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More emotional facial expressions during episodic than during semantic autobiographical retrieval

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Abstract There is a substantial body of research on the relationship between emotion and autobiographical memory. Using facial analysis software, our study addressed this relationship by investigating basic emotional facial expressions that may be detected during autobiographical recall. Participants were asked to retrieve 3 autobiographical memories, each of which was triggered by one of the following cue words: *happy*, *sad*, and *city*. The autobiographical recall was analyzed by a software for facial analysis that detects and classifies basic emotional expressions. Analyses showed that emotional cues triggered the corresponding basic facial expressions (i.e., happy facial expression for memories cued by *happy*). Furthermore, we dissociated episodic and semantic retrieval, observing more emotional facial expressions during episodic than during semantic retrieval, regardless of the emotional valence of cues. Our study provides insight into facial expressions that are associated with emotional autobiographical memory. It also highlights an ecological tool to reveal physiological changes that are associated with emotion and memory.

Keywords Autobiographical memory · Emotion · Facial analyses · FaceReader

Autobiographical memory enables the reconstruction of personal experiences or events that are related to the self (Conway & Pleydell-Pearce, 2000). In this way, it allows individuals to define themselves and make sense and meaning of their life story. Autobiographical memory is composed of two main components, a semantic one and an episodic one (Conway, 2005; Conway & Pleydell-Pearce, 2000). The semantic component refers to generic representations and general events that do not describe a particular situation or a particular time and place. Generic representations cover lifetime periods and general events; lifetime periods refer to knowledge about long periods in life (e.g., "When I was young"), whereas general events refer to thematic events that occur repeatedly (e.g., "I used to hike every weekend"). In contrast, the episodic component refers to memories of specific personal experiences that occurred at a particular time and place (e.g., "That day on that mountain when I lost my compass"). Besides its semantic and episodic facets, a core component of autobiographical memory is emotion.

Emotion has been widely defined as a critical element of memory, and emotional information has been found to enhance episodic recall in younger adults (Cahill & McGaugh, 1998). This memory enhancement has been attributed to increased encoding and consolidation in the hippocampus via the amygdala (for a review, see LaBar & Cabeza, 2006), and to enhanced rehearsal and attention (for a review, see Christianson & Engelberg, 1999). As regards to autobiographical memory, there is a wealth of empirical literature supporting the involvement of emotion in this memory system. Studies analyzing autobiographical memories, as recorded in participants' diaries, have shown that emotional events are typically easier to retrieve than neutral ones (Brewer, 1988; Wagenaar, 1986). The emotional involvement in autobiographical memory has also been highlighted by studies on flashbulb memories, which are memories of circumstances in which one first learned of a very surprising and emotionally arousing public event (Brown & Kulik, 1977). In this area of

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research, Brown and Kulik found that, even a decade after the assassination of John F. Kennedy, most participants remembered the circumstances in which they had learned about this event, such as where they were and what they were doing. The emotional involvement in flashbulb memories has been the subject of extensive replication, showing that an intense emotional state is typically associated with a better recall of these autobiographical memories (Bohannon, 1988; Christianson, 1989; Pillemer, 1984; for an emotional account of flashbulb memories, see Finkenauer et al., 1998).

The emotional involvement in autobiographical memory can also be illustrated by a study by Conway (1989), who found that emotional cues were much more likely than neutral ones to cue autobiographical memories. These findings were mirrored by a study showing that emotional information serves as an effective cue for autobiographical recall in younger and older adults (Schulkind & Woldorf, 2005). Studies have also observed more sensorial and contextual details during emotional autobiographical recall than during neutral recall (Comblain, D'Argembeau, & Van der Linden, 2005; St. Jacques & Levine, 2007). Another study found that emotional autobiographical memories were experienced with more vividness than neutral ones (Schaefer & Philippot, 2005). In a similar vein, emotional cue words were found to trigger memories that were more emotional, were accompanied with stronger recollective experiences, and received more rehearsal than neutral cue words (Maki, Janssen, Uemiya, & Naka, 2013). Reflecting these outcomes, autobiographical recall was found to involve rich emotional content, which defines the subjective experience of remembering (Talarico, LaBar, & Rubin, 2004). Moreover, the emotional intensity of autobiographical retrieval was found to be related to vividness, sense of reliving, and rehearsal (Demiray & Janssen, 2015). Taken together, there is a wealth of empirical evidence to suggest that emotion is one of the core dimensions of autobiographical memory construction.

