

Olfaction and emotion: The case of autobiographical memory

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This study investigated (1) the influence of verbal and conceptual processing on the retrieval and phenomenological evaluation of olfactory evoked memories, and (2) whether the experienced qualities of retrieved information are affected by olfactory exposure per se. Seventy-two older adults were randomized into one of three cue conditions (odor only, name only, or odor name) and asked to relate any autobiographical event for the given cue. The results indicated that semantic knowledge of an odor's name significantly affects the age distribution of memories such that the memory peak in childhood observed for odors only was attenuated. Also, experiential factors such as pleasantness and feelings of being brought back in time were lower when odors were presented with their respective names. Olfactory evoked memories were associated with a higher emotional arousal that could not be accounted for by the perceptual stimulation alone. Taken together, the overall pattern of findings suggests that retrieval of olfactory evoked information is sensitive to semantic and conceptual processing, and that odor-evoked representations are more emotional than memories triggered by verbal information.

Research suggests that memories triggered by olfactory information are different than memories evoked by verbal and visual information (e.g., Herz & Schooler, 2002; Willander & Larsson, 2006). For example, it is well established that verbal cuing of memories generates a reminiscence bump between the age of 10–30 years at event (e.g., Conway & Haque, 1999; Rubin, 1982; Rubin & Schulkind, 1997; Rubin, Rahhal, & Poon, 1998). However, in contrast with a memory peak in young adulthood, olfactory cued memories have been localized to the first decade of life indicating that odor representations are older than verbal and visual ones (Chu & Downes, 2000; Willander & Larsson, 2006).

Likewise, evidence suggests that the phenomenological experience of olfactory memory differs from the processing of other sensory information. For example, the feeling of being brought back in time to the occurrence of the event is experienced as stronger for odor-cued memories than memories evoked by words and pictures (Herz, 2004; Herz & Schooler, 2002; Willander & Larsson, 2006). Also, some research suggests that odor evoked memories may be experienced as more emotional than memories cued by other sensory modalities (e.g., Herz, 1998; Herz & Cupchik, 1995; Herz, Eliassen, Beland, & Souza, 2004; Herz & Schooler, 2002), although other work has failed to replicate these observations (Ehrlichman & Bastone, 1992; Willander & Larsson, 2006). A possible explanation for these discrepant findings may be methodological differences across studies such that the experiential qualities have been assessed in conjunction with the olfactory stimulation or after the stimulus presentation (Herz & Schooler, 2002; Willander & Larsson, 2006).

Thus, previous results reporting an advantage of odors as cues to emotional autobiographical memories may be a result of participants evaluating the olfactory cue rather than the retrieved memory. The underlying assumption for the advantage of odors as cues to emotional memories is the direct synapsing from the olfactory areas to the amygdala–hippocampal complex, the neuronal substrate of emotional memory (Herz et al., 2004; Packard, Cahill, & McGaugh, 1994; Savic, Gulyàs, Larsson, & Roland, 2000). Because passive smelling of odors may influence the emotional arousal in individuals (e.g., Lehrner, Marwinski, Lehr, Jöhren, & Deecke, 2005; Savic et al., 2000), without memory recollection, it is of interest to investigate the role played by olfactory perception in the recollection and phenomenological evaluation of retrieved memories (cf. Chu & Downes, 2002; Herz & Schooler, 2002).

An unexplored question concerns whether verbal and conceptual processing has an impact on the age distribution of olfactory-evoked memories. A review of related evidence suggests that olfactory perception is influenced by verbal knowledge of an odor. For example, Distel and Hudson (2001) showed that intensity, pleasantness, and familiarity ratings were higher when odor judgments were done in conjunction with a verbal label as compared with a no-label condition. Also, Herz and von Clef (2001) reported higher positive judgments in pleasantness, intensity, and familiarity when an identical odor was presented with a positive label (i.e., Parmesan cheese) as compared with a negative label (i.e., vomit). In a similar vein, research also indicates that semantic olfactory knowledge, such as perceived familiarity and identifiability are positively related to episodic retention

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of olfactory information, suggesting that odor recognition may be a joint product of perceptual, semantic and episodic information (Larsson, 1997; Larsson & Bäckman, 1997).

