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A naturalistic study of autobiographical memories evoked by olfactory and visual cues: Testing the Proustian hypothesis

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The emotional and evocative qualities of autobiographical memories evoked by odors and visual cues were compared using a new repeated-measures paradigm in which the sensory cue was presented after the memory had been retrieved by its verbal label. Memory cues were chosen to be able to elicit salient memories. Results revealed that memories recalled in the context of odors were significantly more emotional than those recalled in the context of the same cue presented visually and by the verbal label for the cue. Odor-evoked memories also tended to make participants feel more “brought back” to the original event. This work is the first unequivocal demonstration that naturalistic memories evoked by odors are more emotional than memories evoked by other cues.

In *Swann's Way* (Proust, 1928), the smell of a madeleine biscuit dipped in linden tea triggers intense joy and memory of the author's childhood. This experience, often called the Proust phenomenon, is the basis for the hypothesis that odor-evoked memories are more emotional than memories evoked by other stimuli. Currently, there is descriptive and laboratory-based support for this proposition.

Descriptive autobiographical memory studies have shown that odor-evoked memories are highly emotional, as measured by both self-report and heightened heart rate responses (Laird, 1935; Herz & Cupchik, 1992; Herz, 1998a). Several cross-modal laboratory experiments have further demonstrated that memories associated with odors are more emotional than memories associated with cues perceived through other modalities (vision, tactile, verbal) (Herz & Cupchik, 1995; Herz, 1996; Herz, 1998b). In these studies, a series of very familiar source objects (cues) were presented to participants in either olfactory, verbal, visual, or tactile form (e.g., smelling orange, hearing the word *orange*, seeing an orange, or feeling an orange) while participants viewed emotionally evocative paintings at the encoding session. Participants were told that

the experiment concerned the effects of different environmental cues on the appreciation of artwork. No mention of memory was ever made. Two days later, however, when participants returned to the lab, they were given a surprise cued recall test for their painting experiences, and the accuracy and emotionality of their memories were assessed by several dependent measures. In each experiment, it was found that memories evoked by the various cue types did not differ in accuracy (the same number of paintings were correctly recalled to each), but memories recalled by odors were significantly more emotional than memories recalled by any other cue.

These data present strong behavioral evidence that memories associated with odors are distinguished from other types of memories by their emotional potency. Neuroanatomical evidence is consistent with these findings. The olfactory area is unique among the senses in synapsing directly with the amygdala–hippocampus complex, the neural substrate of emotional memory (Aggleton & Mishkin, 1986; Cahill, Babinsky, Markowitsch, & McGaugh, 1995). Nevertheless, the only naturalistic cross-modal memory experiment to date, in which autobiographical memories cued to odors were compared with memories cued to the same object perceived through other modalities, yielded equivocal results (Rubin, Groth, & Goldsmith, 1984).

In two experiments, Rubin et al. (1984) gave participants 15 familiar stimuli (coffee, Johnson & Johnson baby powder, cinnamon, cigarettes, rubbing alcohol, mint, mothball, Ivory soap, banana, onion, peanut butter, chocolate, Band-Aids, bourbon, popcorn) in olfactory, verbal, or picture form. For each item, the participant described the memory that was evoked and rated it on several scales: age of memory, vividness, emotionality at time of event, emotionality at time of recall, how many times it had been thought of, and when it was last recalled (before the experiment). From these measures, the only effects that were statistically reliable were that memories evoked by odors were thought of and talked about less often than memories evoked by words and pictures. There was a trend for odor-evoked memories to be more emotional, but this effect was not statistically consistent.

Rubin's study had several features that may have attenuated the emotionality of the odor-evoked memory effect. For one, an array of odors that were quite familiar and connected to routine events (e.g., coffee) was used. It has been shown that odors are superior reminders if they are novel or distinctive (Herz, 1997). This is because more attention is paid to odors that are environmentally salient and because specific odor–event associations break down if an odor is repeatedly encountered in various different contexts (Herz & Engen, 1996). Additionally, childhood is a time when a high proportion of odors become con-

