2nd	Impaired	−1.574	5th–6th	Borderline*
External details						
D.A.	−0.721	19th–21st	Average–Low average	−1.226	10th–12th	Low average
D.G.	−1.850	3rd–4th	Borderline	−0.718	23rd–25th	Low average
L.D.	0.404	66th	Average	−0.059	47th–50th	Average
B.L.	1.459	92nd–93rd	Superior	1.241	88th–90th	High average
S.N.	1.230	88th–90th	High average	2.653	99.6th	Very superior

Notes. 'Superior' performance indicates an excess of details.
*Clinically significant improvement.

Episodic memory

Figure 3 shows the performance of each amnesic case in response to specific, personal cues relative to Galton–Crovitz cues. As with episodic prospection, autobiographical episodic memory benefited from personal cueing in some but not all of the cases. Three of five amnesic cases (D.G., L.D., and B.L.) showed improved internal detail generation in

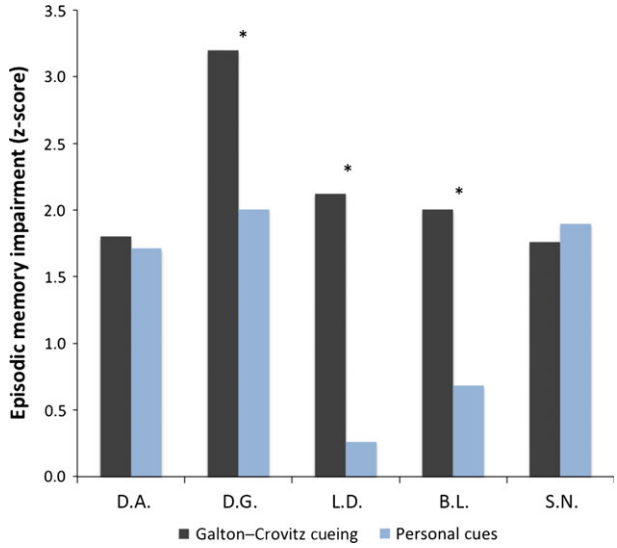

Figure 3. Episodic memory using Galton–Crovitz and Personal cueing. *Z*-scores indicating degree of impaired episodic memory in each amnesic case response to Galton–Crovitz cue words and specific, personal cues. *Z*-scores are reversed so that higher numbers indicate greater impairment. Asterisks denote clinically significant improvement, defined as improvement across diagnostic labels of function in a standardized psychometric conversion table.

response to personal cues, whereas two of the cases (D.A. and S.N.) did not show an appreciable change in internal detail generation across cue type. As with the results from the episodic prospection conditions, specific cueing did not have any consistent effect on the amnesic cases' external detail generation during autobiographical recollection. These findings are summarized in Table 3.

Discussion

The present study investigated whether episodic prospection in individual cases of MTL amnesia improves when specific, personally meaningful cues are provided rather than generic, Galton–Crovitz cue words, which are more typically used. We found a benefit of personal cues for the generation of internal details in three of the five cases, in both past and future conditions. Closer inspection of the performance of each individual case suggests that extent of neurological damage and/or overall level of impaired episodic memory and prospection affected the degree to which a case benefited from personal cueing.

Episodic prospection comprises numerous component processes, ranging from basic constructional processes, such as generating and binding relational details, to higher-order phenomenological processes, such as autonoetic consciousness (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010). Many of these processes are believed to have distinct neural substrates. The current finding that some MTL amnesic cases benefit from specific, personally meaningful cues suggests that basic constructional processes in episodic prospection may be compromised. This might explain seemingly discrepant findings across two studies with developmental amnesic case H.C., whose