Given that autobiographical odor memory draws on episodic memory, it is of interest to explore whether verbal processes also influence the recollection of autobiographical olfactory information. In the present work, this topic was examined by cuing subjects with odors in conjunction with their respective names, as contrasted with two control conditions where subjects only received names or odors. In this way, we could evaluate the potential effects of cue format on age distributions and phenomenological experience of autobiographical memories.

An additional aim was to investigate vantage point selection in autobiographical odor memory. Recent research has highlighted two different modes of remembering referred to as field and observer vantage points (Georgia & Neisser, 1996; McIsaac & Eich, 2002). The former refers to a recollection in which subjects envision the event as if seeing it again with their own eyes. In the latter, persons take the perspective of a detached spectator (Georgia & Neisser, 1996). Field memories have shown to comprise more affective reactions and physiological states, whereas observer memories include more information about physical appearance and object locations (McIsaac & Eich, 2002). Given that vantage point selection is totally unexplored in autobiographical odor memory we wanted to highlight this experiential factor and its relation to olfactory cues.

Thus, the main aims of this study were to investigate whether (1) verbal and conceptual processing influence the age distribution and phenomenological qualities of olfactory evoked memories; and to elucidate whether (2) the experiential qualities of retrieved information are influenced by olfactory perception.

METHOD

Participants

Seventy-two healthy volunteers (22 men and 50 women) between 65–80 years ($M = 71.69$, $SD = 4.40$) participated. An older age cohort was chosen because of the possibility to investigate whole lifespan memory distributions. The participants were recruited through senior citizen organizations in the Stockholm and Uppsala areas. All participants reported being in good health as indicated by their self-rated health ($M = 3.69$, $SD = .88$) (5-point scale where 1 = *very poor* and 5 = *very good*). Also, participants rated their visual, auditory, and olfactory aptitude on a 5-point scale where 1 = *very poor* and 5 = *very good*. The specific questions posed were: How good or bad is your vision/olfaction/hearing as compared with other persons of your own age? All subjects had sufficient visual ($M = 3.11$, $SD = 1.0$), auditory ($M = 3.21$, $SD = .90$), and olfactory ($M = 3.14$, $SD = 1.1$) capacities in order to manage the sensory demands of the experiment.

Materials

Twenty stimuli were used as test materials and assigned to one of two test sets. Each set consisted of 10 items. Based on previous data (Willander & Larsson, 2006) the two sets of items were constructed so that they would potentially elicit an equal amount of memories. The two test sets comprised the following items: (1) tar, glühwein (mulled wine), clove, whisky, snuff, black currant, chlorine, tobacco, bitter almond, violet; and (2) salubrin (antiseptic), soft soap, cinnamon, liniment, red wine, soap, lily of the valley, anise, cardamom, beer.

All odorants were kept in nontranslucent glass jars and covered with cotton pads to prevent visual inspection. The odors were reg-

ularly replaced to ensure freshness. Words (i.e., the names of the odors) were printed in Arial (size 100 points, lowercase) and presented on a 12-in. LCD computer screen.

Experiential Ratings

The retrieved memories were rated on the following six dimensions: (1) How pleasant is the event at this moment? (2) How intense is the event at this moment? (3) How strong is the feeling of being brought back in time to the occurrence of the event? (4) How vivid is the memory of the event? (5) How emotional do you experience the remembered event at this moment? (6) From what point of view did you recall the event? For Question 1, a 9-point Likert scale (1 = *very unpleasant*, 5 = *neutral*, 9 = *very pleasant*) was used. For Questions 2 to 5, a 9-point Likert scale (1 = *not at all*, 9 = *very much*) was used. Question 6 was assessed with the following three alternatives: (1) field perspective, (2) observer perspective, (3) neither field or observer perspective. The third option was included because some participants were unable to choose a perspective (i.e., field or observer).

