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"I can see clearly now": The effect of cue imageability on mental time travel

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Abstract Mental time travel (MTT) is the ability to mentally project oneself backward or forward in time, in order to remember an event from one's personal past or to imagine a possible event in one's personal future. Recent work has suggested that, although past and future MTT may rely on shared neurocognitive substrates, the two temporal directions may interact differently with components of this underlying system. Here, we asked 151 participants to recall or imagine past and future autobiographical events in response to high- and low-imageable cue words. The results showed that high- and low-imageable cued events differed markedly on almost all measures, suggesting that imagery acts as a facilitator when constructing both past and possible future events. In line with previous work, future events less often referred to specific events, contained fewer details, and were more positive and idyllic than past events. However, these main effects were qualified by a number of interactions. In particular, we found an increased effect of cue imageability for past as compared to future events, suggesting that the generation of past events is more sensitive to the ability of the cues to invoke the sensory components of the encoding context, whereas the construction of future events is more driven by context-independent schemata.

Keywords Autobiographical memory · Mental time travel · Imagery

When we recollect events that belong to our personal past, we often do so with considerable detail, by "seeing with our mind's eye" the setting in which the event took place and the people and objects that were present. Mental imagery is considered a crucial component of vivid remembering (Brewer, 1996; Greenberg & Rubin, 2003; Huijbers, Pennartz, Rubin, & Daselaar, 2011; Moulton & Kosslyn, 2009; Rubin, Schrauf, & Greenberg, 2003) and a defining characteristic of episodic memory (Tulving, 2002; Wheeler, Stuss, & Tulving, 1997). Visual imagery can be used to invoke more details about an event (Greenberg & Rubin, 2003; Robinson, 1992), and the presence of visual imagery also makes memories feel more vivid (Rubin et al., 2003). Theories of autobiographical or episodic memory hold that recollection relies not only on the activation of previously formed memory traces of past events, but also on reconstructive processes (Bartlett, 1932; Brewer, 1996; Conway & Pleydell-Pearce, 2000; Rubin et al., 2003). In the present article, we examine the role of imagery in the reconstruction of memories of past events and the imagining of possible events in the future—an ability termed *mental time travel* (MTT; Wheeler et al., 1997).

Converging evidence supports the idea that past and future MTT share common neural and cognitive underpinnings (for reviews, see Berntsen & Bohn, 2010; D'Argembeau, 2012; Schacter & Addis, 2007; Szpunar, 2010). Notably, previous studies have shown the two processes to be affected in similar ways by a variety of experimental manipulations (e.g., Addis, Wong, & Schacter, 2008; Berntsen & Jacobsen, 2008; D'Argembeau & Van der Linden, 2004; Larsen, 1998; Szpunar & McDermott, 2008) and by individual differences in the capacity for visual imagery (D'Argembeau & Van der Linden, 2006).

At the same time, the research has also evidenced systematic differences between past and future MTT, reflecting that the former, in contrast to the latter, involves a reference to events that were actually experienced and encoded in the past. Imagined future events contain fewer sensory and contextual details, less frequently refer to specific events, and require

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more cognitive effort than past remembering. On the other hand, future events are rated as being more important or personally significant, as well as more emotionally positive, than past events (e.g., Arnold, McDermott, & Szpunar, 2011; Berntsen & Bohn, 2010). These differences suggest that future MTT is driven by more schema-based construction, whereas past MTT, in addition to schema-based construction, to a greater extent may involve recapitulation—that is, a process in which "the reactivation of sensory–perceptual and contextual details during retrieval recruits the neural network which originally processed such information" (Addis, Pan, Vu, Laiser, & Schacter, 2009, pp. 2236–2237). This is consistent with brain-imaging studies showing that the sensory areas activated during encoding are reactivated during retrieval (Danker & Anderson, 2010). The fact that memories are more strongly linked with sensory–perceptual experience, in contrast to imagined events that are more generic and "experience-distant" (Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2003), may affect the role of sensory cueing, in that the facilitative role of imagery cueing on memory may be less strong for future MTT.

Consistent with this view, recent studies have shown that some experimental manipulations of cueing have differential effects on past and future MTT. Berntsen and Bohn (2010) elicited past and future event representations in response to cue words and requests for important events. Whereas the use of cue words is thought to be a random sampling technique, a request for important events is known to tap memories that are perceptually rich, emotional, and self-referential, and thus that are better encoded and rehearsed than word-cued memories (Rubin & Schulkind, 1997a). Berntsen and Bohn replicated earlier findings from the MTT literature. However, contrary to previous research, these overall findings were qualified by a number of interactions, reflecting larger effects of the important versus word-cued manipulation in the past as compared with the future condition, with the important past events being rated higher on imagery, vividness, and rehearsal than the word-cued past events, whereas such differences were absent in the future condition. This suggests that a request for important events tapped an encoding and maintenance effect that is present for past MTT but absent from future MTT (Berntsen & Bohn, 2010).

Examining the effect of different cue modalities (verbal, visual, and odor) on past and future MTT, Miles and Berntsen (2011) replicated previous findings (Chu & Downes, 2000; Willander & Larsson, 2006) showing a unique ability of odors to evoke remote autobiographical memories. However, instead of witnessing a mirror effect for the temporal distribution in the future condition, as has been previously reported for word-cued events (Berntsen & Jacobsen, 2008; Spreng & Levine, 2006) and as largely seen in the verbal and visual conditions of their study, Miles and Berntsen found a reversed distribution for the odor condition, causing an interaction between cue condition, temporal direction, and temporal distance. Thus, again, the manipulation of cue modality seemed to have tapped factors that were present only in the past, not in the future, condition.

