



Effects of handedness & saccadic bilateral eye movements on the specificity of past autobiographical memory & episodic future thinking



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ABSTRACT

The present research investigated the effects of personal handedness and saccadic eye movements on the specificity of past autobiographical memory and episodic future thinking. Handedness and saccadic eye movements have been hypothesised to share a common functional basis in that both influence cognition through hemispheric interaction. The technique used to elicit autobiographical memory and episodic future thought involved a cued sentence completion procedure that allowed for the production of memories spanning the highly specific to the very general. Experiment 1 found that mixed-handed (vs. right handed) individuals generated more specific past autobiographical memories, but equivalent numbers of specific future predictions. Experiment 2 demonstrated that following 30 s of bilateral (horizontal) saccades, more specific cognitions about both the past and future were generated. These findings extend previous research by showing that more distinct and episodic-like information pertaining to the self can be elicited by either mixed-handedness or eye movements. The results are discussed in relation to hemispheric interaction and top-down influences in the control of memory retrieval.

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1. Introduction

1.1. General overview of the current experiments

The research presented here is concerned with the influence of handedness and saccadic eye-movements, on the production of specific personal cognitions about the past (episodic autobiographical memory) and the future (episodic future thinking). Previous research has typically found superior episodic memory in mixed-handed persons and also following a brief period of saccadic eye-movements prior to retrieval. A common basis for the effect of both handedness and eye-movements has been hypothesised to be related to hemispheric interaction; with these interactions being greater in mixed-handed individuals and momentarily enhanced by saccadic eye-movements. As interhemispheric communication is considered to be important for episodic memory (Habib, Nyberg, & Tulving, 2003), variables that influence such interactions should affect episodic memory (Christman & Propper, 2010).

Existing research links together past and future personal cognition to the extent that future thinking about the self is, in part, reliant on the retrieval of past episodic memory. Thus, prospective thinking about the self in imagined future scenarios depends on

the ability to recall relevant autobiographical information. To date, no research has considered jointly handedness and saccadic eye movements on both past and future thinking. Consequently, the principal objective of the current work was to assess whether handedness and saccadic eye-movements influence the generation of more specific cognitions about the past and the future.

1.2. Autobiographical memory & the specificity of personal thought

Autobiographical memory is personal memory and refers to both episodic and semantic information about the self (Conway, 2005; Conway & Pleydell-Pearce, 2000; Levine, 2004). The episodic component denotes memory for event-related experiences involving conscious awareness of the self located in time and place (Tulving, 1985, 2002). Consequently, an additional defining feature of this form of memory is the unique and specific character of the remembered personal experience (Piolino, Desgranges, & Eustache, 2009). During recall, this involves the retrieval of the sensory, emotional & contextual information, which in turn provides a basis for reliving the event and the feeling of mental time-travel. The semantic component of autobiographical memory relates to personal memories that are more generalised and less specific in character. Such memories could include personal autobiographical self-knowledge (e.g., beliefs about one's personality traits or opinions and attitudes), or generalised knowledge about periods within

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one's life (e.g., period at secondary school or the years spent in a particular relationship).

The distinction between general and specific memories has been conceptualised in the theoretical model of Conway (2005, 2009). This model posits a hierarchically organised autobiographical knowledge base in which personal information is represented in a structured manner ranging from the very general to the most specific. General autobiographical knowledge takes the form of lifetime periods that represent thematic and temporal information typically covering large periods in one's life (Conway, 2005). These periods pertain to relatively abstract or generalised knowledge about persons, activities, plans and goals that are identifiable within particular lifetime phases. Subsumed under this level of representation are general events. The latter comprise single, repeated and extended events. Although, more specific than lifetime periods, such representations are in the order of days to weeks or months. Both general events and lifetime periods can be conceptualised as forms of personal semantic knowledge (Conway & Pleydell-Pearce, 2000; Coste et al., 2015).

The most specific form of personal knowledge is event-specific knowledge (ESK) and constitutes a form of episodic memory specific to events and possessing direct reference to place and time. Represented at this level are features of events that include sensory, emotional and contextual details. This is the most detailed form of autobiographical remembering in which the temporal extent can range from seconds and hours to a full day.

1.3. Episodic future thinking; functions & processes

Although personal episodic memory is about the past, the function of this form of memory is not simply to enable the individual to recollect past events and people; rather it has been argued that recalling episodic information can serve as a basis for planning the future and in decision-making (e.g., Atance & O'Neill, 2001; Klein, 2013; Schacter, 2012). One manner in which this can be achieved is through *episodic future thinking* (EFT) (Schacter, Addis, & Buckner, 2008). Episodic future thinking refers to the retrieval, construction and use of episodic knowledge in order to prospect the future by constructing possible scenarios that the individual may encounter. This type of future oriented cognition is distinct from generalised thought about the future to the extent that the contents of thought are constrained by their autobiographical and personalised nature (Schacter, Benoit, De Brigard, & Szpunar, 2015).

