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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 backwards 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 suggests that while 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. 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.

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"I can see clearly now": The effect of Cue Imageability on Mental Time Travel

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 in imagining 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 found 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, 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

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contextual details, less frequently refer to specific events and require more cognitive effort than past remembering. On the other hand, future events are rated as more important or personally significant, and as more emotionally positive than are 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 extend 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, et al., 2009, pp. 2236-2237). This is consistent with brain imaging studies showing that 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-cuing, 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 of 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 are better encoded and rehearsed than word-cued memories (Rubin & Schulkind, 1997a). Berntsen and Bohn (2010) 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

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MTT but absent from future MTT (Berntsen & Bohn, 2010).

Examining the effect of different cue modalities (verbal, visual, and odour) on past and future MTT, Miles and Berntsen (2011) replicated previous findings (Chu & Downes, 2000; Willander & Larsson, 2006) showing a unique ability of odours to evoke remote autobiographical memories. However, instead of witnessing a mirror effect for the temporal distribution in the future condition, as 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 (2011) found a reversed distribution for the odour 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 have also been reported in several studies examining the effect of emotional valence on MTT (D'Argembeau & Van der Linden, 2004; Rasmussen & Berntsen, 2013; Rubin, 2013). 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 extend is constrained by the reality of the actual events. Rubin (2013) reported that future negative events ("that might occur within the next year and that would impact you a lot") were rated 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 posttraumatic stress disorder (PTSD) symptoms in response to the negative future events, these were rated as substantially higher than the symptoms reported for the negative past events. On the basis of these findings, Rubin (2013) concluded that the simulation of future events is more schema-driven that the reconstruction of past events.

These findings stresses 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 examine 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, as almost all personal memories are accompanied by some degree of visual imagery (Brewer, 1986; Rubin et al., 2003; Rubin, 2005; 2006). Further support for this relationship comes from neuropsychological data showing that brain damage to areas known to support visual imagery can, as a secondary consequence, 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 & Schiffmann, 1974), in which participants are presented with a series of cue words that are rated high (HI) or low (LI) 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 consistently has shown that HI cue-words are associated with shorter latencies (Fitzgerald & Lawrence, 1984; Rubin, 1980; Rubin & Schulkind, 1997b; Williams et al., 1999) and seem to facilitate access to more specific memories, than do LI cue-words (Dewhurst & Conway, 1994; Mortensen, Berntsen & Bohn, in press; 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

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modality of the memory cues revealed that only visual (relative to olfactory, tactile, auditory, motor and abstract) imagery facilitated specific memory retrieval (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 HI words compared to LI 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 times, HI words producing older memories and shorter latencies. Rubin and Schulkind (1997b) suggested that the HI cues may trigger earlier memories by promoting a more perceptually driven retrieval, whereas LI cues promote more conceptual or semantic processing (also see Conway & Pleydell-Pearce, 2000; Mortensen et al., in press, for a similar view). 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 effect of cue imageability on past and future MTT. Anderson, Dewhurst and Nash (2012) asked subjects to retrieve past or imagine future specific events. Their dependent variables were latency to generate a specific event, number of specific events generated, and age of the event. In accordance with the autobiographical memory literature, Anderson et al. (2012) found that, compared to events cued by LI words, future events cued by HI words took shorter time to generate and more often resulted in the reporting of specific versus general events. This suggests that imagery not only plays an important facilitative role in the retrieval of specific autobiographical memories but also in constructing specific future events. Importantly, Anderson et al. (2012) reported an unpredicted interaction between the temporal direction and cue type for latency to generate specific events, with participants being slower at generating specific events in the future task in the HI cued condition, whereas past and future response latencies did not differ in the LI condition. Although not discussed by the authors, it thus seems that for this measure, the facilitating effect of HI cues was reduced for future events compared 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 a 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. (2012) replicated previous findings from the MTT literature, in that future events were temporally closer to the present compared to past events. They also looked at possible effects of temporal distance as a function of cue type, and reported that LI cued events were closer in time than HI cued events. The authors did not report possible interactions between temporal distance, temporal direction and cue type.

