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Eye movement during retrieval of emotional autobiographical memories

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ABSTRACT

This study assessed whether specific eye movement patterns are observed during emotional autobiographical retrieval. Participants were asked to retrieve positive, negative and neutral memories while their scan path was recorded by an eye-tracker. Results showed that positive and negative emotional memories triggered more fixations and saccades but shorter fixation duration than neutral memories. No significant differences were observed between emotional and neutral memories for duration and amplitude of saccades. Positive and negative retrieval triggered similar eye movement (i.e., similar number of fixations and saccades, fixation duration, duration of saccades, and amplitude of saccades). Interestingly, the participants reported higher visual imagery for emotional memories than for neutral memories. The findings demonstrate similarities and differences in eye movement during retrieval of neutral and emotional memories. Eye movement during autobiographical retrieval seems to be triggered by the creation of visual mental images as the latter are indexed by autobiographical reconstruction.

1. Introduction

Autobiographical memories or memories for personal experiences allow individuals to define themselves and make sense and meaning of their life history (Conway & Pleydell-Pearce, 2000). These memories are reconstructed and regulated by control processes that seek to maintain consistency between one's beliefs, goals, emotional state, and the reality of the remembered event itself (Conway, 2005). For instance, individuals may retrieve memories about past victories in order to support their current positive emotion, or selectively retrieve negative memories to prepare themselves for a potential failure. Therefore, it appears that emotion may play a pivotal role in the reconstruction and regulation of autobiographical memories (Holland & Kensinger, 2010). Besides its role in autobiographical regulation, emotion has been found to improve autobiographical memory by enhancing retrieval of sensory and contextual details that were encountered during encoding (Comblain, D'Argembeau, & Van der Linden, 2005; St Jacques & Levine, 2007). Reflecting these outcomes, emotional autobiographical memories have been reported to be experienced with more visual imagery than neutral ones (Schaefer & Philippot, 2005), and rich emotional content has been found to trigger rich subjective experience during autobiographical retrieval (Talarico, LaBar, & Rubin, 2004).

Studies on the involvement of emotion in autobiographical memory have mainly evaluated how emotion influences subjective experience (e.g., vividness) during retrieval of emotional memories (Schaefer & Philippot, 2005). Besides this evaluation, research on cardiovascular and electrophysiological activity during retrieval of emotional autobiographical memories found that significant physiological changes occur (Schaefer & Philippot, 2005). Our paper aimed to further assess the oculomotor behavioral changes that are associated with retrieval of emotional autobiographical memories by testing whether such retrieval may trigger specific eye movement.

In our view, decoding eye movement during retrieval of emotional autobiographical memories may provide a new, ecological and reliable tool to describe the physiological activities that occur simultaneously. This approach might also provide insights into emotional processing in autobiographical memory. A previous study assessed whether autobiographical retrieval is associated with visual exploration or not (El Haj et al., 2014). To this end, participants were asked to retrieve in detail an event in their lives, and in a control condition, they were asked to count aloud. In both conditions, the participants had to look at a blank screen while their gaze location was recorded by an eye-tracker. We found a lower number of fixations but a larger number, duration and amplitude of saccades in the autobiographical condition than in the control one. These findings were attributed to visual imagery as triggered by autobiographical recall (El Haj et al., 2014).

Attributing visual exploration, as assessed by eye movement, to visual imagery fits with the consideration that autobiographical memories come to mind in the form of visual images and that the latter are the main format of autobiographical reliving (Conway, 2009). According to Conway and Pleydell-Pearce (2000), the creation of visual

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mental images facilitates autobiographical recall by increasing the ease and speed of search through the hierarchical structure of autobiographical memory. The contribution of mental imagery to autobiographical memory is also supported by a study showing better autobiographical recall in healthy individuals with high visual imagery than in those with low visual imagery (Vannucci, Pelagatti, Chiorri, & Mazzoni, 2016). Also, Brandt and Stark (1997) assessed visual exploration during imagery. This by comparing the viewing pattern of a diagram of an irregularly checkered grid with the eye movements while subjects imagined that particular grid. The authors found that, for an imagined grid, eye movements were closely correlated with those recorded while viewing the same grid. The authors concluded that eye movements during imagery are not random but reflect the content of the visualized scene. Brandt and Stark (1997) interpreted their findings with the scanpath theory of Noton and Stark (1971), according to which when people are reexposed to a given stimulus, the first visual exploration tends to follow the same scanpath established during the initial viewing of the stimulus, which facilitates stimulus recognition.

Other insights into the contribution of visual imagery to autobiographical memory come from neuroimaging studies showing an association between autobiographical retrieval and increased activation in posterior cortical regions, brain areas that play a major role in the ability to generate visual images (for reviews, see Cabeza & St Jacques, 2007; Svoboda, McKinnon, & Levine, 2006). Taken together, there is substantial behavioral and neurological evidence to suggest the contribution of visual imagery to autobiographical memory.