Table 3. Episodic memory with Galton–Crovitz cues and specific, personal cues

	Galton–Crovitz cue words			Personal specific cues		
Case	Z-score	‰ Rank	Descriptive label	Z-score	‰ Rank	Descriptive label
Internal details						
D.A.	−1.802	3rd–4th	Borderline	−1.715	4th–5th	Borderline
D.G.	−3.200	0.07th	Impaired	−2.005	2nd	Impaired–Borderline*
L.D.	−2.124	1st–2nd	Impaired	−0.261	39th–42nd	Average*
B.L.	−2.003	2nd	Borderline–Impaired	−0.684	23rd–25th	Low average–Average*
S.N.	−1.762	3rd–4th	Borderline	−1.899	3rd	Borderline
External details						
D.A.	−0.490	30th–32nd	Average	−0.765	21st–23rd	Low average
D.G.	−1.724	4th	Borderline	1.164	88th	High average
L.D.	0.673	75th	High average	−0.185	42nd–45th	Average
B.L.	1.022	86th	High average	0.316	62nd	Average
S.N.	3.117	99.91st	Very superior	2.786	99.7th	Very superior

Notes. 'Superior' performance indicates an excess of details.
*Clinically significant change, defined as improvement by at least one diagnostic level according to a standardized psychometric conversion table.

episodic prospection was impaired when tested with Galton-Crovitz cue words (i.e. '*lemon*', Kwan *et al.*, 2010), but not when tested with more elaborate scene cues that better scaffold narrative construction (e.g., '*Imagine you're lying on a white sandy beach in a beautiful tropical bay*', Cooper, Vargha-Khadem, Gadian, & Maguire, 2011). The current results are also consistent with fMRI studies of episodic prospection that show increased hippocampal activation during the initial construction phase of prospection and subsequently decreased activation as participants elaborate on the constructed event (Addis, Wong, & Schacter, 2007; Rabin, Gilboa, Stuss, Mar, & Rosenbaum, 2010).

The role of the hippocampus in initial event construction indicates the importance of having some kind of scaffold or framework to help structure future event details in at least some individuals with hippocampal amnesia. Identifying potential scaffolds is of theoretical and clinical interest. A memory schema, defined as an associative network structure based on multiple episodes that is adaptive and lacks detail (Ghosh & Gilboa, 2014), may serve as such a scaffold. A schematic cue to scaffold episodic prospection might be, 'Imagine how you would make lemonade in the future', as this draws on scripted and generic conceptual knowledge on how to make lemonade. In contrast, a specific personal cue to scaffold episodic prospection, as in the current study, might be, 'Imagine your granddaughter's lemonade sale next summer'. Both types of cues likely afford greater episodic prospection than the Galton–Crovitz cue equivalent, 'lemonade'. Relatedly, Irish and colleagues suggest that semantic memory in particular can act as a scaffold for prospective thinking (i.e., 'Semantic Scaffolding Hypothesis', Irish, Addis, Hodges, & Piguet, 2012; Irish & Piguet, 2013), while Klein (2015) suggests that autonoetic consciousness, a unique experiential awareness of the self across time, scaffolds the ability to travel through mental time into one's future. Thus, specific personal cues may be just one of multiple routes of action to support episodic prospection (and memory).

Because internal details are taken as the measure of episodic strength in Autobiographical Interview scoring, we expected to find a cue-related increase in internal details if

specific, personal cueing is better able to elicit past and prospective narratives than Galton-Crovitz cueing. Although we did not have specific predictions regarding the effect of specific personal cues on external detail generation, it is important to note how internal and external details may differentially inform the clinical picture of episodic prospection impairment in a given disorder. Patients diagnosed with Parkinson's disease, amnestic mild cognitive impairment, and healthy ageing exhibit impaired internal detail generation and elevated external detail generation (de Vito *et al.*, 2012; Gaesser, Sacchetti, Addis, & Schacter, 2011; Gamboz *et al.*, 2010; respectively), whereas those with post-traumatic stress disorder show selective elevation of external details with internal details in the normal range (McKinnon *et al.*, 2014). However, it is not always the case that the generation of fewer internal details is accompanied by a greater number of external details. For example, individuals diagnosed with bipolar disorder and even cases of MTL amnesia have been found to produce prospective narratives that are significantly impoverished in terms of number of internal details, yet the number of external details produced was found to be similar to that of controls (King *et al.*, 2011; Race *et al.*, 2011, respectively).