In the present study, we aim at pursuing more systematically the possibility that HI versus LI cueing interact differently with future versus past MTT. In order to do so, we include a number of dependent variables for which such interactions are likely to be identified, thereby extending prior research strategies in important ways. Firstly, retrieval effort is measured in two ways. Similar to Anderson et al. (2012) we obtain latencies, however we also assess self-reported retrieval strategies. Secondly, we measure specificity using the same coding methods as used by Anderson et al. (2012), as well as by subjective ratings. Apart from this fairly broad level of categorizing events with regards to their temporal specificity, we examine the qualitative nature of the details comprising past and future events representations. In particular, we code these details according to whether they are internal or external to the reported event, thereby treating the distinction between episodic and semantic information as two continua rather than as a dichotomy (Levine, Svoboda, Hay, Winocur & Moscovitch, 2002). We also examine whether the details are 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. Thirdly, we examine a number of subjective qualities associated with the generated events such as reliving quality and visual imagery. Taken together, these different measures allow 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 are 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 HI versus LI cue words, and 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; Moscovitch et al., 2005; Tulving, 2002). In particular, we coded event descriptions for internal versus external details (i.e. based on the episodic versus semantic distinction) (Addis et al., 2008; Levine et al., 2002) and for how central and peripheral 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 findings suggest 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 HI versus LI cue manipulation to result in main effects across both temporal directions, with HI cued events being more specific and containing more peripheral and episodic event specific details, and this being especially the case for sensory-perceptual details. Given that imagery is a rich source of recollective experience, we also expected HI cues to yield higher scores on variables related to vividness and feeling of reliving, as compared with their LI 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 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 HI versus LI 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 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. All of 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: HI vs. LI) x 2 (time: future vs. past) within-subjects design. Each participant generated two of each type of events, making it a total of eight event representations. The order of the events was counterbalanced across four groups, with 41, 38, 38 and 34 participants

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in each group.

Materials

Cues. The cue-words were selected from the Pavio, Yuille, and Madigan's (1968) corpus of 925 nouns from which high and low imageability ratings were taken. Furthermore, cue-words were matched for prevalence in Danish (Bergenholtz, 1992). The high imageable cue words were *bird*, *orchestra, letter* and *landscape*. The low imageable cue words were *ownership, truth*, *thought*, and *duty*. An independent samples t-test, showed a significant difference in ratings of imageability for cue-words in the high imageable cued (M = 6.56, SD = 0.19) versus low imageable 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 high and low imageable 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

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many event details as possible within 3 min. They were instructed to record all kinds of details, even details 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 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 (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. Hereafter the participants practiced the procedure thoroughly before the study was initiated.

Questionnaire. The questions that were asked after eliciting all memories 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 shown 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 remembered or imagined event measured in years or days from the present moment. Question 1 addressed the ease, with which participants generated the event, and Question 3-10 addressed the amount and type of subjective re-experiencing 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 the labels 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; for example, a semantic association to the cue word), or an omission (i.e., no response) (Williams & Dritschel, 1992) by two independent raters blind to the hypothesis of the study. The inter-rater reliability was acceptable (Cohen's $\kappa = .71$) (inter-rater 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) were 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 were considered to reflect episodic p/re-experiencing. Internal details separated into five mutually exclusive subcategories: *time*, *place, perceptual, thought/emotion,* and *event details*. External details were those details that pertained to extraneous information that did not require recollection of a specific time or place and was not uniquely specific to the main event, they were subdivided into four categories: *external event details (specific details external to the main event), semantic information (facts and extended events), repetitions,* and *other (meta-cognitive statements, editorializing)*. The inter-rater agreement for the composite scores was good as measured by intra-class correlations (two-way random effects model; McGraw & Wong, 1996) of .92 and .78 for internal and external details, respectively.