ected to emotional events and are able to trigger Proustian recall because so many experiences are new and meaningful during this stage of life. However, the odors Rubin et al. selected (except for Johnson & Johnson baby powder and potentially Ivory soap) were not likely to have been first experienced during childhood. This is substantiated by the fact that Rubin et al. failed to find that odor-evoked memories were particularly old. Most importantly, Rubin's study confounded issues of memory selection with memory recollection. Specifically, in Rubin's paradigm the cue was provided before selection of the memory, providing two distinct ways in which olfaction could exert its influence. One possibility is that the memory cue influenced what particular autobiographical memory participants chose to recall. Alternatively, or in addition, the cue may have influenced the manner in which participants recalled the experience. Because the particular memories participants selected in the olfactory and visually cued conditions were not necessarily comparable, it is difficult to evaluate the recollections associated with the two types of cues, and we must wonder whether differences (or the lack thereof) between conditions may have resulted from the specific memories individuals selected.

A more powerful test of the effect of odors on the recollection of memories requires the development of a technique that can match the memories selected before the introduction of the olfactory cue. The present study introduced a new two-stage protocol to unconfound the effects of odor on the selection and recollection of memories. In this paradigm, participants were given a verbal odor name (e.g., "Coppertone suntan lotion") and were then asked to think of a memory from their past and to rate it on a variety of dimensions. They were then given either a visual (a photograph of a Coppertone bottle) or an olfactory (the odor of Coppertone) cue and were again asked to think about the memory. Selecting the memories in response to verbal names before the introduction of the sensory cues thus allows matching of the memories selected in the two cue conditions. Any difference in the quality of the memories that are subsequently observed between the visual and olfactory condition therefore can be attributed to the effects of the cues on memory recollection rather than memory selection.

In sum, prior research provides tantalizing evidence for the claim that odors are unique in their capacity to elicit emotionally evocative memories. However, most of the research on which these conclusions have been based involves contrived laboratory pairings (e.g., Herz & Cupchik, 1995; Herz, 1996; Herz, 1998a) and not long-term autobiographical experiences. Moreover, the study that did use an autobiographical memory procedure did not demonstrate conclusive results with respect to the emotional quality of odor-evoked memories (Rubin et al., 1984).

The purpose of the present experiment was to compare autobiographical memories evoked by items presented as odors with the same items presented visually, using a stimulus set that would be evocative of salient (e.g., childhood) events. Additionally, the present study introduced a new repeated-measures paradigm in which the olfactory or visual cue is introduced after the memory is initially retrieved. This repeated-measures paradigm may both provide a more sensitive measure of the affective contribution of olfactory versus other sensory cues to autobiographical memories and enable us to investigate and compare how olfactory and visual cues influence the experiential quality and the selection of memories.

It was hypothesized that memories evoked by odors would be more emotional and evocative than memories evoked by the same item presented visually. It was not expected that the emotionality of the original event would differ between the two cue types because all the childhood-based memories were expected to be personally meaningful. In previous studies, odor-evoked memories have not been found to differ in concreteness (e.g., vividness, specificity) from memories evoked by other cues, so we expected similar results here (Herz 1998a, 1998b; Rubin et al., 1984).

EXPERIMENT

METHOD

Participant recruitment

Participants were adult visitors to the Exploratorium Science Museum in San Francisco, California. During the period from the fall of 1998 to January 1999, the museum hosted an exhibit on memory of which smell memory was one facet. Visitors were approached while they were in the vicinity of the exhibit and asked to take part in a short study (approximately 15 min). If the visitor agreed, informed consent was obtained. Participants were recruited during the first 2 weeks of January 1999 and were not paid for their participation.

Participant characteristics

Participants were 25 women and 20 men. The age range of participants was 18–65 years; the mean age was 33.8 years. All participants had a self-reported normal sense of smell. Thirty-eight participants had never smoked, six reported that they smoked occasionally, and one participant was a regular smoker. The majority of participants were from California, and English was their first language. All participants had at least a high school education.

Memory cues

Five items that were expected to be associated with salient childhood events were used as memory cues: Crayola crayons, Coppertone suntan lotion, Play-

doh, Vicks Vapor Rub, and Johnson & Johnson baby powder. Item selection was based on discussions with pretest volunteers. When the item was presented as an odor, the participant flipped open the lid of an opaque plastic bottle that contained the odorant and held it under his or her nose while squeezing the bottle and inhaling. When the item was presented visually, participants were shown a 4 × 5-inch color photo of the item. In each case, sensory information was limited to the specific modality under investigation.