Procedure

All subjects were tested individually and were randomly assigned to one of the three cue conditions: name only ($n = 24$; 16 women, 8 men), odor only ($n = 24$; 17 women, 7 men), or odor name ($n = 24$; 17 women, 7 men). Participants in the odor-only condition were presented with 20 odors and asked to relate any autobiographical event for the given cue. In instances when a memory was retrieved, the participant was asked to write down a short description of the event, and to rate its experiential attributes (see above). The same instructions and rating procedure were applied in the name-only condition, with one exception; here subjects were exposed to only names. Participants in the odor-name condition were presented with both an odor and its congruent name. Here, the participants were asked to retrieve autobiographical events for each pair of items. The participants were instructed to direct an equal amount of attention to both of the cues. The respective odor name was presented on the computer screen in conjunction with the presentation of the odor. The rating procedure in the odor-name condition was the same as in the name-only and odor-only conditions, with the exception that the subjects were exposed to both the odor and its congruent name. Across conditions, thirty seconds were allowed for retrieval. When all cues had been presented the memories were dated according to the participants' age at event.

Importantly, each participant received 20 stimuli and the evoked memories were rated immediately after retrieval. For half of the cues ($n = 10$), the ratings were done in presence of the respective retrieval cue, and for the other half ($n = 10$) the ratings were done without cues. The two rating formats were counterbalanced across participants in order to prevent potential effects of presentation order. In addition, each participant was given a unique randomized item presentation order. The rating procedure was followed by distribution of the questionnaire concerning health status and sensory aptitude.

RESULTS

The Number of Memories

The number of evoked memories across the three cue conditions (i.e., odor only, name only, odor name) was analyzed with a two-way ANOVA with cue condition and gender as between-groups factors. The results from the ANOVA showed that the number of elicited memories varied over cue type [$F(2,66) = 3.10$, $p < .05$]. Specifically, Tukey post hoc comparisons showed that the name-only ($M = 9.46$, $SD = 4.05$) and odor-name ($M = 10.79$, $SD = 4.20$) conditions triggered equal number of memories, but more than the odor-only condition ($M = 7.58$, $SD = 4.26$). The effect of gender was not significant ($F < 1$).

The Distribution of Memories Over the Life Span

For each participant, the number of evoked memories dated to a specific decade was divided by the subject's total number of memories. The proportions were then submitted to a mixed two-way ANOVA with cue type as between-groups factor, and decade as within-group factor. The analysis yielded a main effect of decade [$F(7,63) = 12.18, p < .001$]. Post hoc testing showed that a higher proportion of memories were located to the first two decades as compared to the third to eight decades. Also, more memories were overall localized to the first than to the second decade. Interestingly, the interaction between cue type and decade was significant [$F(14,126) = 1.76, p < .05$]. The source of this interaction was related to the first decade where more memories were generated in the odor-only condition as compared to the name-only condition. The amount of memories generated in the odor-name and odor-only conditions, and odor-name and name-only conditions did not differ reliably ($ps > .05$). No other comparisons were reliable. The age distributions across the three cue conditions meaningful gender analyses could not be performed.

Experiential Ratings

The experiential data for the evoked memories across the two conditions (rating with the cue/rating without the cue) were submitted to a 3 (cue type) \times 2 (rating condition) mixed ANOVA. The first factor varied between subjects and the second within subjects.