Central/peripheral details. Responses where scored for 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 if (2) it could not be left out or replaced without a major change in the content of the event. Otherwise, it was classified as peripheral (Berntsen, 2002). The inter-rater agreement was good as assessed by intra-class correlations (two-way random effects model; McGraw & Wong, 1996) of .79 and .90 for central and peripheral details, respectively.

Idyll. The two raters scored all memories and future event representations on a 3-point rating scale on 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, absence of negative emotions) could be confirmed. If none of the two indicators could be confirmed, the record received an idyll score of 1 (Berntsen & Jacobsen, 2008). Interrater agreement was high (Intra-class correlation (two-way random effects model; McGraw & Wong, 1996) of .89).

Results

We first examine the objective measures, that is, *mean latencies* to generate events and *the objectively scored content and details* of the past and future events as a function of activation through HI versus LI cues. Second, we examine the *subjectively rated phenomenal qualities* of the past and future events across the two cuing conditions. Because each subject 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 subject in each event condition. Following Rubin and Schulkind (1997b), initial analyses for latency were conducted with the arithmetic and the geometric mean (i.e. the logarithm of the arithmetic mean). Since there were only minor differences, 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) x 2 (Time: past vs. future) repeated measures ANOVAs to compare the latency 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 Figure 1. As is shown by Table 2, we found several main effects of temporal direction, consistent with our hypotheses. As expected, past events were retrieved faster, were more specific, and contained more internal details, 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, whereas future events were rated as being more idyllic than past events. These findings are largely consistent with the idea that future events requires more constructive effort than past events, and that the construction of future events therefore is more schema-driven (e.g., Berntsen & Bohn, 2010; Schacter & Addis, 2007; Suddendorf & Corballis, 2007; Rubin, 2013), 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, 2012).

As is also shown by 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 number of specific events. We extended these findings by showing that HI versus LI cued events also differed on the nature of event details. HI cued events contained more internal details, than LI cued events, while 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 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 HI cues. This may be due to LI cues instigating a more conceptual driven processing, engaging more self-referential processes and activating 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 fewer peripheral details, compared to HI cues. These findings are largely consistent with HI cues facilitating event construction by promoting more concrete and perceptually driven processing, while LI promotes more conceptual processing. Also consistent with previous findings (Williams et al., 1999) HI cued events were scored as more idyllic than LI cued events.

Importantly, these main effects of cuing and temporal direction were qualified by a number of significant interactions for latency, idyll, and peripheral details. As illustrated in Figure 1, these interactions reflected that the effects of cuing 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 condition ($p = .25$). For peripheral details and ratings of idyll, the effects of cuing 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 (*p*s < .001).

Phenomenal characteristics of HI and LI cued past versus future events

We conducted a series of 2 (Cue: HI vs. LI) x 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 Figure 1 and 2. As is shown by Table 3, we found a number of main effects of temporal direction, consistent with our hypotheses. As expected, past event were generally more distant in time from the present than 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 (coming to mind less spontaneously) and were experienced more from an observer perspective. Future events were also rated as more positive than past events, whereas memories were rated higher on emotional intensity than were future events. However, looking at ratings of p/re-living, we found the opposite pattern of what we expected, 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 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 the findings on latencies.

As predicted, the main effects of temporal direction and cueing were qualified by a number of significant interactions. As illustrated by Figure 1 and 2, the interactions for search and the age of event were, similarly to 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 Figure 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 condition ($p = .19$). Importantly, as is shown by Figure 2 (bottom panel) while there was an expected foreshortening of the past in the LI cue condition 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 there are a greater percentage of memories reported in the HI cued condition stemming from approximately the first decade of the lifespan (29.0 %) (see Figure 2, for bins -10 to -20), than reported in the LI cued condition (13.5 %) $\chi^2(1) = 7.18$, $p < .01$. Counter to this pattern, the future condition shows a small preponderance of HI cued events for the upcoming year (61.5 %)

that is slightly higher than the one observed for the LI cued events (54.5 %), but this does not represent a significant difference, $\chi^2(1) = 1.01$, $p > .05$. This finding mirrors previous findings from the odour cueing literature (Miles & Berntsen, 2011).