However, the reverse pattern, with manipulations of cueing differentially affecting future more than past events, has also been reported in several studies examining the effect of emotional valence on MTT (D'Argembeau & Van der Linden, 2004; Rasmussen & Berntsen, 2013; Rubin, 2014). For instance, Rasmussen and Berntsen (2013) asked participants to generate past and future events that were emotionally positive versus negative and to rate the phenomenological characteristics of the events. They found increased effects of emotional valence for future as compared to past MTT, showing that the differences between positive and negative events were larger for future than for past events. This is in accordance with the idea that future MTT is biased by uncorrected positive illusions, whereas past MTT to a larger extent is constrained by the reality of the actual events. Rubin (2014) reported that future negative events ("that might occur within the next year and that would impact you a lot") were rated as being higher on intensity than future positive events, whereas a similar difference was absent for past events. Also, when participants were asked to imagine their potential post-traumatic stress disorder (PTSD) symptoms in response to the negative future events, these were rated as being substantially higher than the symptoms reported for the negative past events. On the basis of these findings, Rubin (2014) concluded that the simulation of future events is more schema-driven than the reconstruction of past events.

These findings stress the importance of studying future versus past MTT in response to different cueing techniques, in order to examine how the two temporal directions, when activated by different cues, may interact differently with components of the underlying neurocognitive structures. In the present study, we examined the nature of such interactions, by experimentally manipulating cue imageability—that is, the capability of a cue to evoke mental images (Kosslyn, Ganis, & Thompson, 2001).

The role of imagery in past and future MTT

The importance of imagery for autobiographical memory has been widely noted, since almost all personal memories are accompanied by some degree of visual imagery (Brewer, 1986; Rubin, 2005, 2006; Rubin et al., 2003). Further support for this relationship has come from neuropsychological studies showing that brain damage to areas known to support visual imagery can give rise to retrograde amnesia (Conway & Fthenaki, 2000; Greenberg & Rubin, 2003; O'Connor, Butters, Miliotis, Eslinger, & Cermak, 1992; Ogden, 1993) and that brain regions supporting imagery overlap with those supporting retrieval (Huijbers et al., 2011).

The role of imagery on autobiographical memory retrieval has been examined using variants of the Galton–Crovitz cue word technique (Crovitz & Schiffman, 1974), in which participants are presented with a series of cue words that are rated as being high or low in terms of imageability (e.g., Brewer, 1996; Dewhurst & Conway, 1994; Fitzgerald & Lawrence, 1984; Rubin, 1980; Rubin & Schulkind, 1997b; Williams, Healy, & Ellis, 1999). This line of research has consistently shown that highly imageable cue words are associated with shorter response latencies than are low-imageable cue words (Fitzgerald & Lawrence, 1984; Rubin, 1980; Rubin & Schulkind, 1997b; Williams et al., 1999), and seem to facilitate access to more specific memories (Dewhurst & Conway, 1994; Mortensen, Berntsen, & Bohn, 2014; Williams et al., 1999). For example, Williams et al. (1999) found that cue words high in imageability (but not frequency) facilitated the number of memories retrieved by participants, as well as the time taken to retrieve specific memories. A follow-up study manipulating the sensory modality of the memory cues revealed that only visual (relative to olfactory, tactile, auditory, motor, and abstract) imagery facilitated the retrieval of specific memories (Williams et al., 1999). Overall, this research suggests that imagery is crucial in autobiographical memory retrieval, and that visual imagery, in particular, seems to facilitate the access to specific memories.

Imagery also seems to affect the temporal distribution of autobiographical memories, in that high-imageable words, as compared to low-imageable words, have a tendency to cue older memories (Fitzgerald & Lawrence, 1984; Rubin, 1980; Rubin & Schulkind, 1997b; however, see Williams et al., 1999). For instance, Rubin and Schulkind (1997b) examined the effect of cue imageability on autobiographical memories in a large group of participants varying in age from 20 to 73 years. They found that for all age groups, ratings of imagery correlated with the age of the memories and retrieval time, with high-imageable words producing older memories and shorter latencies. Rubin and Schulkind (1997b) suggested that the HI cues may trigger earlier memories by promoting more perceptually driven retrieval, whereas low-imageable cues promote more conceptual or semantic processing (see also Conway & Pleydell-Pearce, 2000; Mortensen et al., 2004, for similar views). This difference between perceptually and conceptually based processing has also been used to explain the unique age distribution of odor-evoked memories favoring older, childhood memories (Willander & Larsson, 2007).

To our knowledge, only one study has directly compared the effects of cue imageability on past and future MTT. Anderson, Dewhurst, and Nash (2012) asked participants to retrieve past and to imagine future specific events. Their dependent variables were latency to generate specific events, number of specific events generated, and age of the events. In accordance with the autobiographical memory literature, Anderson et al. found that, as compared to events cued by low-imageable words, future events cued by high-imageable words took a shorter time to generate and more often resulted in the reporting of specific versus general events. This suggests that imagery plays an important facilitative role not only in the retrieval of specific autobiographical memories, but also in constructing specific future events. Importantly, Anderson et al. reported an unpredicted interaction between the temporal direction and cue type for latency to generate specific events, with participants being slower to generate specific events in the future task in the high-imageability cued condition, whereas past and future response latencies did not differ in the low-imageability condition. Although this was not discussed by the authors, it thus seems that for this measure, the facilitating effect of high-imageable cues was reduced for future relative to past events. We suggest that the increased effect of imagery cueing for past MTT may be explained by the generation of past events being more sensitive to the ability of the cues to invoke perceptually driven retrieval, whereas the generation of future events is more driven by context-independent schemata. Examining the effect of temporal direction on the age of the events, Anderson et al. replicated previous findings from the MTT literature, in that future events were temporally closer to the present than were past events. They also looked at possible effects of temporal distance as a function of cue type, and reported that low-imageable cued events were closer in time than high-imageable cued events. The authors did not report possible interactions between temporal distance, temporal direction, and cue type.

In the present study, we aimed to pursue more systematically the possibility that high- versus low-imageable cueing interacts differently with future versus past MTT. In order to do so, we included a number of dependent variables for which such interactions were likely to be identified, thereby extending prior research strategies in important ways. First, retrieval effort was measured in two ways. Similar to Anderson et al. (2012), we obtained latencies; however, we also assessed self-reported retrieval strategies. Second, we measured specificity using the same coding methods used by Anderson et al., as well as using subjective ratings. Apart from this fairly broad level of categorizing events with regard to their temporal specificity, we examined the qualitative nature of the details comprising past and future event representations. In particular, we coded these details according to whether they were internal or external to the reported event, thereby treating the distinction between episodic and semantic information as a continua rather than as a dichotomy (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). We also examined whether the details were gist-related or peripheral to the reported events (Berntsen, 2002). If visual imagery invokes more sensory and contextual details about an event, then responses should contain more peripheral details. Third, we examined a number of subjective qualities associated with the generated events, such as reliving quality and visual imagery. Taken together, these different measures allowed us to examine the possibility that the generation of past events is more sensitive to the ability of the cues to invoke sensory components of the encoding context than is the construction of future events.

