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Implicit Testing of Odor Memory: Instances of Positive and Negative Repetition Priming

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Abstract

The study provides a test and evaluation of a new repetition priming procedure designed to solve problems in investigating olfactory-specific priming. Although the results did not reveal any overall priming effect, a post-hoc analysis showed that incorrectly identified odors were more quickly processed than control odors, whereas correctly identified odors were processed more slowly. These results are discussed and interpreted as instances of positive and negative repetition priming respectively.

Introduction

Implicit tests of memory have been of great interest during the last decades, primarily in vision research. Most common have been tests of repetition priming, which measure facilitatory effects on processing speed or accuracy following repeated exposure to a particular event. Studies on implicit testing of odor memory are few and have had limited success (e.g. Schab and Crowder, 1995). Olsson and Cain (1995) demonstrated repetition priming using latency for subvocal identification of odors as the dependent variable. As a priming task, participants rated how long ago they last encountered a number of odors presented to them. After about 10 min they were again to identify double the number of odors, of which half were the same as in the study task. An overall priming effect was found in that primed odors were identified faster than control odors. However, the finding that repetition priming was more obvious when tested via the left nostril (left hemisphere) could suggest that the priming effect is related to (subvocal) naming and driven conceptually rather than perceptually. The current experiment is a follow-up to that of Olsson and Cain. However, to control for the effects of verbal labeling, the test of priming did not require the participant to go so far in the naming process as in the study of Olsson and Cain. It should be noted here that most theories of object naming would agree that at least three stages are present in the naming process: object identification, name activation and response generation (Johnson *et al.*, 1996). Our aim was to diminish the requirements of verbal processing of odors at test by intervention in the naming process and then to see whether any priming in the left hemisphere persisted. This was done in the test phase of the current experiment by asking participants to reject an erroneous name proposed to both new and previously presented odors rather than asking them to identify the odors, as in the test phase of Olsson and Cain's experiment. Response latencies for such 'no'-responses (i.e. rejections) to control (new) odors and to primed (previously presented) odors were then compared. The outcome of this type of priming procedure we refer to as identity-rejection (IR) priming.

Materials and methods

Participants

Thirty-two participants, balanced for gender, took part in the experiment. They ranged in age from 20 to 40 tears (mean = 25.47, SD = 6.09). The participants were primarily students from the Department of Psychology, Uppsala University, Sweden, and were paid 50 SEK (approx. $6) for their participation. All were right-handed as determined by the Edinburgh Handedness Inventory (Oldfield, 1971). Maximally right-handed persons scored 10, whereas maximally left-handed would have scored 0. The handedness scores averaged 9.44 (SD = 0.77, range = 7–10).

Stimuli

Two sets (A and B) of eight odorants were chosen. Set A contained cinnamon, peanut butter, peppermint, curry, lemon (peel), cloves, Ivory soap and tea; set B comprised fruit gum, vinegar, black pepper, chocolate, nutmeg, baby powder, basil and vanilla essence. Odorants were presented in 160 ml tinted glass jars with screw lids. Visual inspection of the stimulus was precluded by cotton pads placed over the material in the jars.

Procedure

Throughout the experiment, odors were smelled monorhinically using the left nostril [the condition under which repetition priming was demonstrated in Olsson and Cain (1995)].

Before the session started, the participants answered some questions concerning their health. In the following study phase, half of the participants smelled the odors in set A and the other half smelled the odors in set B. The eight odors appeared in a uniquely randomized order. In this phase, the participants could hold the odor jars in their hands and smell the odors for as long as they wished. The odors were, as noted, always smelled with the left nostril, the right nostril being pinched off with the thumb until the required response was given. The task was to judge when they last had smelled the odor. Response alternatives included: (1) within the last day; (2) between 1 day and 1 week ago; (3) between 1 week and 1 month ago; (4) between 1 month and 1 year ago; (5) more than 1 year ago; and (6) never. The participants were asked to use the category numbers (1–6) when they responded and otherwise not to speak.

Between the study phase and the test phase, the participants answered the Edinburgh Handedness Inventory (Oldfield, 1971), which also served as a distraction task, and smelled the comparison odor (coffee or orange) in order to become acquainted with it. After that participants practised the timing procedure with an empty jar and four practice odors; then the test itself could commence.

The test phase comprised 16 test odors presented randomly (set A + B) with four additional presentations of the comparison odor randomly interspersed; eight test odors were new and eight were previously presented in the study phase. During smelling, the participant leaned over to the jar placed on the table in front of him/her and gently exhaled as his/her nose approached the jar. When the nose reached about an inch from the jar, he/she pressed the go button on the timer and simultaneously began to inhale (smell). As soon as the participant had decided whether or not the odor was the proposed comparison odor, he/she stopped the timer and vocalized ‘yes’ or ‘no’. The latencies for ‘no’-responses constitute the dependent variable of the test.