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

Discussion

Previous work has demonstrated that past and future MTT is affected similarly 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, 2011; Miles & Berntsen, 2011).

We replicated prior work by showing that it was significantly harder, and took longer, to construct a specific past and 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, 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 latencies, 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 from this pattern. For ratings of seeing the setting and coherence, the cue manipulation affected only representations of future event. These two findings may reflect the 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 each past event has occurred within a unique setting, such information is not necessarily present in constructed representations of future events, as some future events may potentially happen at a number of locations. Second, while both past and future event construction requires retrieval of stored information, only in future event construction does such event details need to be extracted from various past events to be flexibly recombined into novel events. The fact that future MTT puts higher demands on processes related to reconstruction and binding of event details into a coherent scene (Addis, Pan et al., 2009), may explain why the effect of cueing on coherence was greater in the future condition.

Previous research has documented an effect of cue imageability on MTT for latency and event specificity (Anderson et al, 2012). However, the present study is the first to examine more carefully the effect 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 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 co-activation of other sensory components of memory required for retrieval.

Importantly, across a number of variables, we show 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 imageable cued conditions for future events. The significant interactions between cueing and temporal direction for latencies and peripheral details in particular, suggest imagery being especially important in facilitating the retrieval of "experience near" autobiographical memories. In line 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 more fully understand how peripheral details are encoded and retrieved.

We replicated previous work regarding the temporal distribution of events (Rubin & Shulkind, 1997b; Fitzgerald & Lawrence, 1984) showing that HI words cued older memories than LI words. Importantly, we extended this finding by including a future condition. Instead of witnessing a mirroring effect for the temporal distribution, as seen previously 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 Figure 2). This distribution is similar to the findings on odour-cued past and future events (Miles & Berntsen, 2011). Our findings suggest that imagery not only acts as a mere facilitator in the construction of past and future event, if that was the case, we would have expected similar effects of imagery on the temporal distribution for both temporal directions. A possible explanation as to why imagery had differential effects on the temporal distribution on 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 is 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 evident by the 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, *p*s < .05), while the correlation for LI cued past events showed a trend toward significance (r = .16, *p* =.08). The fact, that faster event generation was associated with an experience of a 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 (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. (2012) 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 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/re-living than past events, while no temporal main effect was 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 the former was closer to the present. In line with this, differences in ratings of p/reliving disappeared when we ran the analysis with events more than five years into the past/future filtered out. Secondly, 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 three minutes, before rating the event on the AMQ. This elaboration phase may have affected the subjective ratings. Rubin (2013) demonstrated that the manipulation of having participants think more about the details of future events succeeded in removing the differences between the past and future events on several ratings on phenomenological characteristics including 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 as well as 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 promotes 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

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should result in larger differences between high and low imageable cued past than 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 the 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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Table 1

Questions and Answering Options for Each Events 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 indicate your current age in Question number 11, how many days from today is the event in the past? (estimated in days)

Note. In the analyses, age of event was calculated by subtracting the answer to Question 11 from the participants' current age.

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Table 2

Means and ANOVA's for Objectively Measured Event Characteristics for Past versus Future Temporal Direction in the HI versus LI cue conditions.