As alluded to above, studies on the involvement of emotion in autobiographical memory have mainly evaluated how emotion influences specificity (e.g., Bohannon, 1988; Brown & Kulik, 1977; Christianson, 1989; Comblain et al., 2005; Pillemer, 1984; St. Jacques & Levine, 2007), vividness (e.g., Schaefer & Philippot, 2005), and the subjective experience of autobiographical recall (e.g., Demiray & Janssen, 2015; Maki et al., 2013; Talarico et al., 2004). Besides this psychological evaluation, research has assessed cardiovascular and electrophysiological activity during retrieval of emotional autobiographical memories in younger adults, reporting significant physiological changes (Schaefer & Philippot, 2005). A substantial body of research has also found significant changes in neural activity during retrieval of emotional autobiographical memories (for a review, see Holland & Kensinger, 2010). More precisely, autobiographical recall triggers a state of subjective experience (i.e., autonoetic consciousness) that allows retrieval of emotions and feelings that were experienced during the original event (Comblain et al., 2005), and this affective experience may trigger emotional facial expressions during memory retrieval. To investigate this issue, our work assessed facial expressions that may occur during autobiographical retrieval. Our paper addressed this issue using the software FaceReader. In our view, decoding facial expressions during autobiographical retrieval may provide an insight into the emotional expression of subjective experience during memory retrieval.

Several types of software have been developed to provide emotion expression codes in a manner that is cheaper, quicker, and equally reliable, when compared with human raters (Terzis, Moridis, & Economides, 2012). A number of these software can specifically analyze facial emotional expressions (e.g., Computer Expression Recognition Toolbox). FaceReader can be particularly highlighted because it analyzes 500 key points in the face (Den Uyl & Van Kuilenburg, 2005; Noldus Information Technologies, 2008). Facial analysis in FaceReader occurs through three consecutive steps. First, it uses an algorithm to locate the face in images and videos. Second, it synthesizes the face by describing the location of 500 key points and the facial texture of the area delineated by these points. Third, it classifies facial expressions with an artificial neural network (Bishop, 1995). This network is trained to classify the six basic emotions described by Ekman et al. (1987): happy, sad, angry, surprised, scared, disgusted, and neutral. Although the organization and classification of emotions is still intensely debated (Barrett & Wager, 2006; Ekman, 1992; Izard, 1992; Starkey, 2008), here we will consider emotion categorical and focus on the six "basic" emotions as described by Ekman (1992), which are argued to be universally recognized across cultures (Ekman et al., 1987). These categories are also characterized by facial action units, each of which represents a distinct movement of the face that can occur in isolation from other parts of the face (Ekman & Friesen, 1978; Ekman, Rosenburg, & Hager, 1998). Because our work aims to assess basic facial expressions during retrieval of emotional and neutral autobiographical memories, FaceReader may help to describe these expressions.

To summarize, emotion has been widely defined as a critical element of autobiographical memory (e.g., Comblain et al., 2005; Rubin, 1998; Schaefer & Philippot, 2005; St. Jacques & Levine, 2007). More specifically, empirical research has associated the retrieval of emotional autobiographical memories with significant changes in cardiovascular, electrophysiological (Schaefer & Philippot, 2005), and neuroanatomical activity (for a review, see Holland & Kensinger, 2010). To provide further assessment of the physiological changes that may be observed during retrieval of emotional autobiographical memories, our paper analyzes basic facial expressions when participants retrieve three memories. Each

of these is triggered by one of the following cues: happy, sad, and city, as the latter may be considered a neutral cue (Maki et al., 2013). We expected a high level of happy facial expressions during retrieval of memories associated with the cue "happy," a high level of sad facial expressions during retrieval of memories associated with the cue "sad," and a high level of neutral facial expressions during retrieval of memories associated with the cue "city."

We also expected more emotional facial expressions during retrieval of specific (i.e., episodic) rather than during retrieval of semantic autobiographical memories.