The present study

The goal of the present study was to examine the effects of cue imageability on several theoretical motivated measures, including retrieval time, objectively coded event characteristics, and subjectively rated phenomenological qualities of future versus past events. We therefore asked participants to generate events from their personal past and potential future in response to high- versus low-imageable cue words, to record details for each event, and to answer a series of questions related to the phenomenological characteristics of the constructed events. In order to examine the effect of cue imageability on the content of the events, we adopted two theoretically derived and validated coding schemes from the autobiographical memory literature (Addis et al., 2008; Berntsen, 2002; Levine et al., 2002; Tulving, 2002). In particular, we coded event descriptions for internal versus external details (i.e., based on the distinction between episodic versus semantic information; Addis et al., 2008; Levine et al., 2002) and for how central or peripheral the details were to the event (Berntsen, 2002; Talarico, Berntsen, & Rubin, 2009). We examined the phenomenological characteristics of the constructed events by including a series of questions from the Autobiographical Memory Questionnaire (AMQ; described in Rubin et al., 2003), which also has been successfully applied in studies of future MTT (Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008).

Previous research has suggested that imagery allows for the cueing of visual and other sensory–perceptual information, thereby facilitating the retrieval of visually vivid and detailed past events. If past and future MTT draw upon shared component processes, they should be affected in similar ways by cue imageability. We therefore expected the high- versus low-imageability cue manipulation to result in main effects across both temporal directions, with high-imageable cued events being more specific and containing more peripheral and episodic event-specific details, and with this being especially the case for sensory–perceptual details. Given that imagery is a rich source of recollective experience, we also expected high-imageable cues to yield higher scores on variables related to vividness and feeling of reliving, as compared with their low-imageable word-cued counterparts.

Furthermore, we expected to replicate previous findings from research on MTT, showing that past events are more specific and detailed and are rated higher on variables related to sensory imagery and vividness, whereas future events are rated as being more positive and idyllic and are temporally closer to the present. However, on the basis of memories being more strongly linked to sensory–perceptual experience than imagined future events, we expected such main effects to be qualified by a number of interactions, indicating a stronger effect of cue imageability for past than for future events. In other words, we expected high- versus low-imageable cued events to differ more in the past than in the future condition on measures related to retrieval effort (latency and self-reported search), contextual information (peripheral and sensory–perceptual details), and on subjective qualities related to vividness and reliving, as well as to the age of the events.

Method

Participants

A group of 151 (128 female, 23 men; mean age = 23.96 years, *SD* = 3.87, range: 20–46 years) psychology undergraduates participated as part of a research methods course. The participants were informed that their responses were anonymous, and it was clearly stated that they were free to withdraw at any point during the procedure.

Design

We employed a 2 (Cue: high- vs. low-imageable) × 2 (Time: future vs. past) within-subjects design. Each participant generated two of each type of event, thus, generating a total of eight event representations. The order of the events was counterbalanced across four groups, with 41, 38, 38, and 34 participants being assigned in each group.

Materials

Cues The cue words were selected from Paivio, Yuille and Madigan's (1968) corpus of 925 nouns, from which the high and low imageability ratings were taken. Furthermore, the cue words were matched for prevalence in Danish (Bergenholz, 1992). The high-imageable (HI) cue words were *bird*, *orchestra*, *letter*, and *landscape*. The low-imageable (LI) cue words were *ownership*, *truth*, *thought*, and *duty*. An independent-samples *t* test showed a significant difference in ratings of imageability for the cue words in the HI cued (M = 6.56, SD = 0.19) versus the LI cued (M = 2.99, SD = 0.27) condition; $t(6) = 21.37$, $p < .001$.

A stopwatch was used to record the response latencies.

Procedure

The participants were tested in a group session. They followed the same procedure for both past and future events. They were asked to recall four specific memories and imagine four specific future events in response to word cues. A specific memory or future event was explained to the participant in terms of a personally experienced past or future event that happened, or could happen, at a particular time and place, lasting less than a day. Participants were asked to provide a different event to each cue. The cues were visually presented one at a time in a paper booklet, with HI and LI cue words alternating. The cues for each memory or future event were hidden under a label, and the time of presentation of the cues was controlled by the experimenter. The order of cue category and temporal direction were counterbalanced between participants.

The procedure for each memory or future event had three successive steps. First, participants were instructed to remove the label and read the cue immediately after they had started the stopwatches, and to stop the timing with the first past or future event that came to mind that fit the cue. The participants noted the response time and then wrote a brief description (one or two sentences) of the content of the memory or future event. Secondly, following the procedure of Berntsen (2002), the participants introspected the memory or imagined future event and recorded as many event details as possible within 3 min. They were instructed to record all kinds of details, even those that appeared insignificant. A detail was operationally defined as a fragment of the memory or future event that formed a natural unit of information to the participant. Finally, once the time limit was reached, the experimenter asked the participants to turn the page and fill out a brief questionnaire in which they were asked to rate the qualities and event characteristics associated with the memory or imagined event. They were instructed to keep the event representations in mind while answering these questions. Thereafter, the next cue word was presented.

The experimenter initially informed the participants about the two event tasks: memories for past events and imagined future events. An example of a specific event (e.g., a meeting with a friend) was provided for both the past and future condition, and the experimenter ran both examples through all three successive steps of the procedure. Thereafter, the participants practiced the procedure thoroughly before the study was initiated.