To summarize, autobiographical recall has been found to trigger visual activity (El Haj et al., 2014). Bearing in mind these consideration, the present paper assessed whether any visual activity is also observed with emotional memories. Participants were asked to retrieve neutral, positive and negative memories. Visual activity (e.g., fixations and saccades) was recorded by an eye-tracker. To further assess whether emotional memories trigger more visual imagery than neutral ones, participants were asked to rate the vividness of each memory. We expected that more visual activity (e.g., more saccades) and more visual imagery would be triggered by emotional memories than by neutral memories. We also expected that more visual activity (e.g., more saccades) would be triggered by positive memories than by negative memories, this in light of research suggesting that the affective intensity of autobiographical memories fade more rapidly for negative than for positive event, providing people with a heightened sense of reliving when remembering positive events (Walker, Skowronski, & Thompson, 2003)

2. Method

2.1. Participants

Seventeen graduate/undergraduate students at the University of Lille participated in the study. They were native French speakers. Exclusion criteria were a history of psychiatric, neurological or learning disorders. Informed consent was also obtained in accordance with the principles laid down by the Helsinki Declaration. Their demographic and cognitive characteristics are summarized in Table 1. In the working memory assessment, they had to repeat a string of numbers in the same order (i.e., forward spans) or in reverse order (i.e., backward spans). Episodic memory was assessed using the test of Grober and Buschke (1987) in which participants had to retain 16 words, each describing an item belonging to a different semantic category; after a 20-s distraction phase, they had to recall as many words as they could, the maximum score being 16 points. On the original sample (n = 37), the eye movement data of 11 participants were corrupted and nine other participants were excluded owing to signal loss during recording. The mean signal loss of eye movement in the final sample was 9.96% (Table 2).

Table 1
Demographic and mnemonic characteristics of participants.

Females/males	10/7
Age in years	23.71 (6.78)
Years of education	14.65 (5.28)
Working memory	
Forward span	7.53 (1.42)
Backward span	5.29 (1.13)
Episodic memory	13.65 (3.53)

Note. Standard deviations are given between brackets; performances on the forward and backward spans refer to number of correctly repeated digits; the maximum score on the episodic memory task was 16 points.

Table 2
Eye movement variations, duration of recording, autobiographical specificity and visual imagery rating for all participants on neutral, positive and negative retrieval.

		Neutral	Positive	Negative
Eye movement	Fixation count per min	67.06 (31.98)**	104.12 (38.24)^{ns}	96.00 (30.67)
	Fixation duration in msec	962.84 (481.33)*	570.78 (373.70)^{ns}	579.99 (320.36)
	Saccade count per min	62.82 (24.84)**	105.88 (41.62)^{ns}	96.71 (33.19)
	Duration of saccades in msec	39.17 (16.37)^{ns}	39.06 (16.38)^{ns}	39.66 (14.60)
	Amplitude of saccades in degrees	743.00 (660.53)^{ns}	978.12 (696.97)^{ns}	907.16 (524.88)
Duration of recording in msec		80,572.53 (27,174.35)^{ns}	77,613.12 (32,990.35)^{ns}	73,786.12 (25,533.62)
Autobiographical specificity		3.67 (0.44)^{ns}	3.82 (0.39)^{ns}	3.47 (0.87)
Visual imagery		2.53 (1.00)*	3.41 (0.79)^{ns}	3.35 (0.93)

Note. Standard deviations are given between brackets; maximum duration of recording was 120,000 msec; maximum score on autobiographical specificity and visual imagery was four points; the difference with the following group was significant at: $^{*}p < 0.05$, $^{**}p < 0.01$; ^{ns} the difference with the following group was not significant.

2.2. Apparatus

Eye movements were recorded by a remote pupil-tracking system (RED-m, Senso-Motoric Instruments, Berlin, Germany) based on a pupil eye-tracking system that uses infrared illumination. The system (iViewX) records the position of the eye at a sampling rate of 120 Hz and compensates for slight head movements. Images of the eye are analyzed in real time by detecting the pupil, calculating the center and eliminating artefacts. The manufacturers report a gaze position accuracy of $< 0.1^{\circ}$ for this system. The stimuli were displayed with Experiment Center software (Senso-Motoric Instruments) and the eye movement data were analyzed with the BeGaze software (Senso-Motoric Instruments).

2.3. Procedures

Participants were tested individually in a quiet office at the University of Lille. They were asked to verbally generate three autobiographical events, each of which was cued by one of the following: “happy”, “sad”, and “city”, as the latter cue may be considered a neutral cue (Maki, Janssen, Uemiya, & Naka, 2013). Cues were randomly counterbalanced across participants. Prior to each autobiographical recall, participants were instructed to retrieve in detail an event related to the cue. They were also told that the event had to be personally experienced in the past, and that the description had to be precise and specific (e.g., where and when the event occurred,