Olfactory cuing of autobiographical memory

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In Experiment 1, subjects were presented with either the odors or the names of 15 common objects. In Experiment 2, subjects were presented with either the odors, photographs, or names of 16 common objects. All subjects were asked to describe an autobiograpical memory evoked by each cue, to date each memory, and to rate each memory on vividness, pleasantness, and the number of times that the memory had been thought of and talked about prior to the experiment. Compared with memories evoked by photographs or names, memories evoked by odors were reported to be thought of and talked about less often prior to the experiment and were more likely to be reported as never having been thought of or talked about prior to the experiment. No other effects were consistently found, though there was a suggestion that odors might evoke more pleasant and emotional memories than other types of cues. The relation of these results to the folklore concerning olfactory cuing is discussed.

Folk wisdom tells us that odors are powerful cues for evoking old, previously inaccessible memories (e.g., Laird, 1935). Recent experiments on olfactory memory and on autobiographical memory provide the background information and methods necessary for a more rigorous study of the role of olfaction in the retrieval of autobiographical memories.

Woven throughout the literature on olfactory memory is the underlying theme that olfaction is somehow different from the more commonly studied senses of vision and audition. In addition to physiological evidence (Davis, 1975; Herrick, 1933; Jones, Moskowitz, & Butters, 1975; Jones, Moskowitz, Butters, & Glosser, 1975; Patten, 1972; Potter & Butters, 1980), there is substantial behavioral evidence for this theme (Engen, 1982). Differences occur when odors themselves are remembered. For instance, there is surprisingly little loss in the ability to recognize odors over the normal short-term memory range of 3–30 s (Engen, Kuisma, & Eimas, 1973; Jones et al., 1975; Jones, Roberts, & Holman, 1978) or the long-term memory range up to 1 year (Engen & Ross, 1973; Lawless &

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Cain, 1975). Moreover, "the variables of labeling, codability, serial position, and retention interval had little or no effect on performance. Even the variables of familiarity and pleasantness, salient aspects of odor experience, had no effect on recognition" (Lawless & Cain, 1975, p. 331).

Differences also occur when odors are used as cues. Encoding specificity (Tulving & Thomson, 1973) fails to hold for odor prompts (Eich, 1978). Interference effects are unlike those obtained with verbal material. In particular, in a series of paired-associate experiments in which odors were prompts for to-be-remembered verbal items, Lawless and Engen (1977) demonstrated that there is exaggerated proactive inhibition but no observable retroactive inhibition. Thus, quite different results are obtained when verbal learning tasks normally employed with auditory or visual presentation of words or pictures are employed with odors.

The results obtained from using odors as cues are consistent with the Proustian observation that the chemical senses, when they do trigger autobiographical memories, are especially good at evoking previously inaccessible memories from the distant past (Proust, 1928/1970). The strong proactive inhibition and weak retroactive inhibition indicate that odor cues to a memory will be interfered with less than verbal cues associated at the same time to that memory. The lack of encoding specificity makes it more likely that recall will still be cued for a previously associated odor even when the subject is in a new context or frame of mind (Neisser, 1962; Schachtel, 1947). In addition, the decay with age of olfactory sensitivity, which is more rapid with smell than with other senses (Schiffman, Orlandi, & Erickson, 1979), should increase the relative number of early odor-memory associations. Thus, the psychologist's laboratory work does support the novelist's intuitions. In particular, odors should produce older memories and should evoke autobiographical memories that are often inaccessible with our more commonly used verbal cues. Nonetheless, there seems to be a difference between the real-world and laboratory observations. Odors seem to be associated effortlessly and rapidly with real-world settings, events, and people, but are associated only with the greatest of difficulty and the severest limits with laboratory words and pictures (Cain, 1979). An analogy with Garcia's work with taste aversion may be helpful (Garcia, Ervin, & Koelling, 1966): The function of a system often has to be analyzed in the context in which it developed. To find that context is difficult, but the relation among the real-world and laboratory observations just reviewed suggests that autobiographical memory may be one direction in which to search.

Given this view of the literature, we are faced with the question of how autobiographical memory can be probed with olfactory cues: Exactly what is to be measured, and how are the measurements to be interpreted? The necessary method has been recently revived.

A series of studies of autobiographical memory (e.g., Fitzgerald, 1980; Franklin & Holding, 1977; Robinson, 1976; Rubin, 1981, 1982) all follow the same basic procedure adapted from Galton (1879) by Crovitz and Schiffman (1974). In this procedure subjects are provided with a sample of words. For each word, they are asked to record a phrase describing an episode from their lives. After doing this, they are asked to date each episode.

