

Olfactory Memory: A Case Study in Cognitive Psychology

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ABSTRACT. Over the last decade, interest in the general applicability of psychological research has increased significantly, leading to doubts among some critics of cognitive psychology regarding the usefulness of the modern information-processing approach. In particular, current cognitive models of memory address mainly visual and verbal information processing, with little acknowledgement of the existence of other sensory modalities. However, since the mid-1970s, the literature on olfactory memory has expanded rapidly, and it has remained relatively independent of mainstream memory research. This article outlines the olfactory literature, which has focused principally on examination of the Proustian characteristics of smell. The relationship between olfactory and other types of memory is also examined. The author notes that there is evidence that models of memory intended to be general have taken insufficient account of findings from olfaction and other sensory modalities, an approach that could be considered symptomatic of a dangerous tendency to base purportedly general theories on databases that are too narrow.

IN THE FIFTEENTH BARTLETT LECTURE (Baddeley, 1992), Baddeley expressed the view that a theory is a tool that should provide a reasonably economical, plausible account of existing findings and should also facilitate new discoveries which, in turn, should lead to a gradual, cumulative modification of the theory. In addition, Baddeley suggested that if models can be applied across a wide range of situations, then so much the better; he expressed a personal preference for scope rather than precision.

Despite such views, which reflect the long-standing commitment of experimental psychologists to devise theories that encompass data from diverse sources, the development of a mainstream psychological literature on memory,

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derived from the Ebbinghaus and Bartlett traditions, has tended to concentrate mainly on verbal and—arguably, to a lesser extent—visual, cognition. There is little evidence in contemporary reviews of the literature (for example, Baddeley, 1990; Morris & Gruneberg, 1994) of any attempt to examine whether theories and models of memory currently referred to as models of human memory without reference to modality, can account for memory phenomena in other sensory modalities such as touch, taste, or smell.

Concomitant with what Baddeley has said, the ultimate value of such theories may be questionable if they are restricted to such a narrow range of application. The present climate of emphasis on ecological validity and applicability of psychological research to everyday issues only serves to emphasize the need for theories that encompass a wider data base than has often been the case.

Despite psychologists' failure to examine the contribution of the minor senses to human psychological functioning, other, nonscientific writers have not been so remiss. In particular, the role of the sense of smell in subjective human experience has been emphasized in other literature, resulting in a proliferation of anecdotal accounts of olfactory memory.

The recent development of a small, but rapidly expanding, experimental literature on olfactory cognition (for comprehensive reviews, see, e.g., Richardson & Zucco, 1989; Schab, 1991), and how it has been influenced by the conventional memory literature, makes an interesting case study in the interaction between a new research area and its parent discipline. In general, one is led to the conclusion that the main feature shared by those involved with the many diverse domains of memory research is perseveration. That is, exhibited behavior may often represent a tendency to persist with a particular strategy while ignoring alternative information, just as the patient R. J. (Baddeley, 1986) continued to cut a piece of string while saying, "Yes, I know I'm not to cut it."

Olfactory Memory: The Proustian Account

Much less is known about the physiology, psychophysiology, or psychology of the human olfactory system than is known about the visual or auditory systems, and Gibson's (1966) question as to what it is that imparts odor quality remains unanswered. Early studies (e.g., Laird, 1935) reflected the commonplace belief that smells, like some skills, are never forgotten. Such a traditional view of olfactory memory has embedded in it the notion that memory for smells is intrinsically different than memory in other modalities. Fundamental to that notion are three characteristics that have been attributed to odor memory and have become known in the literature as the "Proustian" characteristics (Annett, 1993; Schab, 1990). They are (a) that odor memory is unique, in the sense of being very different than memory in other modalities; (b) that it is independent of memory in other modalities; and (c) that it is resistant to interference and thus long-lasting.

Until the late 1950s, the Proustian notion of olfactory memory appears to have been supported mainly by anecdotal, subjective, and introspective reports (see, e.g., Bannister & Zangwill, 1941). During the 1960s, conforming with the then-current trend for viewing memory capacity as the main factor limiting the processing of sensory information, a number of studies (see Engen, 1982) concluded that even experts cannot identify nearly as many odors as they can other stimuli, without direct comparison with alternatives.

Such potential differences in cognitive aspects of odors and other sensory stimuli began to be studied more intensively in the early 1970s. Particular emphasis was placed on an examination of the Proustian characteristics by applying the then-current encoding/retrieval two-store models of memory and associated experimental paradigms. For example, as much folklore would have suggested, a number of studies supported the notion that the forgetting curve for odors differed from the rapidly decaying exponential function applicable to other stimuli (Engen, 1977; Engen, Kuisma, & Eimas, 1973; Engen & Ross, 1973; Lawless & Cain, 1975). Thus, the conventional, or modal, model appeared to fail to generalize from vision and audition to olfaction; but the findings of those early research programs were not acknowledged in mainstream memory literature.