Table 1 Questions and answering options for each event shown for the past condition

No.	Variable and Question
1.	*Search*: How did you recall the event? (1 = *the event spontaneously came to mind*, 7 = *I actively searched for the event*)
2.	*Specificity*: The memory deals with (1 = *a concrete event that happened on a specific day, 0 = a mixture of similar events that happened on more than one day*)
3.	*Travel in time*: The memory made me feel as if I traveled back in time to the actual situation. (1 = *not at all*, 7 = *to a very high degree*)
4.	*Reliving*: While remembering the event, it feels as though I relive it in my mind. (1 = *not at all*, 7 = *to a very high degree*)
5.	*Coherence*: As I recall the event, it seems to come to me as a coherent story (as opposed to incoherent or in flashes). (1 = *not at all*, 7 = *to a very high degree*)
6.	*Vividness*: As I recall the event, it appears vivid and clear (1 = *not at all*, 7 = *to a very high degree*)
7.	*See*: While remembering the event, I can see it in my mind. (1 = *not at all*, 7 = *to a very high degree*)
8.	*Setting*: While remembering the event, I can recall the physical surroundings. (1 = *not at all*, 7 = *to a very high degree*)
9.	*Perspective*: While remembering the event, it feels as though I see it from a perspective as seen with (1 = *my own eyes*, 7 = *an observer's eyes*)
10.	*Valence*: The feelings I experience, as I recall/imagine the event are (–3 = *extremely negative*, 3 = *extremely positive*)
11.	*Age at event*: How old were you when the remembered event took place? (age estimated in years)
12.	*Days ago*: If you indicated your current age in Question 11, how many days from today is the event in the past? (estimated in days)

In the analyses, age of event was calculated by subtracting the answer to Question 11 from the participant's current age

Questionnaire The questions that were asked after eliciting past and future event representations are presented in Table 1. The questions were derived and modified from Rubin et al. (2003) and Berntsen and Jacobsen (2008), and the characteristics probed by the questions are theoretically derived basic variables in autobiographical memory research (Brewer, 1996; Conway & Pleydell-Pearce, 2000; Rubin, 2006; Tulving, 2002). The table shows the questions as they were formulated for the past condition. The questions for the future condition were the same, except for changes made in tense in order to apply to future events. As can be seen in Table 1, most questions were rated on 7-point scales, except Question 2, addressing the specificity of the event, and Questions 11 and 12, addressing the distance in time of the event, measured in years or days from the present moment. Question 1 addressed the ease with which participants generated the event, and Questions 3–10 addressed the amount and type of subjective reexperiencing associated with the events. All of the questions were explained thoroughly by the experimenter before the study was initiated. The labels before each question in Table 1 indicate those used in the tables for the results and in the analyses.

Content analysis

Event specificity In order to examine the specificity of memories and future thoughts, each description was coded as either a specific event (i.e., referring to an event at a particular time and place, lasting one day or less), a repeated event (i.e., a group of similar events that have occurred on repeated occasions), an extended event (i.e., a single event lasting longer than one day), no memory/future thought (i.e., a coherent response that was not a memory/future thought), or an omission (i.e., no response) (Williams & Dritschel, 1992), by two independent raters blind to the hypothesis of the study. The interrater reliability was acceptable (Cohen's κ = .71) (interrater agreement was 90%). Disagreements between the two raters were solved by discussion. In accordance with previous research, the number of events categorized as specific (Anderson et al., 2012) in response to the four conditions formed by the two levels of each of the variables cueing (HI vs. LI) and temporal direction (past vs. future) was taken as the dependent variable.

Internal/external details Following previous work within the MTT literature, the qualities of past and future event details were estimated using a standardized coding technique developed by Levine et al. (2002), classifying event details into two broad subcategories: internal and external. *Internal* details were those pieces of information that pertained directly to the main event described, that were specific to time and place, and that were considered to reflect episodic p/reexperiencing. Internal details were separated into five mutually exclusive subcategories: *time*, *place*, *perceptual*, *thought/emotion*, and *event* details. *External* details were those that pertained to extraneous information that did not require recollection of a specific time or place and that were not uniquely specific to the main event. These were subdivided into four categories: *external event details* (specific details external to the main event), *semantic information* (facts or extended events), *repetitions*, and *other* (e.g., metacognitive statements, editorializing). The interrater agreement for the composite scores was good, as measured by intraclass correlations (two-way random-effects model; McGraw & Wong, 1996) of .92 and .78 for internal and external details, respectively.

Central/peripheral details Responses were scored for the number of *central* or *peripheral* details. A detail was classified as *central* if (1) it was related to the key content/theme of the remembered or imagined event and (2) it could not be left out or replaced without a major change in the content of the event. Otherwise, a response was classified as *peripheral* (Berntsen, 2002). The interrater agreement was good, as assessed by intraclass correlations (two-way random-effects model; McGraw & Wong, 1996) of .79 and .90 for the central and peripheral details, respectively.

Idyll The two raters scored all memories and future event representations on a 3-point rating scale for how idyllic they were (Berntsen & Jacobsen, 2008). A maximum score of 3 was given if the response described a situation that most people would find attractive and if the description did not contain any indications of negative emotion. A score of 2 was given if one, but not both, of the two idyll indicators (attractive situation or absence of negative emotions) could be confirmed. If neither of the two indicators could be confirmed, the record received an idyll score of 1 (Berntsen & Jacobsen, 2008). Interrater agreement was high, according to the intraclass correlation (two-way random-effects model; McGraw & Wong, 1996) of .89.

Results

We first examined the objective measures—that is, the *mean latency* to generate past and future events and the *objectively scored content and details* of those events, as a function of activation through HI versus LI cues. Second, we examined the *subjectively rated phenomenal qualities* of the past and future events across the two cueing conditions. Because each participant provided two event records in each of the four conditions, the individual event records could not be treated as independent observations. For that reason, the statistical analyses are based on means or sum scores calculated for each participant in each event condition. Following Rubin and Schulkind (1997b), our initial analyses for latency were conducted with both the arithmetic and the geometric mean (i.e., the logarithm of the arithmetic mean). Since only minor differences were observed, we report the arithmetic means.