Method

Participants

Thirty-two graduate/undergraduate students at the University of Lille took part in the study (18 females; *M* age = 25.91 years, *SD* = 7.49; *M* education = 14.22 years, *SD* = 4.63). The participants were native French speakers, and exclusion criteria were a history of psychiatric, neurological, or learning disorders. All participants were recruited on a voluntary basis and were debriefed following the study. Informed consent was also obtained in accordance with the principles laid down by the Helsinki Declaration. The demographic and mnemonic characteristics of participants are summarized in Table 1. Mnemonic performance was assessed using a French adaptation (Van der Linden et al., 2004) of the task of Grober and Buschke (1987; i.e., episodic memory) and a span task (i.e., working memory). In Grober and Buschke's task, participants had to retain 16 words, each describing an item belonging to a different semantic category. After a 20-s distraction phase, participants had to recall as many words as they could, and the maximum score was 16 points. In the span assessment, participants had to repeat a string of numbers in the same order (i.e., forward spans) or in reverse order (i.e., backward spans). These tasks were assessed as in previous autobiographical research investigating general memory performance (e.g., El Haj et al., 2014).

Procedures

Participants were tested individually in a quiet office in the University of Lille. They were asked to generate three autobiographical events, each of which was cued by one of the following: *happy*, *sad*, and *city*. Cues were provided verbally and 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 instructed 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, what they were doing during this event, who was present). Participants were allocated 2 minutes to describe each autobiographical memory, and the duration was made clear so that participants could structure their memories accordingly (for studies adopting the same 2-minute duration, see El Haj, Antoine, & Kapogiannis, 2015; El Haj, Clément, Fasotti, & Allain, 2013; El Haj, Fasotti, & Allain, 2012; El Haj, Postal, Le Gall, & Allain, 2011; xEl Haj, Postal, & Allain, 2012). Following the autobiographical retrieval, participants were asked to rate the emotional valence of their memories on a 5-point scale (−2 = *very negative*, −1 = *negative*, 0 = *neutral*, +1 = positive, +2 = *very positive*).

Table 1 Demographic and mnemonic characteristics of participants

Episodic memory	13.63 (2.91)
Working memory forward span	7.37 (1.45)
Backward span	5.83 (1.29)

Note. Standard deviations are given between brackets; performance on the episodic task referred to the number of correctly recalled words, and the maximum score was 16; performances on the forward and backward spans referred to the number of correctly repeated digits

Facial expression analysis

The experiment was recorded with an HD camera, after obtaining the participants' informed consent. The camera was placed in front of the participants and the recording was later analyzed by the FaceReader software. For each recording, the software analyzed the video feed to synthesize the face by describing facial expression information (i.e., cheek muscles, lips, eyebrow muscles). Once the analyses were finished, the software provided a pie-chart representation of the percentage of an average expression, across all frames, of the following emotions: happy, sad, angry, surprised, scared, disgusted, and neutral. It also provided percentages of unknown states, referring to situations where the face could not be modeled (e.g., when the participant looked away from the camera).

Episodic/semantic autobiographical distinction

Besides the analyses of facial expression, episodic and semantic autobiographical memories were distinguished. Memories describing personal events situated in time and space, with a duration of less than 1 day, and accompanied by phenomenological details (i.e., perceptions, feelings, thoughts) were considered episodic autobiographical memories. Memories describing (1) events situated in time and space without any phenomenological details, (2) repeated or extended events (e.g., "My summer vacations in town X"), or (3) only general information about an autobiographical theme (e.g., "My vacations") were considered semantic autobiographical memories.

Hence, with this distinction, episodic reconstruction was defined according to two factors: specificity and presence of phenomenological details, a definition that is widely used in evaluations of autobiographical recall (e.g., El Haj et al., 2011; El Haj et al., 2013; El Haj, Fasotti, et al., 2012; El Haj, Postal, et al., 2012; Kopelman, 1994; Piolino et al., 2003). The episodic/semantic distinctions were evaluated by two examiners and inter-rater agreement coefficients of 0.87 and higher were obtained (as assessed by the intraclass correlation coefficient, two-way, random effects model; Shrout & Fleiss, 1979).

Results

First, the subjective evaluation of emotion was compared, as rated by the participants on the 5-point scale. Then, the percentage of happy, sad, and neutral facial expressions was compared as depicted by FaceReader. In light of our second hypothesis, the percentage of emotional facial expressions for episodic and semantic autobiographical memories was also compared.