The outcome of the early experimental studies of olfactory memory also supported the Proustian notion of independence from memory in other modalities. Odors appeared to be more difficult to name than other classes of stimuli (Engen & Eaton, 1975; Engen & Ross, 1973; Lawless & Cain, 1975), producing a frequently occurring "tip-of-the-nose" state (Lawless & Engen, 1977) similar to the "tip-of-the-tongue" state described by Brown and McNeill (1966). Reporting studies that utilized the paired-associate paradigm, Davis (1975, 1977) concluded that olfaction was probably more involved with hedonics than with verbal learning processes. Relatedly, the encoding specificity principle proposed by Tulving & Wiseman (1975) was demonstrated by Eich (1978) not to hold for odors. Many of those findings contrasted, also, with studies of retention of nonvisual, nonverbal stimuli other than odors, such as environmental sounds (Bartlett, 1977) and degraded faces (Freedman & Haber, 1974).

Early experimental work was also used to support the anecdotal evidence that olfactory memories might be resistant to retroactive interference. One favored explanation for the flat forgetting curve obtained by Engen and Ross (1973) was resistance to retroactive interference, whereas complementary evidence for strong proactive interference came from Lawless and Engen (1977) and from the paired-associate experiments carried out by Davis (1975, 1977).

In other words, those interested in olfactory memory used as a starting point the prevailing anecdotal perspective and produced experimental work based on current mainstream psychological theories to support that popular view. However, it is worth noting that negative experimental results were often taken as evidence to support the "Proustian" position.

Evidence Against the Proustian Account

Despite the apparently supportive evidence, other studies began to throw some doubt on the Proustian view. The slow rate of forgetting of odors, once thought to be unlike that for any other kind of stimuli, has since been shown to be similar to that for voices (Legge, Grosmann, & Pieper, 1984) and for simple visual forms (Lawless, 1978). Rate of forgetting may not be determined, therefore, simply by stimulus modality (Walk & Johns, 1984), but rather by particular properties of the individual stimuli (Rabin & Cain, 1984). Similar doubts may also be cast on the view that olfactory memory is unaffected by retroactive interference. With stimuli other than odors, including, for example, environmental sounds (Bartlett, 1977), interference in recognition tasks increases as target and distractor items become more similar to one another and if both are processed via instructions to utilize the same modality (Baddeley, Grant, Wright, & Thompson, 1975; Paivio, 1986; Warren, 1977).

Walk and Johns (1984) demonstrated retroactive, selective, and modality-specific interference for odors. Similarly, the alleged independence of odor memory has been questioned. By contrast with Lawless and Cain (1975) and Davis (1975, 1977), who concluded that retention of olfactory information was relatively unaffected by verbal processing, and following from further studies that examined, among other things, naming of odors (e.g., Cain, 1982; Schemper, Voss, & Cain, 1981), Rabin and Cain (1984) and Walk and Johns (1984) showed that the encoding of additional semantic information did improve subsequent odor recognition without being essential for recognition.

The issue of the usefulness of semantic elaboration in subsequent odor recognition was addressed in further detail by Lyman and McDaniel (1986, 1990). The observed effects of various verbal and nonverbal elaborative activities on the long-term retention of olfactory information differed from that found for other types of stimuli (Groninger & Groninger, 1984; McDaniel & Kearney, 1984). Relatedly, other studies that utilized a suppression paradigm (Annett & Leslie, *in press*; Annett, McLaughlin Cook, & Leslie, 1995; Perkins & McLaughlin Cook, 1990) have also reported a general pattern of effects that differs from that demonstrated for stimuli of other modalities.

Olfactory Memory and Current Theories of Memory

Though it is apparent that olfactory memory may be different in some respects from memory for other kinds of stimuli, the claims made in the early 1970s cannot be justifiably sustained. Consequently, olfactory memory can no longer be conveniently relegated to the sidelines and labelled "different"; nor can the call for a closer look at mainstream memory literature be ignored. In view of the fact that earlier models and principles, such as the modal model and the encoding-specificity principle, failed to generalize to olfaction (but remained

unchallenged by the evidence from olfactory studies), how do theories in the current literature express what is obviously a complex relationship between olfaction and other modalities? As noted earlier, virtually all experimental studies of memory have used visual or verbal stimuli, and in common with that empirical research, theoretical accounts have tended to ignore olfactory memory.