Comparisons of HI and LI cued events in the past and the future

We conducted a series of 2 (Cue: HI vs. LI) × 2 (Time: past vs. future) repeated measures analyses of variance (ANOVAs) to compare the latencies and objectively coded content characteristics for the four event conditions. The results, as well as the means and standard deviations, are presented in Table 2 and Fig. 1. As is shown by Table 2, we found several main effects of temporal direction, consistent with our predictions. As expected, past events were retrieved faster, were more specific, and contained more internal details, as compared to future events. This specifically applied to details on place and thoughts/emotions. In addition, past events contained more central (or gist) details than did future event representations,

Table 2 Means and ANOVA's for objectively scored characteristics of past versus future event representations in the high-imageability (HI) versus low-imageability (LI) cue condition

	Past				Future				Main effects				Interaction	
	HI		LI		HI		LI		Past/Future		Cueing		Past–Future/ Cueing	
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	η_p^2	*F*	η_p^2	*F*	η_p^2
RT	11.53	13.27	21.69	16.86	17.73	15.40	21.35	19.43	8.44**	.08	35.93***	.26	9.36**	.08
Specificity	1.87	0.37	1.70	0.50	1.58	0.56	1.43	0.67	28.91***	.20	11.75***	.09	0.04	.00
Idyll	2.31	0.46	1.73	0.62	2.49	1.17	2.17	1.27	4.75*	.06	78.18***	.51	4.24*	.05
Internal	13.83	4.71	11.81	4.35	12.75	5.00	11.09	5.16	3.94*	.04	26.48***	.24	0.28	.00
Event	4.69	2.58	4.16	2.22	4.70	2.78	3.93	2.35	0.14	.00	9.92**	.10	0.36	.00
Place	0.83	0.71	0.78	0.68	0.65	0.62	0.64	0.58	5.63*	.06	0.22	.00	0.08	.00
Time	0.30	0.42	0.27	0.41	0.26	0.34	0.22	0.32	1.85	.02	1.20	.01	0.02	.00
Th/Em	2.92	1.75	3.84	2.31	2.90	2.05	3.12	2.14	5.22*	.06	9.46**	.10	3.62	.04
Perc	5.22	3.01	3.47	2.38	5.01	3.27	3.67	2.67	0.00	.00	48.41***	.37	1.52	.02
External	1.18	1.68	1.59	2.27	1.72	3.72	2.04	3.31	2.56	.03	1.62	.02	0.02	.00
Central	3.44	1.47	4.61	2.25	3.22	1.90	3.75	2.15	9.73**	.10	23.67***	.11	3.62	.04
Peripheral	6.25	3.65	4.20	3.09	5.94	3.10	4.78	3.10	0.31	.00	56.11***	.40	5.08*	.06

Response Time refers to the retrieval or latency time to recall or imagine the event. * $p < .05$, ** $p < .01$, *** $p < .0001$. Th/Em = thought/emotion, Perc = perceptual

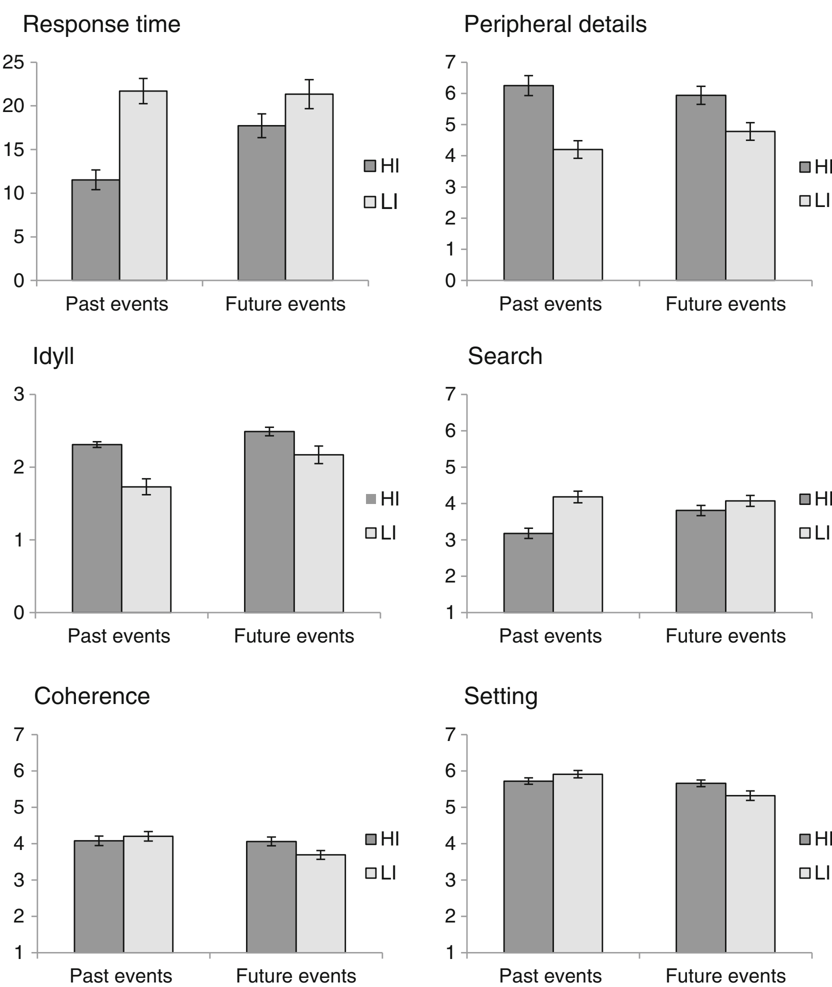

Fig. 1 Mean ratings of response time, peripheral details, idyll, search, coherence, and setting. Error bars indicate the standard errors of the means

whereas future events were rated as being more idyllic than past events. These findings are largely consistent with the notion that future events require more constructive effort than do past events, and that the construction of future events therefore is more schema-driven (e.g., Berntsen & Bohn, 2010; Rubin, 2014; Schacter & Addis, 2007; Suddendorf & Corballis, 2007), whereas the construction of past events to a greater extent may have been influenced by factors present at encoding, such as concrete sensory experiences and less positive emotion (Berntsen & Bohn, 2010; Miles & Berntsen, 2011).