The ANOVA on rated pleasantness (valence) revealed a main effect of cue type [$F(2,69) = 5.18, p < .01$]. Tukey post hoc analysis indicated that odor-only evoked memories ($M = 6.43, SD = 1.74$) were rated as more pleasant than the name-only evoked memories ($M = 5.49, SD = 1.38$). The memories evoked by odor names ($M = 5.97, SD = 1.11$) did not differ from odor-only or name-only evoked memories on rated pleasantness. The main effect of rating condition was not significant ($p < .70$). No interaction effect between cue type and rating condition was observed ($p < .30$).

A main effect of cue type was demonstrated for emotionality [$F(2,69) = 3.59, p < .05$]. Tukey post hoc comparisons indicated that memories evoked in the odor-only condition were more emotional ($M = 5.22, SD = 2.00$) as compared to the name-only ($M = 4.01, SD = 1.54$) and odor-name ($M = 4.23, SD = 1.80$) conditions. The name-only and odor-name conditions did not differ reliably. No main effect of rating condition was observed ($p < .20$). The interaction between cue type and rating condition was not significant ($ps < .90$).

Cue type had a reliable effect on the feeling of being brought back in time to the occurrence of the event [$F(2,69) = 4.30, p < .05$]. The odor-only evoked memories ($M = 6.66, SD = 1.39$) were experienced with a stronger feeling of being brought back in time as compared with memories evoked by name-only ($M = 5.68, SD = 1.28$) or odor-name cues ($M = 5.91, SD = 1.61$). Ratings in the name-only and odor-name conditions did not dif-