Procedure

The experiment was conducted in two phases, carried out in sequence. Each participant was tested individually. In Phase 1, memories were initially retrieved with the verbal label for an item, and in Phase 2 they were re-recalled to the sensory (odor, visual) form of the item. At the start of Phase 1, it was determined whether the participant was familiar with the item that had been selected for him or her. If the participant was not, another item was picked from the set until the participant confirmed familiarity. The participant was then asked to think of a personal memory with which the item was associated. Thus, all participants were given the instruction to select a memory based on the word for the item, not based on the sensory item itself. After being given the verbal instruction, participants described their memory and then rated it on six scales: age at memory encoding, memory vividness, specificity of memory, emotionality at time of event, emotionality during recollection, and the feeling of being brought back during recollection.

After participants had completed their responses for their selected memory event, Phase 2 commenced. Participants were presented with the same item in sensory form, either visual or olfactory, and asked to think about the event they had described and to rate it again on four of the same scales, omitting how old they were when the event occurred and how emotional it was to them when it occurred. Thus, memory vividness, specificity, emotionality, and the feeling of being brought back were repeated measures. In Phase 2, 22 participants received the item as an odor, and 23 participants received the item visually. Ten participants received crayons, 10 received Coppertone, 9 received Play-Doh, 8 received Vicks Vapor Rub, and 8 received Johnson & Johnson baby powder as the test item. The unequal number of item type cases resulted from ordering that was calculated before running the experiment because it had been hoped that more participants would be tested during the time period allotted.

Except for the age question, participants used a nine-point Likert scale to respond to all questions. Questions were as follows: "How vivid is your memory for the event that you described?" (1 = *extremely vague*, 9 = *extremely vivid*); "How specific is your memory of the event that you described?" (1 = *I recall a very specific incident*, 9 = *I recall a very vague association*); "How emotional was the event that you described?" (1 = *not at all emotional*, 9 = *extremely emotional*); "As you think about the event that you described, to what degree do you have the feeling of 'being brought back' to the time that it occurred?" (1 = *I am not at all "brought back"*, 9 = *I am very much "brought back"*); "How emotional do you feel now as you recall the event that you described?" (1 = *not at all emotional*, 9 = *extremely emotional*).

In addition to addressing our hypotheses, the present method has advantages

over a basic cross-modal approach because it unconfounds verbal labeling with sensory modality. Odors typically are more difficult to identify verbally than other sensory items (Lawless & Engen, 1977). However, by using present methods we can be certain that as with the visual stimuli, the odors presented in Phase 2 will be correctly identified and that the interpretation (and hence memorial associations) made to the odors will be comparable to the associations generated to both the verbal labels and visual cues.

RESULTS

To test for differences between olfactory and visual presentations of the items and to compare these responses with those given for the verbal labels of each cue, mixed-design **anovas** with recollection cue (odor, visual) as the between factor and memory ratings to the selection cue (verbal) and the recollection cue (sensory) as the repeated-measures factor were performed on each dependent measure. The means by condition for the four scalar measures are displayed in Table 1. As can be seen, when the recollection cue was an odor, memories were more emotional, $M = 4.61$, than when the recollection cue was visual, $M = 2.68$, $F(1, 43) = 5.22$, $p < .05$. The interaction between recollection cue and selection cue was also significant, $F(1, 43) = 4.65$, $p < .05$. Newman-Keuls post hoc comparisons, $p < .05$, revealed that the recollective experience evoked by odors was more emotional than that evoked by the verbal label for the item but that for visual cues there was no difference in emotionality between verbal labels and visual cues. This finding supports the hypothesis that odors increase the emotional quality of recollective experience, whereas visual cues do not differ from their verbal counterparts.