As is also shown in Table 2, we found a large number of main effects of cueing, which were consistent with previous findings within the autobiographical memory literature. Consistent with Anderson et al. (2012), we found a main effect of cueing for latencies to generate events and for the number of specific events. We extended these findings by showing that HI versus LI cued events also differed as to the nature of the event details. HI cued events contained more internal details than did LI cued events, whereas no main effect was found for external details. Examining the nature of the details more closely, we found that cueing had differential effects on the different subcategories of the internal details. In accordance with our predictions, HI cues resulted in more perceptual details than did LI cues. Interestingly, however, the reverse pattern was observed for details on thoughts/emotions. Here LI cues resulted in more details on thoughts/emotions than did HI cues. This may be due to LI cues instigating more conceptual-driven processing, that engages more self-referential processes, and activates goal-directed retrieval strategies (Conway & Pleydell-Pearce, 2000). This was further substantiated by the finding that LI cues were associated with more central (or gist) details and with fewer peripheral details than were HI cues. These findings are largely consistent with HI cues facilitating event construction by promoting more concrete and perceptually driven processing, whereas LI promotes more conceptual processing. Also consistent with previous findings (Williams et al., 1999), HI cued events were scored as being more idyllic than LI cued events.

Importantly, these main effects of cueing and temporal direction were qualified by a number of significant interactions for latency, idyll, and peripheral details. As is illustrated in Fig. 1, these interactions reflected that the effects of cueing were larger in the past than in the future condition. For mean latency to generate an event, the difference between HI and LI cued events was significant for the past (p < .001) but not for the future (p = .25) condition. For peripheral details and ratings of idyll, the effects of cueing were still notably more pronounced for past than for future events, although the difference between HI and LI cued events also reached significance for these variables (ps < .001).

Phenomenal characteristics of HI and LI cued past versus future events

We conducted a series of 2 (Cue: HI vs. LI) × 2 (Time: past vs. future) repeated measures ANOVAs to compare the subjectively rated phenomenal characteristics for the four event conditions. The results, as well as the means and standard deviations, are presented in Table 3 and Figs. 1 and 2. As can be seen in Table 3, we found a number of main effects of temporal direction, consistent with our hypotheses. As expected, past events were generally more distant in time from the present than were future events, and they were thought to be more specific and were rated higher on details of setting than their future counterparts. Conversely, future events were thought to require more active search (i.e., coming to mind less spontaneously) and were experienced more from an observer perspective. Future events were also rated as being more positive than past events, whereas memories were rated higher on emotional intensity than future events. However, looking at ratings of p/reliving, we found a pattern opposite from the one we expected, with future events being rated higher than past events. We also failed to replicate previous findings of a temporal main effect on rated visual imagery and vividness.

As is also shown by Table 3, several main effects of cueing were found. As expected, HI cued events were rated higher on valence, intensity, see, vividness, and travel in time than LI cued events. These findings are consistent with earlier work, showing that HI cued events are more positive than LI cued events and that visual imagery is a rich source of recollective experience. HI cued events were also rated as involving less active search processes—that is, coming to mind more spontaneously—than LI cued events, consistent with our findings on latencies.

As predicted, the main effects of temporal direction and cueing were qualified by a number of significant interactions. As is illustrated by Figs. 1 and 2, the interactions for search and age of event respectively were, similar to those for latency and peripheral details, due to the cueing manipulation having a larger effect in the past than in the future condition. As is shown by Fig. 1, for ratings of search, the difference between HI and LI cued events was significant for the past (p < .001), but not for the future (p = .19) condition. Importantly, as is shown by Fig. 2 (bottom panel), although we observed the expected foreshortening of the past in the LI as compared to the HI cue condition (p < .001), this was not the case for future events (p = .31). Figure 2 (top panel) displays the time in years from the present to the time of the event across cue types for both temporal conditions. In the past condition, a greater percentage of memories was reported in the HI cued

Table 3 Means and ANOVA's for subjectively assessed characteristics of past versus future event representations in the high-imageability (HI) versus low-imageability (LI) cue condition

	Past				Future				Main Effects				Interaction	
	HI		LI		HI		LI		Past/Future		Cueing		Past–Future/ Cueing	
Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	η_p^2	*F*	η_p^2	*F*	η_p^2
Search	3.07	1.65	4.12	1.80	3.76	1.71	3.99	1.63	4.60*	.04	24.16***	.19	10.38**	.09
Reliving	4.52	1.27	4.55	1.32	5.01	1.17	4.72	1.29	7.54**	.07	1.55	.02	2.40	.02
Perspective	2.62	1.44	2.51	1.45	3.02	1.70	3.27	1.82	13.87***	.12	0.48	.01	2.60	.03
Coherence	4.07	1.53	4.17	1.41	4.06	1.40	3.71	1.41	3.30	.03	1.43	.01	4.24*	.04
Valence	1.23	0.90	0.05	1.16	1.40	0.95	0.49	1.06	9.52**	.09	121.73***	.55	2.32	.02
Intensity	1.43	0.77	1.26	0.75	1.69	0.81	1.32	0.82	4.14*	.04	16.54***	.14	1.81	.02
See	5.16	1.27	5.06	1.18	5.27	1.14	4.97	1.30	0.00	.00	5.64*	.05	1.12	.01
Vividness	4.96	1.31	4.85	1.22	5.25	1.08	4.76	1.38	0.81	.01	9.39**	.09	4.62*	.04
Setting	5.71	1.14	5.91	1.12	5.69	0.96	5.37	1.44	4.15*	.04	0.48	.01	11.55**	.10
Travel in time	3.87	1.62	3.71	1.32	3.92	1.66	3.66	1.62	0.00	.00	5.04*	.05	0.26	.00
Specificity	0.97	0.14	0.95	0.17	0.86	0.28	0.86	0.27	17.07***	.14	0.45	.00	0.19	.00
Age of event	4.06	4.07	2.58	4.07	1.59	4.35	2.01	2.98	11.09***	.10	3.06	.03	10.18**	.09

* $p < .05$, ** $p < .01$, *** $p < .0001$

condition, stemming from approximately the first decade of the lifespan (29.0%) (see the results in Fig. 2 for bins –10 to –20), than was reported in the LI cued condition (13.5%), $\chi^2(1) = 7.18$, $p < .01$. In contrast to this pattern, the future condition showed a small predominance of HI cued events for the upcoming year (61.5%) that was slightly higher than the one observed for the LI cued events (54.5%), but this did not represent a significant difference, $\chi^2(1) = 1.01$, $p > .05$. This finding mirrors previous findings from the odor-cueing literature (Miles & Berntsen, 2011).