In the final phase, the identification phase, participants tried to name the 16 test odors which were presented in the same order as in the test phase, but without any timing of the responses. Identification data were collected to see to what degree participants could identify the study material.

Results and discussion

Analyses of latencies of correct ‘no’-responses (96%) were performed on the logarithms because of positively skewed response distributions. However, geometric means of linear time will be reported in the text. An ANOVA of four two-level factors included one within-subject factor (primed versus control odors) and three between-subject factors: comparison odor (coffee or orange), gender and odor set (A or B). None of these between-subject factors was significant at the 5% level [$F(1,24) = 3.32$; $F(1,24) = 1.82$; $F(1,24) = 0.82$ respectively].

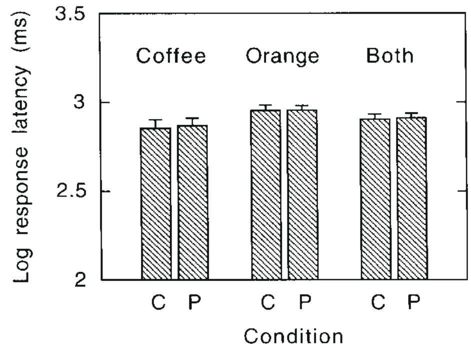

Figure 1 Means and SE of log response latencies (ms) for control (C) and primed (P) odors in the IR priming experiment. Comparisons of means are shown for the two comparison odors (coffee and orange) separately, as well as for overall data.

The main result was that no difference between the response latencies to primed and control odors was found. This held true irrespective of the odorant used as comparison odor: coffee or orange (Figure 1). Response latencies for control odors and primed odors were 801 and 816 ms respectively [$F(1,24) = 0.532$, ns]. The size of these latencies should be compared with those of Olsson and Cain (1995), which averaged ~2000 ms. This difference supports the idea that the current priming procedure, based on identity rejection, does not necessitate the generation of a name or maybe not even identification for the participant to respond. Therefore, if the analysis were to stop here, it could be concluded that the repetition priming effect found in Olsson and Cain (1995) was not of a perceptual type, in the sense of activating a stable sensory quality, but rather reflected some later and perhaps verbal stage in the identification or naming process. But, as we will see below, the IR priming procedure does not promote a ‘process-pure’ measurement of repetition priming, which makes it necessary to postpone the interpretation with regards to Olsson and Cain’s results.

The identification responses in the last phase of the experiment were coded such that hits (naming an orange as ‘orange’) were denoted the value 1, close misses (naming an orange as ‘citrus fruit’) were denoted the value 0.5 and misses 0. Correct identification rates, calculated this way, averaged 48%, ranging from 3% (vanilla essence) to 81% (cinnamon). This level of performance is very typical for odor identification experiments with common odors (de Wijk *et al.*, 1995). Interestingly, a Pearson’s correlation of the 16 odorants between proportion correct and primability, defined as the difference in mean response latency (log) between control and primed odors (calculated as C minus P), yielded $r = -0.46$, which is close to being significant at the 5% level. This implies that although no overall priming effect could be observed with the IR procedure, it appears to differentiate between odors depending on how difficult they are identified. To investigate this more closely, rejection latencies for the trials for which the particular odors were later identified with some accuracy (as hit or close miss) and incorrectly (miss) were compared. Means and 95% confidence intervals were calculated on the entire data matrix to gain statistical power (Figure 2). The results for identifiable odors show that primed odors were rejected more slowly (830 ms) than were control odors (749 ms). Conversely, odors that could not be identified showed faster latencies for primed odors (801 ms) than for control odors (872 ms). If we accept this latter case of reduction of response time as (positive) repetition priming, we could now turn to the former case where we found an increase in response time.

Is it possible to interpret the outcome for identifiable odors in Figure 2 in terms of negative priming (Tipper, 1985)? In the sense that previous presentation and judgements of odors actually delayed the processing time at a later ocurrence, the answer is yes. But more specifically, what are the processes underlying negative priming? One can discern two main accounts of negative priming. First, the inhibition-based account argues that if a stimulus is initially ignored and then attended in a subsequent and similar situation, its representation is inhibited which leads to slowing of the processing. Some alternative mechanisms for this inhibition have been suggested (reviewed in Lowe, 1998). The inhibition depends on that the distractor's 'base-level activation had been lowered', its 'activation threshold had been raised', or it remains activated but is 'blocked from access' to response mechanisms. The second and more recent account is the episodic-retrieval account developed by Neill and colleagues (Neill and Valdes, 1992, 1996; Neill *et al.*, 1992; Neill, 1997; Fox and de Fockert, 1998), developed from episodic theories of (positive) repetition priming (Jacoby, 1983; Logan, 1988). The negative priming process is here seen as dealing with episodes rather than representations of objects. When an ignored object is repeated, it cues contextual information in memory such as whether it should be responded to or not. This information is in opposition to the task requirement on the second encounter, where the same stimulus is to be attended.