The research on autobiographical memory is encouraging for several reasons. First, people can easily perform the required task. Second, if the data of diary keepers are any indication, events are dated quite accurately (Rubin, 1982). Third, the data from many laboratories and experimental situations follow the same basic pattern with respect to the one dimension along which they can be compared: the dating of memories. The number of memories recalled from any hours of one's life can be described quantitatively as a function of how many hours have passed. Although it is difficult to decide which function best describes the data, several functions, including the power function and the single-trace function of Wickelgren (1974), fit with correlations above .95 (Rubin, 1982). Thus, people seem able to report autobiographical memories and to report them in a way that leads to considerable regularity.

EXPERIMENT 1

METHOD

Subjects

Forty undergraduates, who received credit toward a course requirement, were assigned randomly to either the odor or word condition.

Materials

Stimuli were needed that would be familiar enough to be able to evoke autobiographical memories and that would allow for a comparison between olfactory and verbal cuing. Experiment 1, therefore, required familiar odorants that are easily identified by a single label that could serve as a verbal cue. In addition, it was desired that the set of stimuli would cover a range of substances (i.e., not only foodstuffs), and when presented as verbal cues would evoke a range of sensory images in addition to olfaction. Of course, words and odors cannot be made completely equivalent; however, by making the words the common labels of the odors, it was hoped that most of the differences between the verbal and olfactory cues would be due to differences inherent in the two modes of cuing and not due to differences in the objects being referred to.

Through the use of normative studies (Cain, 1979; Cain & Krause, 1979; Desor & Beauchamp, 1974; Underwood & Richardson, 1956), as well as our own intuitions, a tentative set of 27 stimuli was found. A small amount of each substance was placed in an opaque glass bottle with a tight-fitting cap. The stimuli were kept at room temperature and replaced periodically to ensure freshness.

We asked 24 subjects not to smoke for 1 hr before the stimuli selection procedure. Different random orders of the stimuli were presented to individually tested subjects. After each odor was presented, the subjects recorded their ratings of familiarity on a 7-point scale from *not at all familiar* (1) to *very familiar* (7), and their best guess as to the odor's identify. The time taken to record the responses, the pacing of the experimenter, and requests to pause if odors were becoming difficult to identify helped to minimize the fatigue and cross-adaptation often noted in olfactory experiments (e.g., Titchener, 1901/1924).

The data were scored, allowing for near synonyms. For example, "cinnamon-flavored candy" was considered a synonym for cinnamon, whereas "mint" was not. Of the 27 odorants, 15 were correctly identified by at least half of the subjects. Because all of these 15 stimuli had mean familiarity ratings of above 5 on the 7-point scale, these 15 stimuli were selected for use in Experiment 1. The mean correct identification and familiarity scores for these 15 stimuli are 68% and 5.92, respectively. Individual percentage-correct scores for these stimuli are as follows: coffee, 92; (Johnson & Johnson) baby powder, 83; cinnamon, 83; (burnt) cigarettes, 75; (isopropyl) rubbing alcohol, 75; (spearmint flavoring) mint, 71; mothballs, 71; (Ivory) soap, 71; banana, 66; onion, 62; peanut butter, 62; (Baker's Unsweetened) chocolate, 58; (Johnson & Johnson) Band-Aids, 50; bourbon, 50; popcorn, 50.

Procedure

To compare olfactory and verbal cuing, the same stimuli in either olfactory or printed form were presented under similar conditions. Questions were asked to explore the hypotheses that odors evoke memories that are older and are more vivid, emotional, and novel. In addition, a question was included to make use of Freud's (1899/1950) observation that the subject's seeing him or herself in a remembered scene is an indicator of a reconstructed memory.

Each subject was presented with the 15 stimuli in a different random order. A booklet, containing one page for each of the stimuli, was used to specify the order of the stimuli and to record all responses. Subjects were tested in small groups at stations well spaced in a room specifically designed for olfactory experiments. The experiment was self-paced.