Emotionality ratings given for the original event did not vary as a function of whether the recollection cue was subsequently an odor, $M =$

Table 1. Mean scores \pm SEM by memory selection cue and memory recollection cue for each dependent measure

Scale	Selection cue	Recollection cue	Selection cue	Recollection cue
	Verbal	Visual	Verbal	Odor
Vividness	6.09 \pm 0.58	5.14 \pm 0.53	6.13 \pm 0.48	6.13 \pm 0.47
Specificity	4.00 \pm 0.63	4.73 \pm 0.62	4.52 \pm 0.55	4.83 \pm 0.52
“Being brought back”	5.14 \pm 0.63	4.40 \pm 0.58	5.96 \pm 0.48	5.61 \pm 0.49
Memory emotionality	3.14 \pm 0.47	2.68 \pm 0.34	3.87 \pm 0.53	4.61 \pm 0.45

3.91, or a visual item, $M = 3.00$, $t(43) = 1.37$, $p = .17$. This is because participants gave ratings for event emotionality only the first time they recalled the memory with the verbal selection cue, so differences between cue conditions were not expected.

A main effect for cue type was not statistically reliable for the measure “feelings of being brought back.” Therefore, planned comparisons were conducted on the ratings given to odors compared with visual items at the second rating (with the recollection cue) and showed that participants were significantly more brought back by odor cues, $M = 5.61$, than by visual cues, $M = 4.40$, $p < .03$. There were no significant effects or interactions found for ratings of memory vividness or specificity.

We suggested that one of the ways in which our method could facilitate the recall of emotional autobiographical memories was by the use of a stimulus set that was specifically selected to elicit salient childhood memories. The overall mean age participants reported as the time at which the original event occurred was 15.8 years. There were no differences between the mean age of memories re-recalled by odor and visual items. However, none were expected, given that all memories initially were cued by a verbal label. Although 15.8 years of age is past childhood, it is still in adolescence and was half a lifetime ago (mean participant age was 33.8 years). It is also right around the age at which there is a peak in storage of autobiographical memories (Conway & Rubin, 1993). Notably, Chu and Downes (2000) recently compared older adults’ recall of odor and verbally evoked autobiographical memories and found that odor-evoked memories tended to be from childhood (ages 6–10) whereas verbal-evoked memories peaked between ages 11 and 25. This finding is consistent with our data using a verbal cue as the initial trigger for a memory. Accordingly, we would expect that had we assessed the odor version of the cue alone, memories would have been from an earlier time in life.

We also examined how the specific memory cues may have influenced recall by conducting a one-way **anova** collapsed across recollection cue. There were no significant effects found for any of the dependent measures with any specific cue. Thus, the particular cues used did not appear to exert differential influences on memory.

DISCUSSION

The present study demonstrates that olfactory cues can significantly increase the emotional intensity of autobiographical recollections relative to verbal or visual cues. This finding supports the hypothesis that odor-evoked memories are more emotional than memories elicited by the same items presented visually or verbally, whereas visual cues do not

differ from their linguistic counterparts. These data substantiate prior laboratory research comparing memories evoked by odors with those evoked by other sensory stimuli (Herz & Cupchik, 1995; Herz, 1996, 1998a, 1998b, 2000) and provide naturalistic evidence that olfaction is unique in its ability to cue the emotional aspects of autobiographical memory.

Importantly, the present study introduced a new memory cueing paradigm that enabled us to clarify the effects of olfaction on the selection and the recollection of autobiographical memories. The fact that the memories were selected before the introduction of the visual and olfactory cues allows us to conclude that the olfactory cues specifically affected the emotional quality of the recollection and not the initial selection of the memory. The locus of this effect with olfaction is consistent with past work suggesting that it is specifically during recall that odors exert an emotional influence (Herz & Cupchik, 1995; Herz, 1996, 1998a, 2000). These findings also have important implications for understanding the mechanisms involved in encoding and retrieval and the ways in which emotion and olfaction tie into this equation. Recent positron emission tomography research has revealed that encoding and retrieval are subserved by different neural areas, with encoding a function primarily of the left dorsal prefrontal cortex (PFC) and retrieval a function of the right PFC (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994). Notably, emotional processing of odors appears to be dominant in the right hemisphere (Herz, McCall, & Cahill, 1999). These neurological features together with the behavioral data suggest that the functional and local organization of odor-evoked retrieval may predispose uniquely emotional recall.

There are two general ways in which emotion may have increased the emotional quality of participants' recollections. One possibility is that the olfactory cue may have actually enabled participants to access emotional aspects of the memory that were not otherwise available. Alternatively, the olfactory cues may have produced a generalized emotional response, which in turn may have been attributed to the recollection. In other words, odors may have enabled participants to retrieve their original emotions, or they may simply have caused individuals to feel more emotional and in turn assume that their emotion resulted from the recollection. Because in the present study we cannot know how participants felt when their original experiences took place, it is not possible to distinguish between these two accounts.