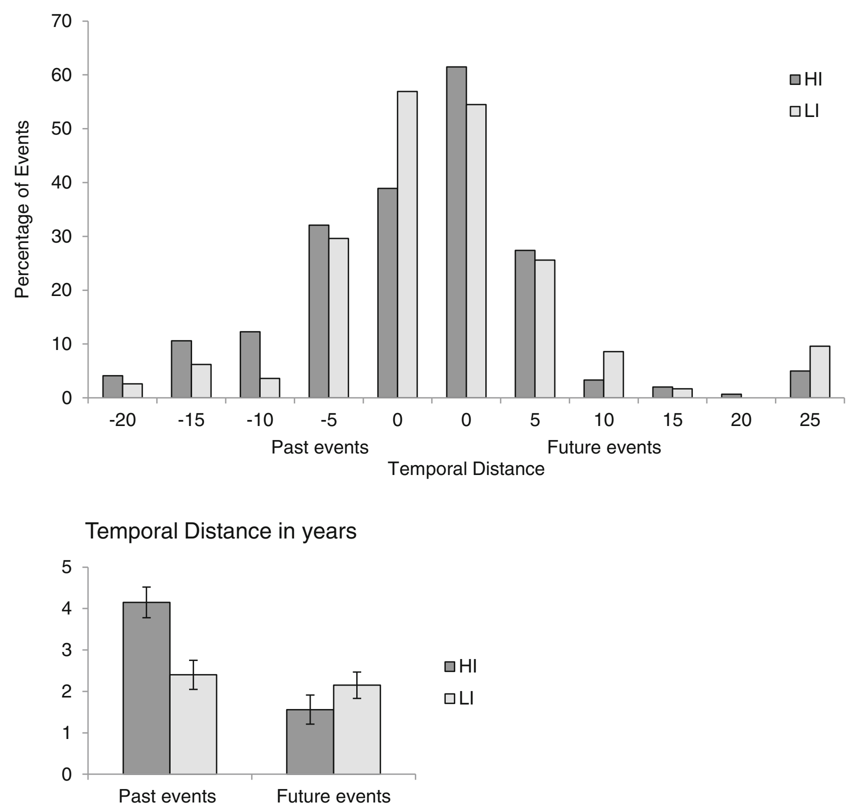

Fig. 2 (Top) Percentages of past and future events across cue types as a function of temporal distance in years from the present, measured in 5-year time bins. (Bottom) Mean ratings of temporal distance. Error bars indicate the standard errors of the means

However, two exceptions to the overall pattern of interactions were also observed, as can be seen in Fig. 1. The interactions for coherence and setting, respectively, were in the opposite direction, with LI cued events being rated lower than HI cued events in the future condition (*p*s < .05), whereas no significant differences on ratings of coherence and setting was found between HI and LI cued events in the past condition (*p*s = .44 and .20, respectively).

Discussion

Previous work has demonstrated that past and future MTT is affected in similar ways by a variety of experimental manipulations. This has been taken as support for the idea that MTT in both directions relies on the same underlying neurocognitive system. Here, we asked our participants to generate past and possible future events in response to HI and LI cue words. Consistent with previous findings within the MTT literature, we found that past events were retrieved faster, more often referred to specific events, contained more details, and were rated higher on field perspective, whereas future events were more positive and idyllic and closer in time (e.g., Anderson et al., 2012; Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; D'Argembeau & Van der Linden, 2004, 2006; Finnbogadóttir & Berntsen, 2013; Miles & Berntsen, 2011).

We replicated prior work by showing that it was significantly harder, and took longer, to construct a specific past or future event in response to LI cues (Anderson et al., 2012). Importantly, we extended previous findings by showing that HI cued events contained significantly more internal event-specific and sensory–perceptual details, and were characterized by more peripheral details, than were LI cued events. Furthermore, the effect of imagery was also mirrored in the phenomenal qualities, with HI cued events being rated higher on imagery, vividness, and travel in time. We also found that the HI cued events were markedly more positive and idyllic than the LI cued events. A similar finding has been obtained previously for autobiographical remembering (Williams et al., 1999).

In accordance with our predictions, we found an increased effect of cue imageability for past as compared to future events across several variables. This more pronounced effect of cue imageability for past relative to future MTT included response latency, self-reported search effort, the amount of peripheral details generated, how idyllic the events were rated, and their temporal distance from the present. However, we also found two exceptions to this pattern. For ratings of seeing the setting and coherence, the cue manipulation affected only representations of future events. These two findings may reflect an inherent difference between past and future MTT, in that the former, in contrast to the latter, refers to events that were actually experienced and encoded at a certain time in the past. First, contextual information on the setting or physical surroundings may not be readily available when imagining future events. Whereas all past events have occurred within a certain setting, such information is not necessarily present in constructed representations of future events, since some future events may potentially happen at a number of locations. Second, whereas the construction of both past and future events requires retrieval of stored information, only in future event construction do such event details need to be extracted from various past events to be flexibly recombined into novel events (Addis et al., 2009). The fact that future MTT puts higher demands on processes related to the reconstruction and binding of event details into a coherent scene may explain why the effect of cueing on coherence was greater in the future condition.