For each stimulus, subjects were asked to record their responses to the following written questions or statements in the order listed: "Please give a description of a specific memory evoked by the stimulus," "How clear or vivid is the memory?" (on a 7-point scale from *no image* to *perfectly clear and as vivid as the actual experience*), "Yes, I saw myself in the memory" versus "No, I did not see myself," "How do you feel emotionally at the time of the memory?" "How do you feel now emotionally as you are recalling the experience?" (both on a 7-point scale from *very unpleasant* to *very pleasant*), "How many times do you think you have thought of this memory? Approximately _____ times before today," "When was the last time you thought about this memory?" and "How many times do you think you have told people about this memory?" After completing all 15 stimuli, the subjects were asked to date each memory as accurately as they could using terms such as 10 s ago, 1 hr ago, or 7 years ago.

RESULTS

Several transformations were made before analyzing the data. The then and now emotionality scales, which ran from *very unpleasant* to *very pleasant,* were also used to provide intensity-of-emotion-independent-of-direction scales by taking the absolute distance of each response from neutral on the 7-point scale, that is, $|\text{response} - 4|$ (Rubin, 1981). Data from the how-many-times-did-you-think-about and how-many-times-did-you-tell scales were transformed by taking the log of one plus each response before any calculations were made in order to make the distribution of responses less skewed. In addition, for each of these two questions, the percentage of memories reported as never having been thought about or told to someone prior to the experiment was computed to provide a novelty scale. The last-time-thought-about question could not be analyzed because of the large percentage of missing data that resulted from subjects either answering in vague terms or not answering at all because the memory had never been thought about before. Finally, the dating of the memories was converted to log hours ago (Rubin, 1981, 1982).

Individual analyses were performed for each measure. Five of the 11 measures, based on three of the seven questions, showed significant differences between the odor and word conditions. Odor-evoked memories were reported as thought of and talked about less than memories evoked by words, 1.98 vs. 4.29 times, $F(1, 38) = 8.07$, $p < .01$, and 0.55 vs. 1.18 times, $F(1, 38) = 6.54$, $p < .05$, respectively. For the percentage of memories reported as never having been thought of or talked about, odor-evoked rather than word-evoked memories were more often novel, 35% vs. 21%, $F(1, 38) = 3.72$, $p = .06$; and 69% vs. 51%, $F(1, 38) = 6.55$, $p < .05$, respectively.

In addition there were significant differences in the two measures based on how pleasant the event was at the time it occurred. Events evoked by odors were judged to be more pleasant at the time of the event, 4.65 vs. 4.26 on a 7-point scale, $F(1, 38) = 4.16$, $p < .05$, and were more different from neutral on a pleasantness scale independent of direction, a mean absolute difference from 4.00 of 1.57 vs. 1.28, $F(1, 38) = 7.44$, $p < .01$. One other measure approached significance. Memories evoked by odors were judged to be more different from neutral on a pleasantness scale at the time of the experiment, 1.24 vs. 0.91, $F(1, 38) = 3.70$, $p = .06$. All other measures (including vividness, whether or not the subjects saw themselves in their memories, the pleasantness of the memory at the time of the experiment, and the average age of the memories) were not significant, all Fs < 1.1.

In summary, the expected differences were found in measures of the number of times events were thought of and talked about and in measures based on emotionality at the time of the event. The expected difference in mean event age, however, was not found. To investigate whether more subtle differences exist in the age of memory data and to see if the Crovitz-Schiffman function found for word cues (e.g., Rubin, 1982) also holds for odor cues, plots of memories per hour as a function of hours ago were formed as follows.

The word condition produced 279 dated memories of a possible 300; the odor condition 266. Histograms of these sets of memories were formed by the same method used by Rubin (1982). The period between 1 hr and 18 years before the experiment was divided into 10 equal segments on a logarithmic scale. Because responses such as "6 years ago" usually indicate a range from 5½ to 6½ years ago, all responses were averaged over ± ½ of their verbal label and assigned to the 10 intervals in proportion to the amount of their range that was in each interval. The total number of responses in each interval was divided by the number of hours in that interval. To compare conditions with different numbers of responses, these values were then divided by the number of valid dated memories in the condition and multiplied by 100, as if there were 100 memories in each condition. This provided the memories per hour for each of the 10 intervals, while the middle of each interval on a logarithmic scale provided the hours-ago value. The two resulting curves for the word and odor conditions are log (memories per hour) = − .64 log (hours ago) − .28 ($r = -.964$) and log (memories per hour) = − .58 log (hours ago) − .53 ($r = -.941$). Thus, in agreement with previous work, the curve relating memories per hour to hours ago is linear on log-log paper. Consistent with the finding of no significant difference in the mean age of memories evoked, the two slopes are quite similar. If it is assumed that people encode an equal number of memories each day of their lives, then the two curves represent the retention functions for autobiographical memories cued by words and odors (Rubin, 1982).