By way of illustration, Penney (1975) lamented the fact that few models of memory take into account modality differences in processing, beyond postulating short-lived sensory registers. Unfortunately, she also apparently considered "modality effects" to refer only to visual or verbal differences. Fourteen years later, Penney still had not expanded her definition (Penney, 1989). Strangely, it is the burgeoning literature on the new connectionist models, and not the traditional symbolic accounts of memory and mental representation, that has begun to accommodate other modalities (see, e.g., Freeman, 1991; Rummelhart & McClelland, 1986; Skarda & Freeman, 1987).

Despite such neglect, recent attempts have been made to integrate experimental studies of olfactory memory into the general cognitive psychological framework. For example, the dual-coding approach (Paivio, 1971, 1986) has provided a useful strategy (Lyman & McDaniel, 1986, 1990; Perkins & McLaughlin Cook, 1990). The recent refinement of allowing modality-specific processing subsystems suggested by Annett & Leslie (in press) could sustain Paivio's view that the early stages of his model are roughly analogous to the working memory area (Baddeley, 1986; Baddeley & Hitch, 1974), and it could provide the opportunity for more specific definition of further modality-specific, direct-access slave systems (see Annett, 1993).

Even if modality-specific representations are elements of a theoretical account, their functions have to be specified. They may not, for example, always be available or accessible in a conscious "top-down" manner, in which they would have bearing on explicit tests of memory. That view is consistent with evidence from both olfactory studies and those involving other sensory modalities.

There is a well-discussed literature related to "subliminal perception" involving both vision and audition (see, e.g., Dixon, 1981) and a parallel but less widely appreciated literature related to olfaction (see, e.g., Van Toller, Kirk-Smith, Wood, Lombard, & Dodd, 1983). On the basis of neurophysiological evidence (e.g., Lynch, 1986), D. Booth (personal communication, 1991) suggested that there is an anatomical basis for allowing that olfactory stimuli are fully processed in their own nonconscious system with output not through specific conscious systems such as verbal codes, but through interaction with intermodal processing of the current event in terms of past situations (i.e., a backward-propagation model). Given such a mechanism, even an unnamed smell could elicit describable contextual memories, as in the tip-of-the-nose phenomenon; this proposal would support the suggestion by Engen, Gilmore, and Mair (1991) that odor memory can be likened to implicit rather than explicit memory.

The evidence discussed so far could all be interpreted as support for the

notion that olfactory memory is qualitatively different from other forms of memory, in that it may imply that olfactory memory involves memory for what are primarily sensations rather than for highly interpreted (and hence verbalized) perceptions. However, the issue may be simply a matter of degree, with memory in all modalities being qualitatively different—with, for example, the sensation/perception (and hence sensation/cognition) contrast being more obvious in olfaction than in vision.

Humphrey (1992) has proposed that what one might call “raw” sensation and perception might be better thought of as parallel strands of activity rather than as successive stages. He further argued that the qualia associated with primary consciousness are more closely associated with sensation than with perception. By Humphrey’s account, memory for olfactory stimuli, simple shapes, voices, and other basic stimulus qualities might be expected to have similar characteristics if they mainly involve memory for basic sensory experiences. By contrast, Humphrey implied that memory for words, pictures, and other complex stimuli all entail memory for the informational outcome of various perceptual operations.

Humphrey’s ideas seem similar to Engen and Ross’s (1973) suggestion that smells can be considered single attributes that create “unitary perceptual experiences,” which result in information storage in a “raw, unencoded form” (Lawless & Cain, 1975). Whereas in the case of olfactory stimuli, sensory qualities might appear to be at the fore, we obviously can also use smell to inform us, just as in other modalities. For example, the sight of a used ash tray may possibly signify that someone has been smoking in a room, but the smell of cigarette smoke almost certainly will. Therefore, it could conceivably be argued that when one becomes aware of a smell, it is almost always interpreted, for example, as being a “smell of” an object or of part of a past event. In light of the recent literature, to relegate olfactory memory to what one might call a “noncognitive” status is hardly justifiable.

Conclusions

Overall, though it is reasonable and appropriate for cognitive and other psychologists to take their initial theoretical ideas from folklore, common sense, and so forth, the contrast between ideas that prevailed in the 1960s and 1970s regarding olfactory memory and those regarding the modal model of memory had an unfortunate outcome. Rather than striving to devise methods that would reveal similarities between olfactory memory processing and that for verbal and other materials—which might allow for generalization of theories—experimenters accepted preliminary negative results as establishing qualitative differences between olfactory and other memory.

It has taken more recent research to establish empirically that there are similarities as well as differences between the two, although the conclusions drawn

in even relatively recent reviews of the area demonstrate that the old notions are difficult to dispel (Richardson & Zucco, 1989; Schab, 1991). In addition, the findings have as yet failed to inform discussion of theories of memory in general. Although phenomena such as the tip-of-the-nose or the diversity of labeling of odors are valid and replicable, they require further research, and their interpretation should be more objective and analytical than has generally been the case.