Valence rating

To compare the subjective evaluation of emotion, as rated on the 5-point scale, the Wilcoxon signed rank-sum test was used due to the scale nature of the data. Analysis showed that memories cued by the word *happy* were significantly rated as more positive ($M = 1.44$, $SD = .76$) than those cued by the word *city* ($M = .09$, $SD = 1.27$; $Z = -3.98$, $p < .001$) or by the word *sad* ($M = -1.41$, $SD = .91$; $Z = -4.97$, $p < .001$). The latter memories were significantly rated as more negative than those cued by the word *city* ($Z = -4.26$, $p < .001$). No significant differences were observed between the subjective rating of memories cued by the word *city* and the zero value of the 5-point scale ($M = .00$, $SD = .00$; $Z = -.44$, $p > .1$); in other words, these memories were significantly rated as neutral.

Facial expressions

Percentages of facial expressions associated with memories cued by the words *happy*, *city*, and *sad* are depicted in Fig. 1. The Wilcoxon signed rank-sum test was used due to the abnormal distribution of the data, as observed with the Kolmogorov–Smirnov tests. Analysis showed a higher percentage of happy facial expressions in memories cued by the word *happy* than in those cued by the word *city* ($Z = -2.94$, $p < .01$) or by the word *sad* ($Z = -4.02$, $p < .001$). A higher percentage of happy facial expressions was observed in memories cued by the word *city* than by the word *sad* ($Z = -2.27$, $p = .015$). For neutral facial expressions, a higher percentage of these was observed in memories cued by the word *city* than by the word *happy* ($Z = -4.08$, $p < .001$) or by the word *sad* ($Z = -3.70$, $p < .001$). No significant differences were observed between percentages of neutral expressions in memories cued by the word *happy* and in those cued by the word *sad* ($Z = -1.55$, $p > .1$). For sad facial expressions, a higher percentage of these was observed in memories cued by the word *sad* than by the word *city* ($Z = -4.14$, $p < .001$) or by the word *happy* ($Z = -4.26$, $p < .001$). No significant differences were observed between percentages of sad expressions in memories cued by the word *city* and in those cued by the word *happy* ($Z = -1.33$, $p > .1$).

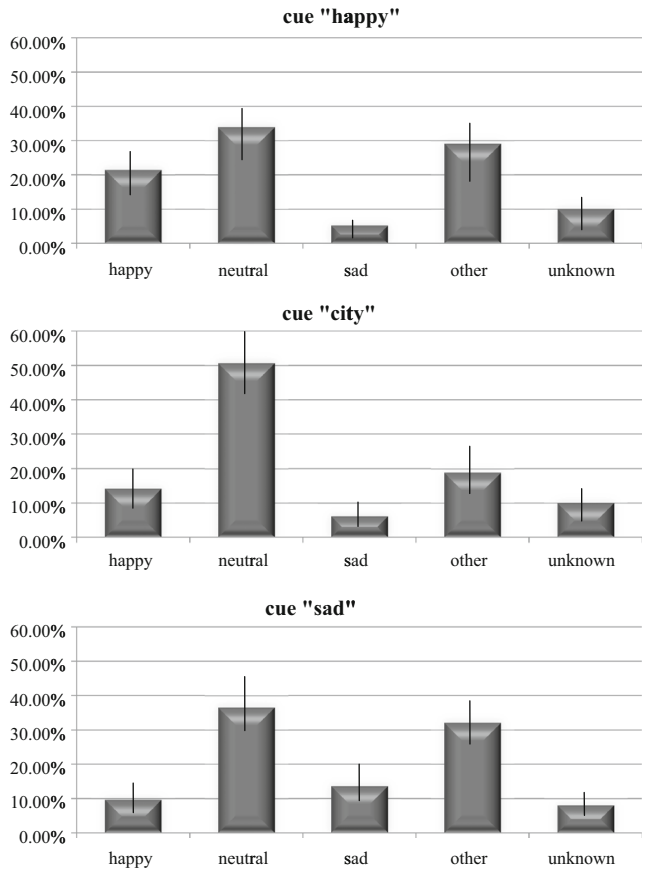

Fig. 1 Facial expressions that were observed during retrieval of autobiographical memories, as cued by the words *happy*, *city*, and *sad*. The state other refers to the sum of angry, surprised, scared, and disgusted expressions. The state unknown refers to situations where the face could not be modeled. Error bars are 95 % within-subjects confidence intervals