Because considering each question independently (often with multiple measures based on each question) makes Type I errors more likely than the nominal values given, another experiment was designed to repeat the current findings. In addition, it is possible that any result found could be due to the difference between verbal and nonverbal cuing and not to any properties of olfaction per se. For this reason, a condition using another nonverbal cue was needed. Because of these problems, a detailed discussion of the results of Experiment 1 is postponed until the completion of the next experiment.

EXPERIMENT 2

METHOD

Subjects

Participants were 101 undergraduates who received credit toward a course requirement.

Materials

Experiment 2 requires stimuli that, when presented as either words, odors, or pictures, have similar referents. To accomplish this, the materials section of Experiment 1 was repeated with the additional requirement that all stimuli used would have to be represented by pictures that are easy to label. Odorants were identified by 29 undergraduates and pictures by 28 undergraduates. An initial set of 24 stimuli, many overlapping with those of the previous experiment, was used. Odors were prepared as in the first experiment. Slides were taken of the stimuli with either a neutral background (e.g., gray paper) or minimal amount of an appropriate background (e.g., an expanse of skin for a slide of a Band-Aid). The stimuli filled as much area of the slide as was possible; brand names were not shown, though some may have been apparent to people familiar with the objects depicted.

The procedure of Experiment 1 was repeated for the 24 odors used. The 16 stimuli properly labeled by at least half of the subjects were presented in slide form to new subjects in one of four random orders. Slides were presented approximately every 40 s. Because all 16 slides were identified by at least half the subjects, no further stimuli were removed.

As with the materials used in Experiment 1, the mean familiarity scores for the 16 individual stimuli were all above 5 on a 7-point scale. The overall familiarity was 6.23 for odorants and 6.63 for slides. The overall mean percentage correct scores for the odorant and slide condition are 75 and 96, respectively. The individual slides all have percentage identification scores above 89. The individual odorants have percentage identification scores as follows: peanuts, 93; licorice, 90; bourbon, 86; oranges, 86; (Johnson & Johnson) baby powder, 83; bread, 83; coffee, 83; banana, 79; (milk) chocolate, 79; (burnt) cigarettes, 72; onion, 72; popcorn, 69; (Ivory) soap, 66; perfume, 59; Band-Aids, 55; paint, 52.

Procedure

The 16 stimuli were presented in random orders to the subjects, who were tested in groups. The booklets, instructions, and procedures used were those from Experiment 1 modified to accommodate the slide stimuli and to attempt to produce more accurate dating. Instead of responding in terms such as "two months ago," subjects were asked to record the exact calendar date on which any events more distant than 2 days ago had occurred (Robinson, 1976; Rubin, 1982). For events more recent than 2 days ago, the elapsed time was requested as in Experiment 1.

The odor, word, and slide conditions had 29, 36, and 36 subjects, respectively.

RESULTS

Analyses identical to those in Experiment 1 were performed. Four of 11 measures, based on two of the seven questions, showed significant difference among conditions. The mean number of times odor-evoked, word-evoked, and slide-evoked memories were reported as having been thought of and talked about were 1.76, 2.85, and 3.41, $F(2, 98) = 4.26$, $p < .05$, and 0.90, 1.52, and 1.52, $F(2, 98) = 3.04$, $p < .05$, respectively. Planned orthogonal comparisons were used to differentiate the odor from the word and slide conditions, and the word from the slide condition. As the means show, the significant main effects were due mostly to differences in the odor condition. The planned comparisons between the odor and the other two conditions were $t(98) = 2.78$, $p < .01$, and $t(98) = 2.45$, $p < .05$, respectively, compared with $t(98) = .87$, $p = .38$, and $t(98) = .01$, $p = .99$, for the planned comparisons between the word and slide condition.

When the times-thought-of and times-told-about questions are examined in terms of the percentage of memories reported as never having been previously recalled, similar results occur. For the odor, word, and slide conditions, 43%, 24%, and 21% of the memories were reported as novel in the times-previously-thought-of question, $F(2, 98) = 11.70$, $p < .001$, and 56%, 41%, and 41% of the memories were reported as novel in the times-previously-told question, $F(2, 98) = 6.32$, $p < .01$. Again, planned comparisons comparing the odor with the other two conditions are significant, $t(98) = 4.77$, $p < .001$, and $t(98) = 3.56$, $p < .001$, whereas those of the word and slide conditions are not, $t(98) = .80$, $p = .43$, and $t(98) = .06$, $p = .96$.