Previous research has documented effects of cue imageability on MTT for latencies and event specificity (Anderson et al., 2012). However, the present study is the first to examine more carefully the effects of imagery cueing on the actual content of past and future events and on the subjective qualities associated with the generated events. Notably, we add to the literature by showing that imagery affects the retrieval strategy and the richness of the events generated—in particular, the proportion of episodic and peripheral details in the reported events. Our findings provide new evidence that cue imageability facilitates the construction of both past and future events, and they further suggest that this facilitative role may be mediated by imagery cueing sensory-perceptual and contextual information, and thereby promoting more perceptual-driven processing. Indeed, Greenberg and Rubin (2003) argued that visual imagery plays a pivotal role in the reactivation of the entire memory trace, in that visual details provide effective cues that result in the coactivation of other sensory components of memory required for retrieval.

Importantly, across a number of variables, we showed increased effects of cue imageability on past as compared to future MTT. This is likely to be explained in terms of some of the same mechanisms: If future as compared to past MTT is less strongly linked with sensory–perceptual processes, this may reduce the usefulness of such perceptual associative processes, and thus result in smaller differences between the HI and LI cued conditions for future events. The significant interactions between cueing and temporal direction for latencies and peripheral details, in particular, suggest that imagery is especially important for facilitating the retrieval of "experience-near" autobiographical memories. In accordance with imagery having accentuated an effect of factors operating at encoding, but not operating to the same extent for future MTT, Koss, Tromp, and Tharan (1995) argued that the recall of peripheral details, in particular, is less likely to be reconstructed from semantic knowledge, and therefore may be used as an indicator of accurate recollection of encoded information, rather than plausible reconstruction, in line with reality-monitoring theory (Johnson, 1988; Johnson, Hashtroudi, & Lindsay, 1993). It will be important for future research to examine more closely how peripheral details are encoded and retrieved.

We replicated previous work regarding the temporal distribution of events (Fitzgerald & Lawrence, 1984; Rubin & Schulkind, 1997b), by showing that HI words cued older memories than did LI words. Importantly, we extended this finding by including a future condition. Instead of witnessing a mirroring effect for the temporal distribution, as has been reported with word-cued events (Berntsen & Jacobsen, 2008; Spreng & Levine, 2006), we observed a reversed distribution for the HI cued condition, causing an interaction between cueing and temporal direction for temporal distance (see Fig. 2). This distribution is similar to the findings on odor-cued past and future events (Miles & Berntsen, 2011). Our findings suggest that imagery does not only act as a mere facilitator in the construction of past and future events—if that were the case, we would have expected to see similar effects of cue imageability on the temporal distribution for both temporal directions. A possible explanation as to why imagery had differential effects on the temporal distribution of past and future events may be that the HI cues elicited memories of more remote events due to a higher degree of encoding–retrieval match, which may be less effective for future MTT, due to future events relying more on schema-based construction.

The findings that HI cued events were more specific and detailed, and that HI cues evoked more distant memories, are seemingly at odds with findings that temporally distant events are more abstract than representations of temporally close events (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Szpunar & McDermott, 2008; Trope & Liberman, 2003). Our findings may be explained by imagery promoting more associative retrieval processes, as is indicated by the shorter response latencies and lower ratings of active search for the HI cued past events. Findings from the involuntary memory literature have generally shown spontaneously arising memories to be more specific than their voluntarily retrieved counterparts (e.g., Berntsen & Hall, 2004).

The notion that more associative or spontaneous retrieval may explain the fact that participants were much faster at generating memories when cued with HI cues is further supported by correlational analysis, showing significant correlations between latencies and ratings of search for the HI cued past events and both the HI and LI cued future events (rs = .22–.30, ps < .05), whereas the correlation for LI cued past events showed only a trend toward significance ($r = .16$, $p = .08$). The fact that faster event generation was associated with an experience of lack of active search suggests that imagery may have given rise to more associative or spontaneous retrieval. This is in line with recent findings reported by Uzer, Lee, and Brown (2012), that highly concrete cues (i.e., object names) are more likely to trigger direct retrieval, as indexed by retrieval time and self-reported search effort, than are abstract concepts such as emotions. Uzer et al. argued that the difference in the frequency of direct retrieval as a function of cue type indicates that event memories are more likely to be indexed by highly concrete cues than by abstract concepts.

Future MTT typically involves less reliving than does past MTT, consistent with the claim that future events require more effort to construct and are more schema-driven (Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; D'Argembeau & Van der Linden, 2004, 2006; Larsen, 1998). However, in the present study, we failed to replicate these findings. Future events were rated higher on p/reliving than past events, whereas no temporal main effects were found for ratings of visual imagery and vividness. Two possible explanations may account for these findings. First, the temporal distribution of past and future events may have resulted in future events being rated higher than memories due to the fact that they were closer to the present. In line with this, differences in ratings of p/reliving disappeared when we ran the analysis with events more than 5 years into the past or future filtered out. Second, in our study we used a new methodology to assess past and future MTT, by asking participants to elaborate on their event representations for a period of 3 minutes before rating the event on the AMQ. This elaboration phase may have affected the subjective ratings. Rubin (2014) demonstrated that the manipulation of having participants think more about the details of future events succeeded in removing the differences between past and future events with respect to several ratings of phenomenological characteristics, including p/reliving and sensory details. Thus, it is likely that the introduction of the elaborate phase in our study may have reduced the effect of temporal direction.

In summary, our study indicates that cue imageability acts as an important facilitator when constructing both past and possible future events. Our findings suggest that cue imageability influences the richness of the events generated—in particular, the contextual and peripheral details retrieved, the valence of the event, and the temporal distance from the present. We suggest that these effects may be explained in terms of high-imageable cues promoting more perceptually driven processing, whereas low-imageable cues promote more conceptual processing. The same mechanism may explain the increased effect of cue imageability for past as compared to future MTT. According to our view, if cue imageability facilitates more perceptual-based processing, this should result in larger differences between high- and low-imageable cued past events than would be found for future events, because past MTT is more strongly linked with sensory–perceptual experience, whereas future MTT is more driven by context-independent schemata.

More broadly, the present study adds further evidence that certain types of cueing interact differently with past and future MTT. Although a substantial amount of evidence supports the idea that remembering past events and imagining future events rely on the same underlying neurocognitive system, the two processes appear to interact differently with components of this system. In particular, cueing methods that may evoke factors operating at encoding, such as concrete sensory experiences, seem to more strongly affect how we remember our past than how we imagine our future.

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