Facial expressions were also compared within each emotional autobiographical category. For memories cued by the word *happy*, happy facial expressions were more prevalent than sad facial expressions ($Z = -4.80$, $p < .001$), however, neutral facial expressions were more prevalent than happy ($Z = -4.02$, $p < .001$) or sad facial expressions ($Z = -4.93$, $p < .001$). For memories cued by the word *city*, neutral facial expressions were more prevalent than happy ($Z = -4.64$, $p < .001$) or sad facial expressions ($Z = -4.94$, $p < .001$), and happy facial expressions were more prevalent than sad facial

expressions ($Z = -3.26$, $p < .001$). For memories cued by the word *sad*, sad facial expressions were more prevalent than happy facial expressions ($Z = -2.45$, $p = .011$), however, neutral facial expressions were more prevalent than happy ($Z = -4.94$, $p < .001$) or sad facial expressions ($Z = -4.71$, $p < .001$).

For convenience, we provide the actual percentage of the remaining emotional states (i.e., angry, surprised, scared, and disgusted) as combined into "other states" in Fig. 1. As for the cue "happy," the percentages were 2.7 % angry, 19.4 % surprised, 2.8 % scared, and 4.2 % disgusted. As for the cue "city, " the percentages were 1.9 % angry, 14.2 % surprised, 1.2 % scared, and 1.6 % disgusted. As for the cue "sad," the percentages were 4.6 % angry, 19.2 % surprised, 3.5 % scared, and 4.8 % disgusted.

Episodic and semantic memories

Here, the episodic/semantic dissociation was assessed for each of the emotional autobiographical categories, as depicted in Table 2. Chi square analysis showed more episodic than semantic retrieval for memories cued by the words *happy*, $\chi^2(1, N = 32) = 12.50$, $p < .001$; *city*, $\chi^2(1, N = 32) = 4.50$, $p = .012$; and *sad*, $\chi^2(1, N = 32) = 6.12$, $p = .01$. No significant differences were observed across the three emotional conditions for the number of episodic memories, $\chi^2(2, N = 71) = 0.03$, $p > .1$ or of semantic memories, $\chi^2(2, N = 25) = 1.04$, $p > .1$.

To assess whether more emotional facial expressions were triggered by episodic than by semantic autobiographical retrieval, we calculated, for each participant, the sum of the emotional expressions (i.e., happy + sad + other expressions, without neutral, for memories cued by each of the three cues). This amount was then compared for all participants with regard to the episodic and semantic autobiographical distinction. The percentage of neutral expressions was also compared with regard to the episodic and semantic autobiographical distinction, to assess whether fewer neutral expressions were triggered by episodic than by semantic retrieval.

The 26 episodic memories cued by "happy" triggered 60.77 % of emotional expressions and 26.50 % of neutral expressions (the remaining 12.73 % referred to unknown states) whereas the six semantic memories triggered 32.00 % of emotional expressions and 54.55 % of neutral expressions (the remaining 12.45 % referred to unknown states). The 22 episodic memories cued by "city" triggered 51.25 % of emotional expressions and 42.91 % of neutral expression whereas the 10 semantic memories triggered 23.90 % of emotional expressions and 66.39 % of neutral expressions. The 23 episodic memories cued by "sad" triggered 61.43 % of emotional expressions and 32.91 % of neutral expressions ,whereas the nine semantic memories triggered 32.78 % of emotional expressions and 58.48 % of neutral expressions.

Table 2 Number of episodic and semantic memories that were cued by the words *happy*, *city*, and *sad*

	Episodic	Semantic	Total memories
Happy	26	6	32
City	22	10	32
Sad	23	9	32

Welch's *t* test was used because the comparison of episodic versus semantic retrieval involved different sample sizes. Welch's *t* test has been widely applied for unequal sample sizes (Kohr & Games, 1974; Welch, 1947). This test showed more emotional facial expressions in episodic than in semantic retrieval as cued by the words *happy*, $F(1, 20.81) = 103.63$, $p < .001$; *city*, $F(1, 22.19) = 30.50$, $p < .001$; and *sad*, $F(1, 14.73) = 35.82$, $p < .001$. Fewer neutral facial expressions were observed in episodic than in semantic retrieval as cued by the words *happy*, $F(1, 7.93) = 34.49$, $p < .001$; *city* $F(1, 21.11) = 28.09$, $p < .001$; and *sad* $F(1, 26.18) = 31.44$, $p < .001$.