The measure of pleasantness of the memories at the time of the experiment approached significance, $F(2, 98) = 2.64$, $p = .08$. The means for pleasantness for the odor, word, and slide condition (4.78, 4.52, and 4.50 on a 7-point scale) are consistent with the marginally significant effect found in Experiment 1 for the measure of the pleasantness of the memories at the time the event occurred. However, the measure of the pleasantness of the memories at the time of the experiment, which approached significance here, did not approach significance in Experiment 1, $F(1, 38) = .35$, $p = .56$, and the measure of pleasantness of the memories at the time of the event, which was significant in Experiment 1, was not significant here, $F(2, 98) = .55$, $p = .58$. All other Fs were below 1.3. Thus, Experiment 2 produced the same basic findings as Experiment 1, except that measures based on how pleasant and emotional the events were judged to be when they actually occurred were significant in Experiment 1 but failed to be significant in Experiment 2.

The odor, word, and slide conditions produced a total of 377, 489, and 501 dated memories of a possible 464, 576, and 576, respectively. For the three conditions, plots of the memories per hour as a function of hours ago were produced using the same method as in Experiment 1. The best fitting line for the odor, word, and slide conditions were log (memories per hour) = $-.73$ log (hours ago) + .02 ($r = -.984$), log (memories per hour) = $-.76$ log (hours ago) + .15 ($r = -.993$), and log (memories per hour) = $-.76$ log (hours ago) + .16 ($r = -.986$), respectively. As in Experiment 1, the fit to the power function is quite good, and the slopes are similar across conditions. This regularity suggests that the lack of differences in the mean ages of memories from the various cuing conditions is not due to the data being overly noisy.

GENERAL DISCUSSION

How can differences between the effects of odors and words (or pictures and words, or spoken and written words) on cognitive tasks be studied? One choice would be to obtain stimuli by randomly sampling odors and words from the world. This would be a good way to obtain results representative of the real world. For instance, the results obtained here would have been more representative of olfaction, in general, if the odors used were not required to have had verbal labels, that is, if rarer, more complex odors were not excluded. If this choice were made, however, the results might be due to the differences in the stimuli that are typical of each modality rather than to the differences in the modalities themselves. The alternative approach taken was to obtain stimuli that have the same referent. These stimuli cannot, in general, be a representative sample of both stimulus dimensions, but any differences that do exist can be attributed to differences in the stimulus dimensions and not to differences in the stimuli selected for each dimension. There are two major potential problems with this approach: mediation and equating stimuli.

When stimuli in two modalities are matched by having the same referent, it is possible that any links to memory are not direct, but rather are mediated through each other or through some more abstract representation. Thus, null effects can be seen as being due to such mediational leakage, and differences can be seen as being due to translation costs between modalities. Although a mediational theory offers no simple explanation of the set of results obtained here, such a theory is difficult to rule out, as demonstrated by recent debates concerning whether imagery representations can be mediated or translated into propositional representations. Moreover, choosing stimuli that do not have the same referent does not remove the problem, but rather makes the problem more difficult because the particular mediators used become different for the two modalities.

The second potential problem, that of equating stimuli across modalities, is also a difficult one. An odor and a word with the same nominal referent may differ in many ways because one is an odor and one is a word, but they may also differ because they are not always perfectly matched. Although in the norming studies performed here nearly all subjects agreed that all odors used were familiar and nearly all subjects could label the odors with some word, not all subjects labeled the odor with the correct word. Thus, for some subjects, if verbal labeling is used as an indicator, some odors may have a different referent than the words to which they nominally correspond. In general, little can be done about this problem when less than perfect identification is obtained, as with olfaction (e.g., Desor & Beauchamp, 1974). For particular findings, however, potential confounding can be examined.

In this paper, four measures of novelty in two separate experiments showed that odors evoke more novel memories than words. One possible explanation for this finding, based on the less than perfect correspondence of odors and words, follows. Subjects are at times presented with an odor that would fail to evoke the correct identification if they were asked to identify it. In such cases, if subjects are using a mediational system to find memories, they might search randomly and produce a bizarre or novel memory. If this explanation is correct, then unit analyses of the 15 stimuli of Experiment 1 and the 16 stimuli of Experiment 2 would yield positive correlations between the percentage of subjects correctly identifying a particular stimulus and the number of times that stimulus was thought of and talked about, and negative correlation between the number of subjects correctly identifying a stimulus and the percentage of never-thought-of and never-talked-about memories. The eight correlations of interest from the two experiments are of moderate size with an average absolute magnitude of .36 (range .16 to .53), and although only one of the eight correlations of interest would be significant at the .05 level if the units were considered as independent observations, none of the eight are in the correct direction for the proposed artifactual explanation of the novelty result.