In terms of the *constructive episodic simulation* hypothesis, (Addis & Schacter, 2012; Schacter & Addis, 2007), individuals are able to envisage future scenarios by retrieving personal episodic information, flexibly reassembling the products of this into a coherent "simulation" of a possible future, and finally encoding/storing the newly formed simulation. The fact that EFT is deemed to be reliant on episodic memory (at least initially) suggests that the retrieval of the personal past and cognising the future share key similarities. In this context, many studies have shown both structural and functional resemblances between the two. For example, amnesic individuals with damage to the medial temporal lobes (MTLs) have been found to experience difficulties in constructing possible futures (Klein, Loftus, & Kihlstrom, 2002). Neuroimaging work also reveals the importance of the MTLs in EFT (e.g., Addis, Cheng, Roberts, & Schacter, 2011). Moreover, a network of regions has been uncovered that show similarities between autobiographical retrieval and EFT that go beyond the hippocampus/MTLs and include prefrontal regions, the parietal cortex, temporal regions and midline cortical structures (Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2007; Spreng & Grady, 2010; Szpunar, Watson, & McDermott, 2007).

1.4. Factors influencing past and future autobiographical cognition

Previous research has examined a range of factors that influence the specificity of autobiographical cognitions about the past and the future (e.g., Lind & Bowler, 2010; Madore, Gaesser, & Schacter, 2014; Race, Keane, & Verfaellie, 2011; Reas, Watkins, Williams, & Hermans, 2008). The experiments presented here examined the effects of both handedness and saccadic eye movements on the specificity of autobiographical memory and EFT. Earlier work has demonstrated that both handedness and saccadic eye movements influence performance on tasks of episodic memory. For instance, superior episodic memory has been found in persons who are mixed-handed (vs strongly right-handed) (Lyle, McCabe, & Roediger, 2008) and following bilateral saccades (Christman, Garvey, Propper, & Phaneuf, 2003). It has been hypothesised that a common neuroanatomical and functional basis underlies the effects on memory of both handedness and bilateral saccades (Christman & Propper, 2010; Prichard, Propper, & Christman, 2013). This basis is related to the connectivity between the two cerebral hemispheres and to hemispheric interaction as proposed within the Hemispheric Encoding and Retrieval Asymmetry (HERA) model.

According to this model, there are functional asymmetries between encoding and retrieval that are implemented in the left and right prefrontal regions respectively. Evidence for this was initially derived from early neuroimaging studies that found preferential activation of the left (vs. right) prefrontal region during encoding (vs. retrieval) of episodic memories (Habib et al., 2003; Nyberg, Cabeza, & Tulving, 1996).

Later work has found similar and broadly consistent results using a range of imaging methods (Babiloni et al., 2004, 2006; Düzel et al., 1999; Kompus, Kalpouzos, & Westerhausen, 2011; Liu, Liang, Kuncheng, & Reder, 2014; Manenti, Cotelli, & Miniussi, 2011; McDermott, Buckner, Petersen, Kelley, & Sanders, 1999; Sandrini, Cappa, Rossi, Rossini, & Miniussi, 2003; Tulving, Kapur, Craik, Moscovitch, & Houle, 1994) and stimulation techniques such as TMS and tDCS (Gagnon, Blanchet, Grondin, & Schneider, 2010; Manenti, Brambilla, Petesi, Ferrari, & Cotelli, 2013; Manenti et al., 2011; Rossi et al., 2004, 2006).¹

Within this context, the degree of personal handedness has been hypothesised to provide a behavioural index for stable or baseline levels of hemispheric interaction and bilateral saccades conjectured to momentarily increase this level (e.g., Christman et al., 2003; Lyle et al., 2008; Prichard et al., 2013). The details pertaining to each of these are outlined in Sections 2 and 5 for Experiments 1 and 2 respectively.

2. Experiment 1. Handedness & past & future autobiographical cognition

Experiment 1 developed previous research on the influence of handedness on memory to autobiographical and EFT specificity. Preceding work has examined handedness on a range of performance measures by contrasting strongly right-handed with mixed-handed groups. The rationale for this comparison is based on observations that handedness is related to underlying neuroanatomical differences in the size of the corpus callosum. Indeed a number of studies have found that this structure is larger in mixed (vs. right-handed) individuals (e.g., Clarke & Zaidel, 1994;

¹ Not all findings are equally supportive of the HERA model with some arguing for a material-specific basis for hemispheric specialisation (e.g., Miller, Kingstone, & Gazzaniga, 2002; Wagner et al., 1998) (but see Habib et al., 2003 for counter-arguments) or differences in hemispheric engagement depending on task complexity (e.g., Nölde, Johnson, & Raye, 1998). In spite of this, the HERA model has proven to be useful for explaining handedness differences in memory.

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