Episodic memories cued by "happy" triggered more emotional than neutral expressions ($Z = -5.91$, $p < .001$), and the reverse was observed for semantic memories triggered by the same cue ($Z = -4.09$, $p < .001$). Episodic memories cued by "city" triggered more emotional than neutral expressions ($Z = -3.19$, $p < .01$), and the reverse was observed for semantic memories triggered by the same cue ($Z = -6.22$, $p < .001$). Episodic memories cued by "sad" triggered more emotional than neutral expressions ($Z = -5.89$, $p < .001$) and the reverse was observed for semantic memories triggered by the same cue ($Z = -4.14$, $p < .001$).

Discussion

This paper assessed changes in facial expressions that may be observed during emotional autobiographical retrieval. With this aim, participants were asked to retrieve autobiographical memories following the cues "happy," "city," and "sad." Using facial analysis software, more happy facial expressions were found during retrieval of memories cued by the word *happy* than during retrieval of the other memories. More neutral facial expressions were observed during retrieval of memories cued by the word *city* than during retrieval of the other memories, and more sad facial expressions were observed during retrieval of memories cued by the word *sad* than during retrieval of the other memories. Hence, memories cued by the words *happy*, *city*, and *sad* were associated with happy, neutral, and sad facial expressions, respectively. Besides these findings, our data revealed more emotional facial expressions in episodic than in semantic retrieval, regardless of the cue valence.

Emotion has been widely considered a critical element of autobiographical memory. According to Rubin (1998), any comprehensive theory of autobiographical memory must take into account how emotion is incorporated into this memory system. This theoretical assumption is supported by a wealth of empirical research demonstrating the involvement of emotion in autobiographical recall. Flashbulb memory studies have highlighted the role of emotion in the construction of these highly accessible autobiographical events (Bohannon, 1988; Brown & Kulik, 1977; Christianson, 1989; Pillemer, 1984; for an emotional account of flashbulb memories, see Finkenauer et al., 1998). Studies have also found that autobiographical emotional memories are typically easier to retrieve than neutral ones (Brewer, 1988; Wagenaar, 1986). In a similar vein, emotional information serves as a better cue for autobiographical recall than neutral information (Conway, 1989; Schulkind & Woldorf, 2005), while emotional autobiographical memories trigger significant specificity (Bohannon, 1988; Brown & Kulik, 1977; Christianson, 1989; Comblain et al., 2005; Maki et al., 2013; Pillemer, 1984; St. Jacques & Levine, 2007). In line with these findings, our study demonstrates that autobiographical memory triggers emotional facial expressions, more precisely, our findings show that autobiographical retrieval induces a particular emotion (e.g., happiness) that is expressed in the participant's face.

A fundamental aspect of social interaction is the ability to communicate emotions and intentions through facial expressions. The human face provides a myriad of crucial information for social communication, and humans are remarkably good at decoding faces to understand emotional information (Ekman et al., 1987; Little, Jones, & DeBruine, 2011). Mirroring the interaction between emotion and facial expressions, we found variations in the latter during retrieval of emotional autobiographical memories. More happy facial expressions were observed in memories cued by the word *happy* than in those cued by the words *city* or *sad*, more neutral facial expressions were observed in memories cued by the word *city* than in those cued by the words *happy* or *sad*, and more sad facial expressions were observed in memories cued by the word *sad* than in those cued by the words *happy* or *city*. As already mentioned, humans depend on faces to communicate and understand emotions and mental states. Facial expressions, as observed during autobiographical retrieval, may serve to communicate emotional traits or subjective reliving of the retrieved event. This may also ensure a better reception of the transmitted emotional message. According to the emotional contagion account, listeners tend to automatically encode, mimic, and synchronize facial expressions to converge emotional messages (Hatfield, Cacioppo, & Rapson, 1994). Taken together, facial expressions that are observed during autobiographical recall may serve to communicate the emotional reliving of these memories.

Emotional states that are intertwined with autobiographical recall can also be attributed to emotional regulation goals. People tend to recruit their emotional autobiographical memories to achieve emotional regulation, an assumption that can be illustrated by the work of Tamir, Mitchell, and Gross (2008). In their study, participants were informed that they would be playing either a confrontational or a nonconfrontational video game. Prior to playing the game, participants were asked to rate their preferences for retrieving different emotional autobiographical events from their pasts. Those who expected to play a confrontational video game showed more preferences for retrieving angry events than those who expected to play a nonconfrontational task. In a similar vein, healthy subjects tend to recruit positive autobiographical memories to cope with effortful contexts, such as preparing a speech (Tamir, 2009). Hence, emotional states that are intertwined with autobiographical retrieval can be attributed to regulation goals (for a similar view, see Holland & Kensinger, 2010).