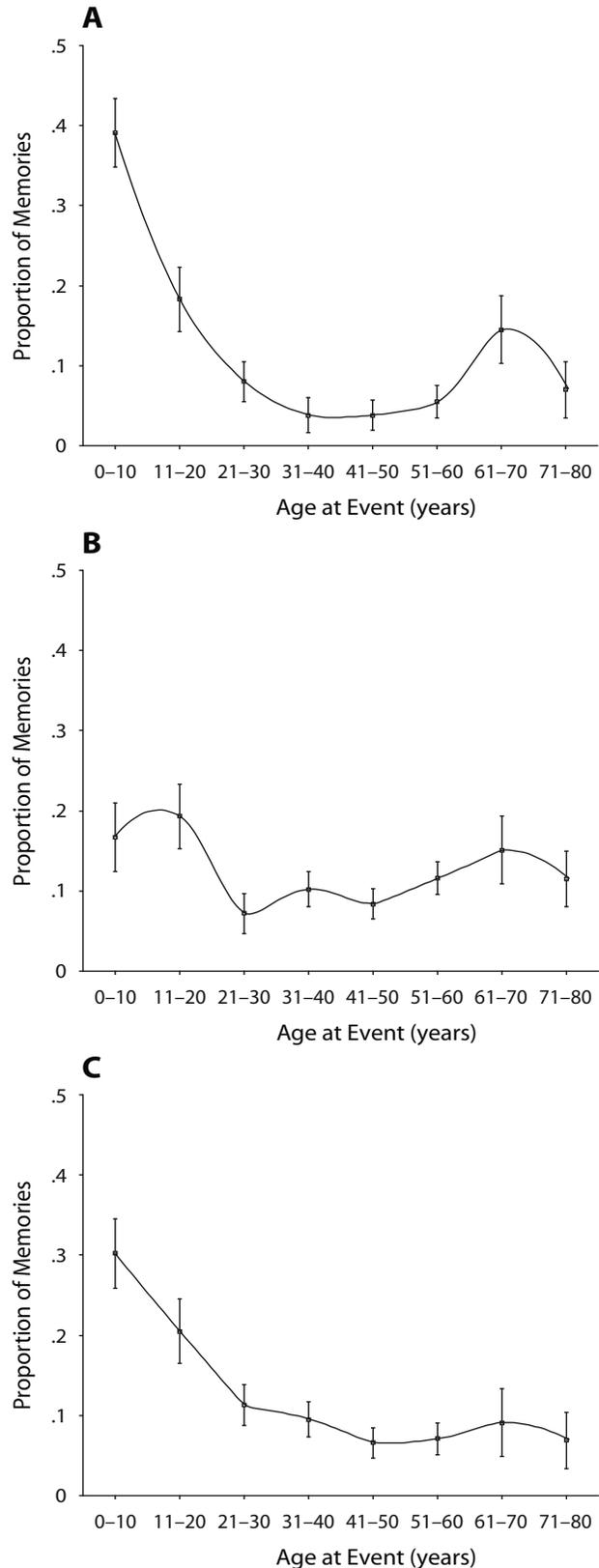


Figure 1. The distribution of (A) odor-only-, (B) name-only-, and (C) odor-name-evoked autobiographical memories across the life span. Error bars indicate ± 1 standard error.

Table 1
Mean Proportions (With Standard Deviations) of Vantage Points As a Function of Cue Type

Vantage Point	Cue Type					
	Odor Only		Name Only		Odor Name	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Field	.73	.26	.78	.24	.69	.29
Observer	.20	.23	.17	.22	.24	.25
Neither	.07	.19	.05	.07	.07	.22

fer reliably ($p < .90$). Rating condition did not reach the level of significance and the interaction effect between cue type and rating condition did not influence the feelings of being brought back in time ($ps < .20$).

Regarding vividness no main effect of cue type or interaction effect between cue type and rating condition were statistically reliable ($ps < .30$). However, a main effect of rating condition was found for vividness [$F(1,69) = 4.76$, $p < .05$] such that rating with the cue ($M = 6.65$, $SD = 1.51$) produced higher vividness ratings as compared to ratings without the cue ($M = 6.33$, $SD = 1.61$).

Finally, for the intensity ratings no reliable main effects of cue type or rating condition ($ps < .30$) were observed. Also, the interaction was not reliable ($p < .10$).

The vantage point proportions were submitted to a two-way mixed ANOVA with cue type (i.e., odor only, name only, and odor name) as between-group factor and vantage point (i.e., field, observer, or neither) as within-group factor. The mean proportions of the vantage point ratings are displayed in Table 1. The ANOVA showed a main effect of vantage point [$F(2,68) = 114.77$, $p < .001$]. Post hoc testing indicated that more memories were experienced with a field perspective rather than an observer perspective, that in turn were more common than events categorized as neither. The interaction effect was not significant ($p < .80$).

DISCUSSION

In agreement with previous findings, the present work suggests that odor-evoked memories are different from other memory experiences. Events evoked by olfactory information were older than memories associated with verbal information (Willander & Larsson, 2006). Also, odor-evoked memories were experienced as more emotional and pleasant, and associated with stronger feelings of being brought back in time as compared to events evoked by verbal cues (Chu & Downes, 2000; Herz & Cupchik, 1995; Herz & Schooler, 2002). Of more interest however, were the observations that the age distribution, the phenomenological qualities, and the number of evoked memories were affected by explicit knowledge of the provided odor cue. This outcome suggests that conceptual processes may have a significant influence on the retrieval of autobiographical olfactory information.

Specifically, when odors were presented together with its congruent name, the age distribution of memories for the first three decades was significantly affected such that the memory peak in childhood observed for odors only was attenuated. In fact, knowledge of an odor's name resulted in a distribution taking an intermediate position; not statis-