Both accounts of negative priming, described above, could be applied to the current results of the IR procedure, given that the instruction to 'ignore' the primed set together with the actual presentation of the comparison odor before the test phase commenced could have a retroactive and inhibitory effect on the primed odors. Alternatively, that the primed odors, when presented in the test phase would cue the memory of the instruction defining these odors as not among those to be attended. Limited previous data exist that could shed light on this issue. However, Neill (1997)

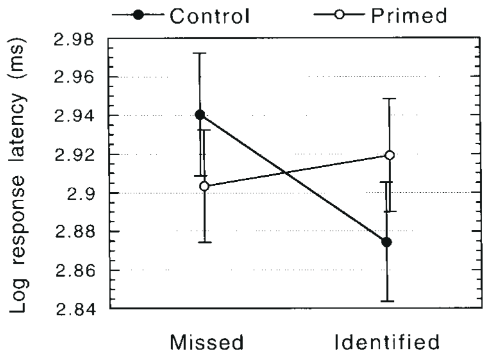

Figure 2 Mean log response latencies for primed and control odors that was later either identified (as hit or close miss) or missed. The bars represent 95% confidence intervals.

presented a target and a distractor with only partial overlap in time and could still observe a negative priming effect when the distractor appeared as a target in a consecutive trial, indicating that these two events must not necessarily coincide perfectly in time to cause negative priming.

To conclude, a new procedure for repetition priming was suggested intending to measure olfactory-specific repetition priming using latency of identity rejection as response variable. No overall effect could be observed. Although the IR priming procedure did not meet its intentions to be a process-pure test of priming, the results have some virtues. First, it demonstrates the occurrence of negative priming in olfactory processing. Second, the size of the observed positive and negative priming is substantial (~10% of latency) compared with priming results of many other studies in vision research. Third, the results, again, point to the importance of understanding and controlling encoding processes in olfactory tests of perception and cognition. Here, the identification success was of critical importance for the type of priming observed. Because most odor memory experiments almost inevitably use both identifiable and unidentifiable odors to some ratio, the results are likely to reflect that particular ratio.

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References

de Wijk, R.A., Schab, F.R. and **Cain, W.S.** (1995) *Odor identification*. In Schab, F.R. and Crowder, R.G. (eds), Memory for Odors. LEA, Mahwah, NJ, pp. 21–37.

Fox, E. and **de Fockert, J.W.** (1998) *Negative priming depends on prime-probe similarity: evidence for episodic retrieval*. Psychonom. Bull. Rev., 5, 207–113.

Jacoby, L.L. (1983) *Perceptual enhancement: persistent effects of an experience.* J. Exp. Psychol.: Learn. Mem. Cogn., 9, 21–38.

Johnson, C.J., Pavio, A. and **Clark, J.M.** (1996*) Cognitive components of picture naming.* Psychol. Bull., 120, 113–139.

Logan, G. D. (1988) *Toward an instance theory of automatization.* Psychol. Rev., 95, 492–527.

Lowe, D. (1998) *Long-term positive and negative identity priming: evidence for episodic retrieval*. Mem. Cogn., 26, 434–443.

Neill, W.T. (1997) *Episodic retrieval in negative priming and repetition priming.* J. Exp. Psychol.; Learn. Mem. Cogn., 23, 1291–1305.

Neill, W.T. and **Valdes, L.A.** (1992) *Persistence of negative priming: steady state or decay?* J. Exp. Psychol.; Learn. Mem. Cogn., 18, 565–576.

Neill, W.T., Valdes, L.A., Terry, K.M. and **Gorfein, D.S.** (1992) *Persistence of negative priming: II. Evidence for episodic trace retrieval.* J. Exp. Psychol.; Learn. Mem. Cogn., 18, 993–1000.

Oldfield, R.C. (1971) *The assessment and analysis of handedness: the Edinburgh Inventory*. Neuropsychologia, 9, 97–114.

Olsson, M.J. and **Cain, W.S.** (1995) *Early temporal events in odor identification* (abstract)*.* Chem. Senses, 20, 753.

Schab, F.R. and **Crowder, R.** (1995) *Implicit measures of odor memory.* In Schab, F.R. and Crowder, R.G. (eds), Memory for Odors. LEA, Mahwah, NJ, pp. 71–92.

Tipper, S.P. (1985) *The negative priming effect: inhibitory priming by ignored objects.* Quart. J. Exp. Psychol., 37A, 571–590.

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