

Does Olfactory Memory Depend on Remembering Odors?

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Key words: brain research, learning, memory, odor

Introduction

The question mark in the title indicates that what follows is not a theory explaining odor memory, but a series of findings that question the traditional view of memory, in which acquisition and retrieval of 'memory items' dominate all questions asked. That such questions arise in an area that deals with odors is not surprising. Odors are the least palpable and most evanescent of stimuli. Odors are not 'things', unlike visual, auditory and tactile stimuli they do not have structured properties in space and/or time. Odors are notoriously hard to describe, classify and identify. We are surrounded by an almost infinite number of odors, although we usually do not pay attention to them. Our houses, our cities and we ourselves all smell different. We live amidst smells without noticing unless something happens that changes them. Lending your house or car to friends, a slight change in the flavor of your favorite marmalade are reminders that you have a good memory for odors that you could nevertheless not describe in any detail.

Strangely enough, incidentally learned implicit odor memory has hardly been investigated. Most studies (see Herz and Engen, 1996; White, 1998) deal with remembering well-known odors presented under controlled laboratory conditions. Often subjects were instructed to inspect the odors attentively, to identify or to memorize them for later memory tests. Other studies explicitly associated odors with pictures or words to test the influence of smelling these odors on memory for the other stimuli or investigated the role of odors in evoking autobiographical memories. The few studies on spontaneous odor or flavor memory in everyday situations (Baeyens *et al.*, 1996; Aggleton and Waskett, 1999; Haller *et al.*, 1999; Garcia *et al.*, 2001) showed that memory may have widespread and long-lasting effects, even if during learning no conscious effort at feature analysis or memorizing is made.

Some recent findings

Incidental odor learning and implicit memory were studied by Degel *et al.* (2001) and Köster *et al.* (2002). While performing psychological tests, subjects were exposed to weak odors that remained unnoticed, as checked by debriefing and four independent behavioral criteria (see Degel *et al.*, 2001). Later, in a different experiment, they indicated how well each of 12 odors (including the one they had been exposed to) fitted to each of 12 rooms (including the one they had been exposed in). They rated the fit of the exposure odor to the exposure room higher than a control group, but only if they could not identify the previously unnoticed odor by name. Evidently, there exists an implicit pre-semantic episodic memory for odors and in this spontaneous memory odors are mainly remembered by their link to the situation in which they were experienced. Objectifying odors by name identification, effaces this subtle memory connection with the environment. Olsson (1999) also found that identifying odors interfered with memory. These findings disagree with the relationship between odors and odor names found in explicit learning studies, which show that odor identification has a positive influence on recognition of odors (Engen, 1987; Larsson, 1997) and consider odor naming as a high level of cognitive processing (Lehrner *et al.*, 1999).

Identification provides the subject indeed with a second (verbal) memory channel, but the question is whether this is memory for the odor itself. Once identified, the name is remembered and the memory of this name is reactivated when the odor is identified again. To test whether odors can be well remembered without verbal mediation, Møller *et al.* (2004) carried out an incidental versus intentional learning recognition experiment with very uncommon odors using young and elderly subjects. All subjects remembered the odors significantly better than chance. With incidental learning the elderly did slightly better than the young. With intentional learning however, the young performed significantly better. Interestingly, it was shown that the young did only better in the intentional condition than in the incidental condition because they made less false alarms and not because they made more hits. This and the fact that they did not use verbal mediation in their memory, a finding similar to results of Herz (2000), led the authors to doubt whether the difference between elderly and young in intentional learning was due to deterioration of working memory, as reported for other memory (Baddeley, 1986; Dobbs and Rule, 1986). They postulated that odor memory was tuned at detecting changes in the odorous environment rather than at the precise recognition of previously experienced odors and questioned whether working memory for odors was functional. An experiment comparing incidental and intentional memory for odors and faces (Köster, Gosses, Prescott and Köster, unpublished data) employed two encoding procedures: (i) subjects rated liking for odors and faces presented and (ii) subjects rated how much the odor or face resembled an odor or face they knew (more active memory search and deeper encoding). Odors were slightly better remembered under the liking condition, whereas faces were significantly better remembered under the resemblance condition, indicating that deeper encoding was ineffective in odor memory.

The postulate about tuning of odor memory to detection of change, was also supported by experiments on odor imagination using a same-different reaction time paradigm (Köster *et al.*, 1997) with subjects who claimed they could imagine odors (imagers) and subjects who could not (non-imagers). All subjects performed under four conditions (odor or name of the odor as prime, each combined with odor or odor name as target). Odor names were presented visually, odors with an olfactometer. An interval of 4 s separated presentation of the prime (odor or name) and target (odor or name). Imagers were 300 ms faster than non-imagers in response to odor targets, but not to name targets. This real difference in odor perception between the groups proved to be unrelated to olfactory memory (never a correlation between odor imagination and odor recognition performance). This may indicate that odour recognition memory is not related to reconstruction of mental odour representations, and that memory may not involve template identification. More importantly, in both groups reaction times to odor targets were ~300 ms shorter when the target did not match the prime than when it did, whereas, like in the literature (Posner, 1986), for visually presented name targets match was 50 ms faster than non-match. Evidently, we deal with odors and visual or verbal stimuli very differently. Finding

differences is more important in olfaction (and probably in other 'near' senses) than identification. Similarly, when subjects rate confidence in their response in food memory experiments (Köster *et al.*, 2004; Mojet and Köster, 2004), their certitude is much higher for correct rejections than for hits, misses and false alarms. That detecting change is more important than identification makes good evolutionary sense (Møller *et al.*, 2004; Köster *et al.*, 2004). Since we can not stop breathing and should spit out poisonous food before swallowing, early detection of the unusual is more important than identification in olfaction and taste (also pain and passive touch?). In 'near' senses there is little time for complex template matching and there is only one adequate reaction upon danger (fleeing, spitting out, or retracting, respectively), whereas in far senses there is time to identify and choose the proper reaction from a variety (hiding, hitting, running, freezing). Thus, a primitive episodic memory based on immediate feelings of (not) knowing, or detecting unexpected deviant odor notes in the situation, prevails in daily odor memory, rather than precise odor recognition in full scale template matching based on detailed feature analysis in working memory.

Consequences

If odor memory functions independently from naming and is mainly tuned at detecting changes, this probably has consequences for the way in which the brain mechanisms involved in odor memory should be studied. Odors, explicitly presented out of context in the laboratory or in an fMRI machine, may show atypical reaction patterns. Odors are not 'things', they are linked to personal situations and the same odor may be pleasant in one situation and unpleasant in another. They may lose their original meaning when identified. Unidentified lavender is normally disliked, whereas people who identify it like it. So what about the discussion on left-right localization of 'pleasant and unpleasant' odors? Is differentiation between neural effects of odor and effects of odor naming possible with well-known odors? Many brain studies on olfaction deal naively with such matters. They also require repetition of odor presentation to filter out artifacts by averaging. Apart from changes through sensory adaptation, this will lead to habituation, further 'objectification' and loss of meaning.

These handicaps being unavoidable, it seems necessary to verify them using adequate psychological methods and to consider them when interpreting the data.

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