	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^2_p	*F*	η^2_p	*F*	η^2_p
RT	11.53	13.27	21.69	16.86	17.73	15.40	21.35	19.43	8.44**	0.08	35.93***	0.26	9.36**	0.08
Specificity	1.87	0.37	1.70	0.50	1.58	0.56	1.43	0.67	28.91***	0.20	11.75***	0.09	0.04	0.00
Idyll	2.31	0.46	1.73	0.62	2.49	1.17	2.17	1.27	4.75*	0.06	78.18***	0.51	4.24*	0.05
Internal	13.83	4.71	11.81	4.35	12.75	5.00	11.09	5.16	3.94*	0.04	26.48***	0.24	0.28	0.00
Event	4.69	2.58	4.16	2.22	4.70	2.78	3.93	2.35	0.14	0.00	9.92**	0.10	0.36	0.00
Place	0.83	0.71	0.78	0.68	0.65	0.62	0.64	0.58	5.63*	0.06	0.22	0.00	0.08	0.00
Time	0.30	0.42	0.27	0.41	0.26	0.34	0.22	0.32	1.85	0.02	1.20	0.01	0.02	0.00
Th/Em	2.92	1.75	3.84	2.31	2.90	2.05	3.12	2.14	5.22*	0.06	9.46**	0.10	3.62	0.04
Perc	5.22	3.01	3.47	2.38	5.01	3.27	3.67	2.67	0.00	0.00	48.41***	0.37	1.52	0.02
External	1.18	1.68	1.59	2.27	1.72	3.72	2.04	3.31	2.56	0.03	1.62	0.02	0.02	0.00
Central	3.44	1.47	4.61	2.25	3.22	1.90	3.75	2.15	9.73**	0.10	23.67***	0.11	3.62	0.04
Peripheral	6.25	3.65	4.20	3.09	5.94	3.10	4.78	3.10	0.31	0.00	56.11***	0.40	5.08*	0.06

Note. Response Time refers to retrieval or latency time to recall or imagine the event. *p<.05, **p<.01, ***p<.0001

Perc = perceptual; Th/Em = thought/emotion.

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Table 3

Means and ANOVA's for Subjectively Assessed Characteristics of Past versus Future Event Representations in the HI versus LI cue conditions

	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^2_p	*F*	η^2_p	*F*	η^2_p
Search	3.07	1.65	4.12	1.80	3.76	1.71	3.99	1.63	4.60*	0.04	24.16***	0.19	10.38**	0.09
Reliving	4.52	1.27	4.55	1.32	5.01	1.17	4.72	1.29	7.54**	0.07	1.55	0.02	2.40	0.02
Perspective	2.62	1.44	2.51	1.45	3.02	1.70	3.27	1.82	13.87***	0.12	0.48	0.01	2.60	0.03
Coherence	4.07	1.53	4.17	1.41	4.06	1.40	3.71	1.41	3.30	0.03	1.43	0.01	4.24*	0.04
Valence	1.23	0.90	0.05	1.16	1.40	0.95	0.49	1.06	9.52**	0.09	121.73***	0.55	2.32	0.02
Intensity	1.43	0.77	1.26	0.75	1.69	0.81	1.32	0.82	4.14*	0.04	16.54***	0.14	1.81	0.02
See	5.16	1.27	5.06	1.18	5.27	1.14	4.97	1.30	0.00	0.00	5.64*	0.05	1.12	0.01
Vividness	4.96	1.31	4.85	1.22	5.25	1.08	4.76	1.38	0.81	0.01	9.39**	0.09	4.62*	0.04
Setting	5.71	1.14	5.91	1.12	5.69	0.96	5.37	1.44	4.15*	0.04	0.48	0.01	11.55**	0.10
Travel in time	3.87	1.62	3.71	1.32	3.92	1.66	3.66	1.62	0.00	0.00	5.04*	0.05	0.26	0.00
Specificity	0.97	0.14	0.95	0.17	0.86	0.28	0.86	0.27	17.07***	0.14	0.45	0.00	0.19	0.00
Age of Event	4.06	4.07	2.58	4.07	1.59	4.35	2.01	2.98	11.09***	0.10	3.06	0.03	10.18**	0.09