A paucity of internal details and an increase in number of external details may reflect two distinct clinical features. Specifically, a low number of internal details may suggest a basic deficit in detail construction and/or binding and may be the source of the episodic prospection deficit in MTL amnesia (Mullally, Hassabis, & Maguire, 2012; Rosenbaum *et al.*, 2009; Verfaellie, Race, & Keane, 2012). In contrast, an abnormally high number of external details may reflect executive difficulties involving inhibitory cognitive control, suppression of task-irrelevant thought, or sustained attention (McKinnon *et al.*, 2014), or may simply reflect age-related changes in narrative style, especially in the case of healthy ageing (see Schacter, Gaesser, & Addis, 2012 for discussion). As noted, there are conditions in which both low internal and high external detail generation co-occur, but distinct patterns among clinical populations suggest that they reflect a simultaneous breakdown of dissociable processes. A more sensitive taxonomy of details is needed to fully explore this possibility.

In the current study, episodic prospection in response to Galton–Crovitz cues led to highly variable external detail generation in the amnesic cases, ranging from borderline impaired (a low number of details) to superior (an elevated number of details). External detail generation was also highly variable in response to personal specific cues, with some cases showing reductions in the number of external details generated, others showing increases, and still others showing no change. Even among controls, external details ranged from an average of 6.25 to 46.25 details (SD = 11.38) with Galton–Crovitz cue words and from 6.83 to 40 details (SD = 8.85) with specific personal cues. It is unclear why there was such variability in external detail generation. As mentioned earlier, one reason may be that external details include any part of the narrative that is not central to the imagined episode, including repetitions, editorializing, and even attempts at engaging the experimenter in conversation. Taking this into consideration, it is perhaps not surprising that the amnesic cases vary so widely in the number of external details produced, regardless of cue condition. Some cases complete detail generation within a short period of time and speak little during the remaining time, whereas others may switch to an unrelated topic or attempt to initiate conversation in order to fill the silence. External details can thus reflect overall verbosity or conversation seeking in addition to semantic details.

Comparisons of episodic prospection with episodic recollection in the current study provide insight into the well-documented neurocognitive overlap between the two

processes. Specific, personal cues benefited both episodic recollection and prospection in three of five cases, showing that benefits to impaired prospection can also extend to improve episodic memory. We expected that amnesic cases who benefited from personal cueing on episodic memory would be the same cases who benefited in episodic prospection. We found this to be the case for B.L. and L.D. but not D.G., who improved (albeit modestly) only for past memories, or S.N., who improved only for episodic prospection. The unexpected asymmetry between D.G. and S.N.'s selective benefit for memory and prospection, respectively, shows that the two abilities also differ in some respects (Addis, Pan, Vu, Laiser, & Schacter, 2009; see Suddendorf, 2010 for review) and that cue-related benefits to one temporal branch of episodic thinking might not apply to the other. D.G.'s selective cue-related benefit in memory, but not prospection, is ostensibly due to the added difficulty associated with generating a novel, not-yet-lived experience and the degree to which this taxes the hippocampus beyond autobiographical recollection (Addis, Cheng, Roberts, & Schacter, 2011; Köhler, Danckert, Gati, & Menon, 2005). It is less clear why S.N. showed selective cue-related improvement only in prospection, or stated differently, why he failed to improve in memory. It is possible that this relates to unique impairments that might accompany lateral dorsal thalamic infarction. Unlike the other amnesic cases, S.N. exhibits both recollection impairments and additional executive dysfunction, including disorganized speech and behavioural disinhibition – a pattern that has been reported in the few cases of lateral dorsal thalamic stroke described in the literature (Carrera & Bogousslavsky, 2006; Edelstyn, Hunter, & Ellis, 2006). One explanation, although speculative, is that episodic memory reconstruction may require greater inhibitory control or is more susceptible to task-irrelevant speech than constructing a new prospective event.