Besides its relationship with regulation goals, emotion has been found to be related to the subjective experience of autobiographical recall. Studies have reported more sensorial details during emotional autobiographical retrieval than during neutral retrieval (Comblain et al., 2005; St. Jacques & Levine, 2007). This episodic enhancement was attributed to the important subjective experience of the emotional retrieval (St. Jacques & Levine, 2007; Talarico et al., 2004). In a similar vein, autobiographical memories cued by emotional words were found to trigger stronger reliving, stronger rehearsal, and greater importance than memories cued by neutral words (Maki et al., 2013). Emotional autobiographical memories were also found to be experienced with more vividness than were neutral memories (Schaefer & Philippot, 2005). However, emotion can have a detrimental effect on the specificity of autobiographical memory, as observed in patients with depression (Williams et al., 2007), posttraumatic stress disorder (Dalgleish, Rolfe, Golden, Dunn, & Barnard, 2008) or addictive behaviors (Gandolphe, Nandrino, Hancart, & Vosgien, 2013; Nandrino, Doba, Lesne, Christophe, & Pezard, 2006). With regard to our data, more episodic than semantic retrieval was observed, regardless of the cue valence, and no significant differences were observed across the three emotional conditions for the number of specific memories. Although one may expect more specific memories for emotional cues than for neutral cues, our findings may be due to the simplicity of our autobiographical task, in which participants had to recall only one event for each cue. Moreover, memories cued by "city" may trigger some emotional reliving, as shown by the presence of some emotional facial expressions, which may explain the specificity of these memories.

Our findings revealed emotional facial expressions in memories cued by the word *city*, and neutral facial expressions in memories cued by the words *happy* and *sad*. In this way,

emotional memories are not only associated with emotional facial expressions, and the same can be said for neutral memories. Relatedly, and regardless of their valence, the three cues triggered more neutral than positive or negative emotions. Thus, neutral emotion seems to be prevalent during autobiographical retrieval (see Fig. 1). Another finding that emerged from this study was that the word *happy* cued some sad facial expressions, and vice versa. Our data also showed more emotional facial expressions during episodic than during semantic retrieval. This finding is of interest because specific memories can be suggested as triggering significant emotional facial activity.

One limitation of our study is the assessment of a single memory per emotional category; future research should address this issue by assessing several memories for each emotional cue. Relatedly, and although sadness tends to be equated with negative emotion, Fontaine and colleagues (Fontaine, Scherer, Roesch, & Ellsworth, 2007) showed that across three languages, sadness is closer to neutral in valence than unpleasant, as was the situation for anger. Another issue that should be considered is that although FaceReader calculates an average of thousands of faces from several face picture data bases (Den Uyl & Van Kuilenberg, 2005), and that average is used as the corresponding facial emotion expression template, this method might miss some sad and happy facial expressions that do not match the data bases. Similarly, although facial expressions are considered as a reliable sign of the experienced emotion, we cannot be totally sure that all participants have experienced the same affective states as reflected by their facial expressions. Indeed, individuals with emotional dysregulation tend to show an inhibition of emotional expressions of their affective states; it would be of interest to assess whether or which dissonant facial expressions can be expressed during autobiographical retrieval in these individuals. Also, we did not control for baseline facial emotion expression; such a measure might be important to investigate whether participants were inclined to produce specific emotional expressions at baseline (e.g., participants who are happy at baseline may more easily retrieve a happy memory). Finally, facial emotion expression scoring was done while the subjects were talking, which might influence their facial expressions.

Despite its limitation, and although research surrounding software coded facial emotion expressions stills in its infancy, this paper has the merit to provide empirical description of facial expressions that are not only triggered by autobiographical recall but also by retrieval of specific autobiographical information. To the best of our knowledge, no published research has addressed this issue, even with facial electromyography (EMG) analysis. Not surprisingly, as technical constraints of the EMG (e.g., electrode attachment) interferes with verbal narration.

To summarize, our study provides new insight into facial expressions that are associated with emotional autobiographical recall. By using facial analysis software, psychological research can benefit from ecological tools to reveal further the emotional reliving that is triggered by memory encoding and retrieval.

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