In addition to demonstrating the distinctive emotionality of odor-evoked autobiographical memories, the present study documented another longstanding anecdotal observation about the impact of olfac-

tion on memory for the past: its ability to bring memories back to life. In recounting his efforts to deliberately recall his childhood experiences in Combray, Marcel Proust noted that the recollections “preserve nothing of the past itself . . . to me in reality it was all dead” (1928, p. 33). However, after tasting a bit of cake dipped in tea and again ruminating on his memories of Combray, Proust suddenly felt the memory spring to life: “And the whole of Combray and its surrounding, taking their proper shapes and growing solid, springing into being, town and gardens alike, from my cup of tea” (p. 66). Consistent with Proust’s famous introspection about the effects of the gustatory and olfactory experience on memory, the present study found that participants who revisited their memories in the presence of an odor were significantly more likely to feel “brought back” than those who were given a visual cue.

Although the present data supported Proust’s observation that olfaction can make memories seem to come back to life, the data did not support his view that odors are also unique in bringing back specific vivid details. Indeed, no significant effects or interactions were found for ratings of memory vividness or specificity. The fact that olfactory cues uniquely affected participants’ recollections with respect to emotionality and feeling “brought back” but not with respect to memory vividness or specificity also helps rule out an alternative interpretation of the present findings. Specifically, it is possible that some participants were explicitly aware of the Proustian hypothesis that smell is a uniquely powerful memory cue. If so, it would be expected that the effects of the odor cue would be particularly substantial with respect to memory vividness and specificity because a flooding of memory detail was one of the central elements of Proust’s original claim. However, the fact that olfaction had an influence on emotionality and feeling “brought back” but not on memory vividness and specificity argues against the notion that our findings were driven by participants’ lay theories because it seems highly unlikely that lay theories would include such subtle distinctions.

Although the dissociation between emotionality and vividness may be outside the realm of lay knowledge about the impact of olfaction on memory, it is consistent with prior experimental examinations comparing memories evoked by odors with memories evoked by other sensory cues (Herz & Cupchik, 1995; Herz, 1998a; Rubin et al., 1984). Using laboratory paradigms with short memory intervals, prior research has demonstrated that olfactory cues, though unique in their capacity for eliciting emotion, are not distinctively effective for bringing back the specific details of memories. It thus seems likely that the impression of odor memory vividness is a misconstrual of the unique emotionality of

these memories, which leads them to be interpreted as more vivid than they are. This suggestion leads to the unpalatable but perhaps not improbable suggestion that the experiences and emotions that are “brought back” to life in response to olfactory cues may be illusions resulting from the affect that olfaction induces. Additionally, or alternatively, the emotions that are brought back to life by odors may have more to do with the meaning of the event at the time of recollection than with a reliving of the original experience (Herz & Cupchik, 1995). Thus, although Proust may have been prescient in noting the relationship between olfaction and the phenomenological experience of reliving emotions of the past, his confidence in the precise contents of his odor-cued recollections may have been ill founded. It should be noted that in a recent study Aggleton and Waskett (1999) found that an average of 6 years after initial exposure, smells associated with a Viking museum exhibit were better reminders for details of the Viking exhibit (55% correct questionnaire responses) than smells that were not associated with the Viking exhibit (45% correct). This shows that odors associated with past events are effective recall cues after long delays but does not show that odors bring back more vivid or veridical recollections than other stimuli associated with the same event.

In sum, the present research shows that odors evoke more emotional and evocative autobiographical memories than visual or verbal cues. Moreover, by having participants select their memory before encountering the olfactory cue, we can be confident that the unique qualities associated with odor-cued memories did not result from the way in which the memories were selected. Rather, we can unequivocally conclude that olfaction colors the *manner* in which we recall the past. To exhaustively conclude that odors are matchless in their capacity to elicit emotional memories, we need to compare odors with all other sensory stimuli (auditory, tactile, visual) using the paradigm developed here. Moreover, future research should explore whether odors differ from other sensory cues in the types of autobiographical experiences they tend to elicit.

Notes

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