While the majority of amnesic cases showed the expected cue-related prospection improvement, amnesic cases D.A. and D.G. offer clues into why some clinical cases might not benefit. Our examination of these cases' neurological and neuropsychological profiles suggests that severity of episodic prospection impairment with Galton–Crovitz cueing might explain the lack of benefit from specific, personal cues. Classification of amnesic cases in terms of clinical severity is challenging and somewhat subjective given that severity can imply extent of damage within the hippocampus, MTL, and/or beyond as well as degree of functional memory and/or cognitive impairment. A further complicating factor is that severity of neural insult does not always correspond to severity of cognitive deficit. We nonetheless believe that it is informative, and at times necessary, to consider clinical cases along a continuum of severity, whether in relation to neurological or cognitive compromise, which is not always possible at the group level.

D.A. is the most severe of the cases in terms of location and extent of damage, which includes the MTL bilaterally (Figure 1) as well as regions of posterior temporal, ventral frontal, occipital, and anterior cingulate cortices on the right (see Rosenbaum *et al.*, 2008 for a detailed description). In contrast, D.G.'s clinical severity is evident in the magnitude of his baseline functional impairment – Of the five amnesic cases described in the current study, D.G. is the most impaired in both episodic prospection and memory when given Galton–Crovitz cues (Figures 2 and 3). D.A.'s and D.G.'s lack of improvement may be a consequence of severity of tissue loss and/or cognitive impairment, indicating that a minimum level of function must be reached in order for episodic prospection to benefit from structured cueing and possibly other compensatory aids.

An additional possibility is that the structural and/or functional abnormalities in D.A. and D.G. were associated not only with episodic prospection, but also with semantic prospection. While overall semantic prospection is believed to be spared in MTL amnesia (Klein *et al.*, 2002), more recent research shows that subtle aspects may nevertheless be impaired (Race, Keane, & Verfaellie, 2013). If a bank of semantic details can provide the scaffolding for episodic prospection (Irish & Piguet, 2013), perhaps the cases who do not benefit have both impaired semantic and episodic prospection, whereas those who benefit may have intact semantic prospection on which to draw. As we did not directly assess semantic prospection in this study and these inferences are based on only two cases, formal investigation of semantic prospection along with detailed characterization of degree of neurological damage and/or cognitive impairment in additional cases are important avenues for further investigation.

The current results show that the frequently used Galton–Crovitz cueing paradigm (Crovitz & Schiffman, 1974) may be too restrictive and does not promote the level of detail that patients are capable of producing. Tasking MTL amnesic individuals with generating detailed episodes from non-descript everyday nouns puts them at a particular disadvantage given that hippocampal damage impairs a host of related abilities including representational generation (Duff, Kurczek, Rubin, Cohen, & Tranel, 2013), generative free association (Sheldon, Romero, & Moscovitch, 2013), detail generation and binding (Rosenbaum *et al.*, 2009), and open-ended problem-solving (Sheldon, McAndrews, & Moscovitch, 2011). Impairment in these related processes bypasses the divergent thinking involved in creating a detailed episode from a single word.

A sensitive diagnostic approach can aid the individualization of rehabilitative methods and allow greater functional recovery by tailoring treatments to the residual capacities of the individual. Current results indicate that more structured diagnostic tests and compensatory aids may provide the best measurement and later support of cognitive ability. This is particularly important for future planning and future goal setting, two common practices for patients in rehabilitation settings. Occupational therapists often use open-ended questionnaires that require patients to identify future goals with detail and specificity (e.g., the SMART method; see Bovend'Eerdt, Botell, & Wade, 2009). Rather than asking unstructured questions such as 'What is a goal for the future?' our results provide evidence-based suggestions for creating more effective ways to structure questions for memory-impaired populations. Cues and questions should be specific rather than broad, personally meaningful rather than generic, and detailed rather than sparse. In the clinical endeavour to rehabilitate individuals with impaired episodic memory and/or prospection, our results show that consideration of the manner in which cues are constructed and administered is a promising starting point.

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