tically different from the age distributions obtained for neither the name-only or odor-only cue conditions. A similar pattern was observed for the phenomenological qualities, such that perceived pleasantness, emotionality, and feelings of being brought back in time were lower when odors were presented with their respective names as compared to when only an odor was presented. Indeed, when participants were aware of the odor's identity, the experiential ratings did not differ from the ones obtained for names. These observations suggest that olfactory knowledge produces a shift from a perceptual to a more conceptually driven retrieval process (cf. Herz, 2000, 2003). Given that the present findings suggest that different types of sensory cues recruit different types of retrieval processes, it is of interest to consider postulated retrieval models of autobiographical memory information. Notably, Conway and Pleydell-Pearce (2000) distinguished between two different retrieval processes of autobiographical memory: strategic and automatic. In strategic retrieval, cues entail an intentional cyclic and elaborative search process of information in memory until a specific memory is formed, a process that has been associated with verbal cues (Haque & Conway, 2001). In automatic retrieval, recollection is direct and effortless and immediately activates a representation of an event in memory. To the extent that odors presented with labels primarily were experienced as verbal items, the present observations suggest that participants in the odor-name condition engaged in a more strategic retrieval process, whereas, a presentation based on odors alone may have induced a more direct and automatic activation of sensory-specific autobiographical information (Conway & Pleydell-Pearce, 2000). Moreover, the analysis on the number of memories triggered over the three different cue types showed that more memories were generated when a verbal cue was present (i.e., the name-only and odor-name conditions) and fewer memories were accessed when only an odor served as a retrieval cue. This outcome suggests that

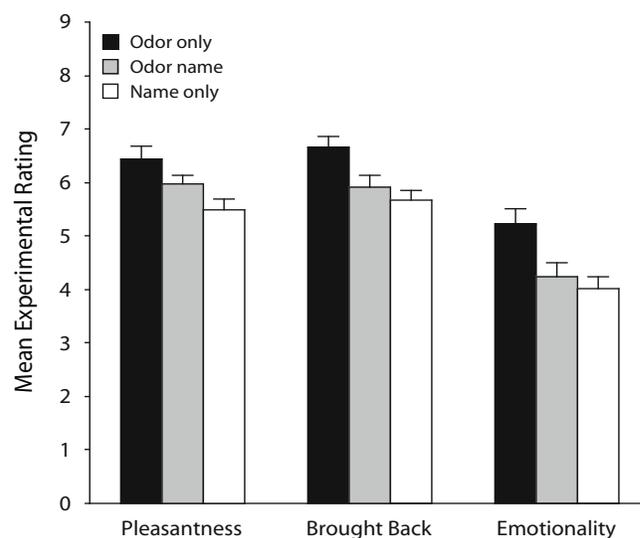


Figure 2. Experiential ratings across cue type. Error bars indicate ± 1 standard error.

verbal cues overall are more efficient reminders of past experiences. Taken together, the overall pattern of findings suggests that retrieval of olfactory evoked information is sensitive to semantic and conceptual processing.

The results of this study support the notion that olfactory evoked memories are more emotional than memories evoked by verbal cues (Chu & Downes, 2002; Herz, 2004; Herz & Cupchik, 1995). As noted above, evidence is equivocal regarding whether it is the memory by itself that is more emotional or whether it is the perceptual properties of the olfactory cue that produce the higher emotional arousal. In the present work, reexposure of the target cue during rating did not significantly alter the phenomenological evaluations of the retrieved events. This observation suggests that olfactory evoked memories themselves are associated with a higher emotional response and that the perceptual stimulation alone cannot account for the higher emotional arousal.

As noted above, recent work has highlighted two different modes of remembering denoted field and observer vantage points. In congruence with other research addressing vantage point selection in autobiographical memory, our findings indicated that retrieved events, irrespective of cue type, were experienced from a field rather than from an observer perspective (D'Argembeau, Comblain, & Van der Linden, 2003). Also, taking a field rather than an observer perspective has been associated with more affective and emotional reactions. Given that vantage point selection did not vary across the different cue types, the present results may reflect a general emotional tone in recollected events.

Taken together, the results of this study indicate that retrieval of olfactory evoked information is sensitive to semantic and conceptual processing. Specifically, the age distribution, the phenomenological qualities, and the number of evoked memories were significantly affected by explicit knowledge of a provided odor cue. Also, the outcome of this study supports the notion that olfactory evoked memory representations are more emotional than memories triggered by verbal information.

AUTHOR NOTE

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