Thus, even if the general issue of mediation poses theoretical problems, it does not pose a particular problem for the studies done here. Although to some the potential limitations may be seen as serious enough to ban all cross-modality research, it makes more sense to obtain data and draw inferences consistent with the data available, thereby eliminating possible confounding factors on an experiment by experiment basis.

For the basic results obtained here, the only consistent, reliable differences found from cuing autobiographical memory with olfactory stimuli were in the how-many-times-have-you-thought-of and how-many-times-have-you-talked-about questions. Olfactory cues produced memories that were reported to be thought of and talked about less often than memories evoked by words or slides. Olfactory cues also produced more memories that were reported to be never thought of or talked about previously. Perhaps these differences might simply occur because olfactory cues are encountered much less frequently than words or visual stimuli, and thus memories tied to olfactory cues would also be less frequent. For the stimuli used here, however, such an explanation appears unlikely, although the results do support the claim that none of the stimuli used here commonly trigger autobiographical memories spontaneously. There was some hint of odors producing more pleasant and more intense emotions, but this finding was not consistent across experiments. No other differences were noted. No differences were revealed even by a detailed examination of the distributions of the age of the events evoked, although these distributions were in good agreement with previous work (Rubin, 1982). The five plots fit the power function with correlations between .941 and .993, and the slopes were consistent with earlier work.

Two expectations arose from the verbal learning and folklore literature concerning olfactory cuing. The first expectation was that previously inaccessible memories would be evoked by olfactory cues. This expectation was borne out, but the second expectation, that memories evoked by odors would be older, was not.

How can the finding that odors did not evoke older memories than words be reconciled with the common belief that odors often evoke old events? One possibility is that the older memory claim is an artifact of the inaccessibility of the memory; the novelty caused by the previous inaccessibility of the memory makes the memory stand out from other memories especially if it is older. Recalling for the first time something that happened last year is more notable than recalling for the first time something that happened last week. Because approximately half of the memories cued in the experiments reported here are over 1 year old, a substantial pool of older memories does exist. Similarly, the verbal learning findings of increased proactive inhibition and decreased encoding specificity led to predictions of older memories being recalled through the mechanism of changes in accessibility.

Another reason for the lack of a difference in the age of odor-evoked and word-evoked memories may be the controls used here. It may be noted that, with the exception of Eich (1978), the laboratory studies cited did not attempt to match the odors with the words with which they were compared. Because the odors, words, and slides used here were chosen to have the same referents, the words were all concrete and easy to image. In addition, many of the stimuli were emotionally laden, either in their hedonistic value as food or through other evoked associations (e.g., Band-Aids, perfume). In a study in which 34 independent variables were used (Rubin, 1980), imagery (mediated in part by meaningfulness) and emotionality were among the best predictors of the age of memories evoked by words. Thus, compared with most words, the words used here could, in general, be expected to evoke older memories. That is, part of the reason odors in, or outside, the laboratory may seem to evoke older memories is that they tend to have concrete, emotional referents, and this effect could be independent of any special olfactory effects.

The data bear out this explanation of a lack of difference in the age of memories. The geometric mean age of memory for the word conditions of the two experiments performed here is 398 days, which is close to the 1-year median reported by Crovitz and Schiffman (1974) for their 20 high-imagery, high-meaningfulness, high-frequency words, but is much larger than the geometric mean of 37 days reported by Rubin (1980, 1981) for his more mixed set of 125 words. A more graphic comparison can be made by examining the stimuli from the Rubin (1980, 1981) study in more detail. The five words that evoked the oldest memories (death, fire, horse, ship, and tree) were either concrete or emotional, whereas the five words with the most recent memories (contents, context, memory, time, and virtue) were abstract. The geometric mean ages of these two sets of memories were 346 and 0.6 days, respectively. Although choosing values that happen to be the most extreme in an experiment may add chance to repeatable factors, the size of the effect of cue words is more than large enough to account for the difference between the age of memory findings presented here and those observed outside the laboratory. Compared with a haphazardly sampled set of words, a haphazardly sampled set of odors probably does evoke older memories (Petrinovich, 1979).

Notes

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