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

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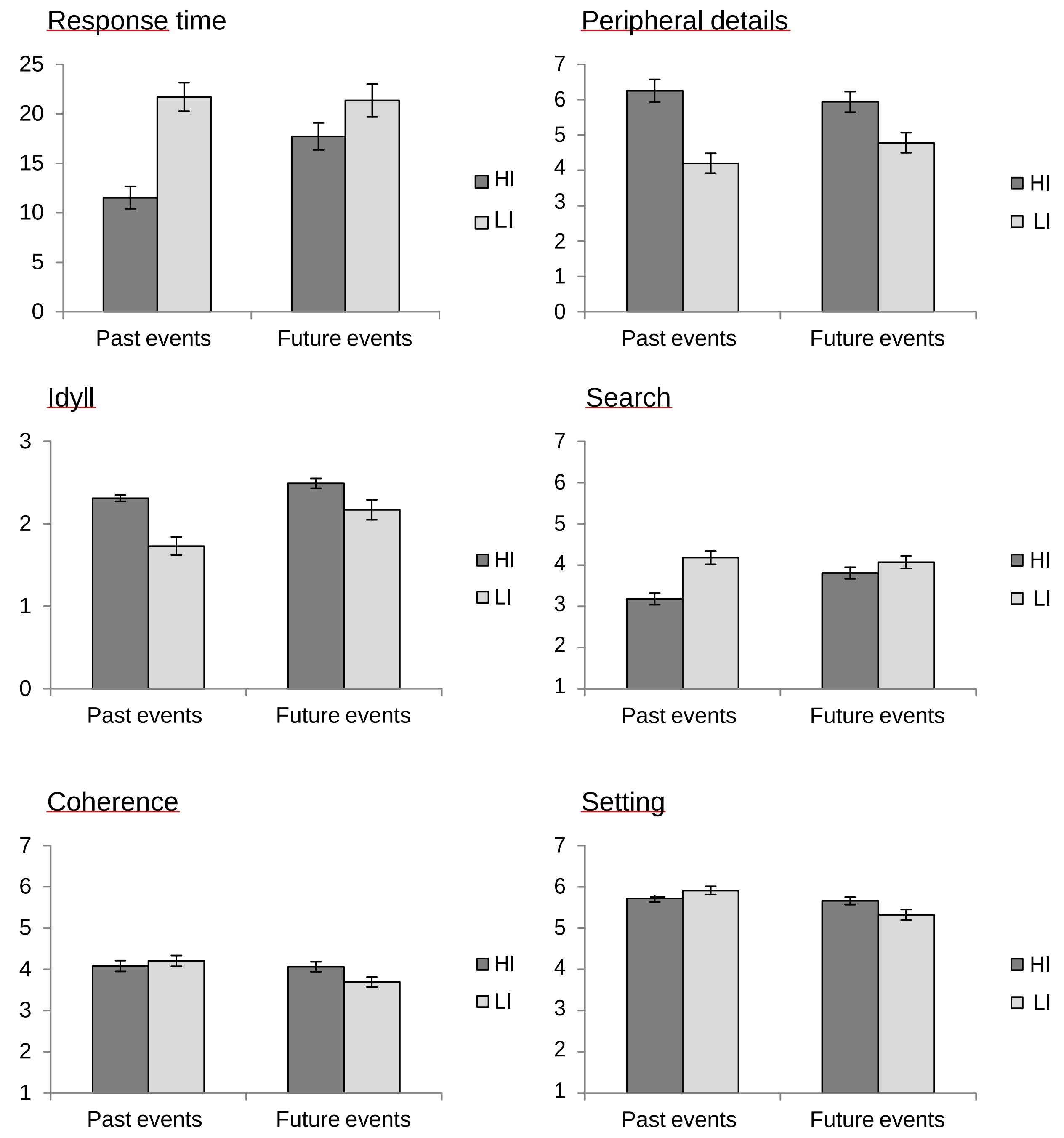
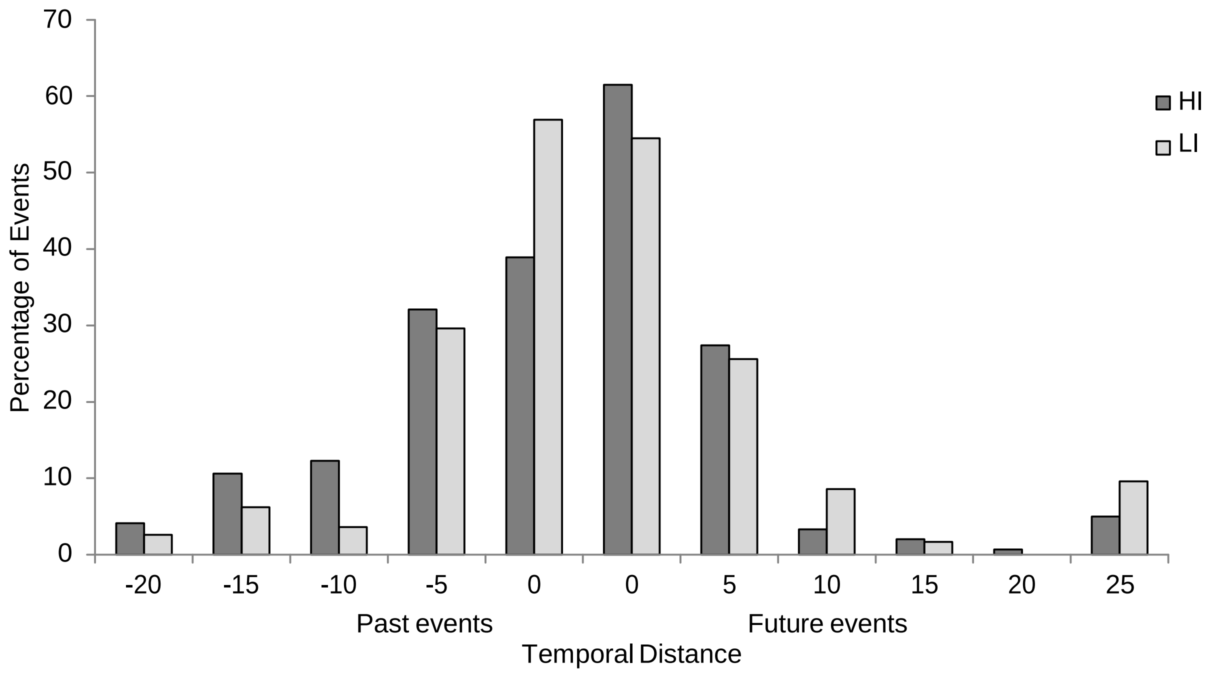