The history of the study of olfactory memory thus provides illustrations of the dangers both of allowing limited empirical evidence to restrict the vision of those working within a particular area of research and of the failure of those formulating general theories to incorporate a broad spectrum of empirical evidence.

Discussion of both of those issues, in a general sense, is not new. For example, Jenkins (1979) described what he called "a tetrahedral model of memory experiments." Observed phenomena, he suggested, depend on the interaction between four elements: the nature of the experimental subjects, the nature of the orienting tasks, the nature of the criterion tasks employed, and the nature of the stimulus materials. The results of any experiment reflect a unique interaction, and changing the parameters of any of the four elements must change the pattern of results. The implications for the generalizability of memory models based on restricted stimulus materials is obvious, and the selected history of olfactory memory research presented here can be seen to support Jenkins's assertion that it would be relatively easy to undermine many generalizations about memory.

Often, the theoretical literature and the attendant literature on "applications" reflect little communication between proponents of particular approaches, even those derived from a common source. For example, there is now a substantial literature on face recognition (e.g., Bruce, 1988) derived from Morton's 1969 and 1979 models of word recognition. However, the development of face-recognition models has been almost independent of work on word recognition, which tends to be reported under the general heading of "psycholinguistics." Neither makes substantial reference to Paivio's dual-coding theory (1986). Perhaps part of the explanation for that omission is reflected in the fractionization within memory research, which was aptly described by Claxton (1980, 1988) as being akin to the noncommunication exhibited by the inhabitants of thousands of geographically neighboring but culturally remote little islands.

The worrying aspect of all of this is the effect that such lack of generalizability may have on the wider applicability of memory research. There is ever-increasing pressure to produce applied research, and the "applied aspects of memory" movement has gained much momentum since Baddeley (1979) described applied research as a "pardonable perversion." Herrmann and Gruneberg (1993) boldly claimed that "the ecological validity issue in memory research has largely been solved It is now time to move beyond this applied research."

But my case study in olfactory memory demonstrates that the basic theoret-

ical issues may not be as clear-cut as Herrmann and Gruneberg implied. Although it may be, as Mednick (1989) suggested, that development of alternative models is not as attractive as jumping on the "conceptual bandwagon," it should not require an enormous shift in orientation to look beyond the conventional literature.

Prospects

Gibson (1994) highlighted the fragmented nature of psychology as a discipline, as well as the continuing fragmentation within the relatively new cognitive science, which had carried high hopes of bringing together cognitive psychologists, philosophers, linguists, computer scientists, and neuroscientists. Although Gibson acknowledged that some progress may have resulted from "composing precise formulations about limited problem areas," her apparent disappointment is entirely reasonable. With specific reference to cognitive science, she endorsed the view that a developmental approach might well reveal connections between some of the individual contributions.

An illustration of how a lifespan-developmental approach could be applied to the memory literature, to draw together different strands of research and include an applied aspect, is provided by consideration of age-related effects. Burke (1992) remarked that age-related changes in memory are not uniform across different memory functions and thus necessitate distinctions between different kinds of memory. She focused on two memory functions that feature in discussions of age-related memory deficits: memory for new information and the production of well-known words, particularly proper names. Those are both discussed in terms of the traditional range of stimulus materials. However, perspectives on both issues are readily available within the literature on olfactory cognition. For example, odors are apparently initially more difficult than other stimuli to memorize. Also, the tip-of-the-nose phenomenon has been identified.

Such examples illustrate that consideration of characteristics of olfactory cognition exhibited by so-called normal participants from a range of age groups may be important when formulating explanations of similar characteristics displayed in response to other modality stimuli by selected groups. As I (Annett, 1993) have suggested, parallels may be drawn between prosopagnosia, aphasics' failures to name objects, the tip-of-the-tongue state, and the tip-of-the-nose state. Such a proposal is compatible with the currently popular implicit/explicit formulation of memory, which has become particularly prominent in the literature discussing age-related aspects of memory (including Burke's review).

The results of further research that diversify the types of stimuli examined and experimental paradigms used should produce at least an increasing awareness of the need for less dogmatic statements about the way in which particular types of stimuli are processed and how memory in general operates. Although, as acknowledged by Gibson (1994), belief in any "grand theory" no longer exists,

there is nevertheless an obligation to consider as much empirical and other evidence as possible when promoting theories—especially in undergraduate textbooks.

The whole of psychology, and not just the literature relating to memory, is replete with examples of areas of ignored and neglected research findings, awaiting assimilation into “mainstream” consciousness. Wolf (1993), in a discussion of the feminist “genderquake,” reminded her readers that earthquakes are not sudden, unpredictable events, but result from eons of silent tectonic pressure. Perhaps the past, present, and future of memory research is analogous to such seismic activity, and we await the cognitive “odorquake.”

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