Figure 1. Mean ratings of response time, peripheral details, idyll, spontaneity, coherence and setting. Error bars indicate the standard errors of the means.



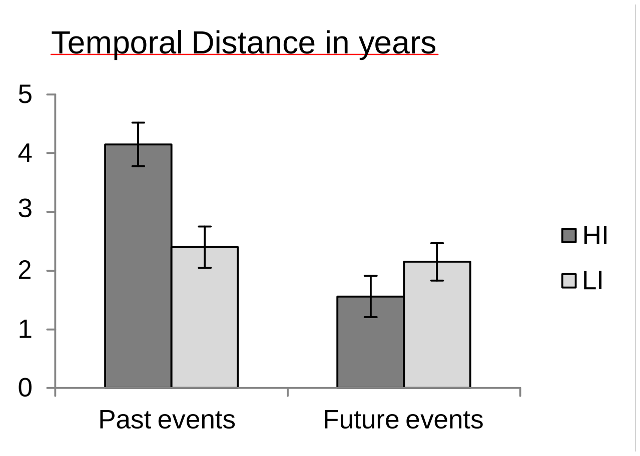


Figure 2. (Top) Percentages of past and future events across cue types as a function of temporal distance in years from the present, measured in 5-year time bins. (Bottom) Mean ratings of temporal distance. Error bars indicates the standard errors of the means