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Odor Emotionality Affects the Confidence in Odor Naming

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Abstract

Previous research has demonstrated that participants are overconfident in the veracity of their odor identifications. This means that their confidence expressed as subjective probabilities is, on average, higher than the actual proportion of correct odor identifications. The current experiment tested the hypothesis that the more arousing an odor is, the more participants are overconfident in their identification of it. The results indicated that part of the overconfidence in odor identification can, indeed, be due to the arousing properties of the odors. This suggests that emotional variables should be taken into account when researching metamemory.

Key words: arousal, confidence, metacognition, metamemory, odor identification, valence

Introduction

Metamemory can be defined as the cognitions a person has about his or her own memory, e.g. confidence in the veracity of a memory. A previous study has demonstrated that participants are overconfident in their odor identifications (Jönsson and Olsson, 2003). This means that confidence, expressed as subjective probabilities, is higher than the actual proportion of correct odor identifications. We here investigated whether the emotional properties of odors could explain part of this overconfidence. More specifically, we hypothesized that the more arousing the odor experienced is, the more overconfident participants are in the identification of that odor. That emotionality can interact with the accuracy of metamemory judgements has been proposed before (Brigham *et al.*, 1983), and also in the case of odor-cued memories (Herz, 1998a, 2000), but research is scarce.

Odor-evoked memory, emotion and confidence

There are several indications that odors and odor-evoked memories are more emotionally laden than other types of stimuli. Researchers often refer to the so-called Proust phenomenon, that is, the ability of odors to cue personal memories that are emotionally colored, vivid, and old. It was named so after Marcel Proust (1919), who wrote a novel describing such an experience. Chu and Downes (2000) argued that there is some evidence that olfactory stimuli can cue autobiographical memories more effectively than cues from other sense modalities. They hypothesized that affectively arousing stimuli (such as odors) may be especially effective retrieval cues. Such a hypothesis is difficult to test, because in ecologically valid autobiographical studies of the kind reviewed by Chu and Downes, there is no control of the accuracy of the memories reported. A standard paired-associate learning paradigm is more suitable for the investigation of the relation between accuracy and emotionality of odor-evoked memories. In several experiments Herz and colleagues (Herz, 1998a; Herz and Cupchik, 1995) let participants encode olfactory, visual, tactile, lexical and musical stimuli (cues) together with pictures of paintings. In a later test phase the cues were presented again and the task was to remember the associated painting and rate the memory of it on several scales. Although no difference between cues could be found in the correctness of the memories, odor-evoked memories were consistently rated as being more emotional.

Experiments in the evaluative conditioning paradigm have shown that odors can alter subjective preference ratings of neutral pictures of peoples' faces (Todrank *et al.*, 1995) and neutral pictures of abstract paintings (van Reekum *et al.*, 1999). Robin *et al.* (1999) found that participants with previous negative experiences of visiting the dentist rated eugenol (an odor often encountered at the dentist) as unpleasant, whereas those who had no such negative experiences instead rated it as pleasant. The first group also showed autonomic nerve system (ANS) stimulation associated with negative emotion, whereas the second group did not. The two groups did not differ on two control odors. The above studies

imply that odors can evoke emotionally colored memories and perhaps more so than other stimuli.

Herz (2000) proposed a close interaction between the belief (i.e. confidence) in the correctness of odor-evoked memories and their emotionality. She stated that 'odors are no better than other sensory cues at eliciting an accurate recollection. Rather, it seems, the emotional intensity of odor-evoked memories leads to the false impression that such memories are especially accurate. In other words, it is emotional intensity, not accuracy that accounts for the impression that odors are the best memory cues' (*P*. 37). More specifically, Herz proposed that participants should be more confident (i.e. overconfident) in the correctness of memories cued by odors than in memories cued by stimuli from other modalities. This difference is thought to be due to the emotional intensity of the odor cue and its effects on the cued memory. Although this remains to be proven empirically, it is an interesting hypothesis.

To the authors' knowledge, research investigating a possible interaction between emotionality and confidence (or overconfidence) is very scarce. This is surprising, because there are areas where such a relationship is plausible. Eyewitness testimonies and flashbulb memories are examples of memories that, like odor-evoked memories, are both personal and often affectively laden. Flashbulb memories refer to memories of surprising and shocking events and are supposed to be recalled over long periods of time. Several recent comparisons of everyday and flashbulb memories (Weaver, 1993; Schmolck *et al.*, 2000; Talarico and Rubin, 2003) have shown that the decline in the consistency (i.e. accuracy) of those memories are equal in size, but with striking differences in the subjective judgements of those memories. Ratings of vividness, recollection and belief in the correctness of the memories remained high for flashbulb memories, but decreased over time for everyday memories. Talarico and Rubin (2003) concluded that flashbulb memories are not special in their accuracy, only in their perceived accuracy. Schmolk *et al.* (2000) argued that 'the fact that individuals were frequently as confident in their inaccurate recollections as they were of their accurate recollections, and failed to say that they did not remember, suggests that some of the findings reflect a difficulty in metamemory' (*P*. 44). The above metamemory arguments are similar to the proposition by Herz (2000) about peoples' metamemory of odor-evoked memories. On the other hand, Hosch and Bothwell (1990) found that eyewitnesses' confidence in their identifications was negatively correlated with a physiological measure of arousal, which is also in line with an observation of Talarico and Rubin (2003). One of their measures of emotion, namely visceral emotion (an arousal-related subjective scale), was for the flashbulb memories negatively related to belief in the correctness of the reported memories, but unrelated to their consistency.

In a related field of inquiry, Allwood and Björhag (1991) examined the effect of depressed mood on the realism of participants' confidence in the correctness of answers to general knowledge questions. They found no difference on any measure (confidence, proportion correct and three measures of metamemory accuracy). Brigham *et al.* (1983) investigated the effects of arousal on facial recognition. Recognition accuracy was lower in the high than in the moderate arousal condition, but their hypothesis that the relationship between confidence and accuracy should get weaker the higher the arousal was not supported (no difference). Taken together, the reviewed studies indicate that under certain conditions, an interaction between emotion and metamemory takes place. However, the results have hitherto not been consistent across situations and measures.

The emotionality of odors

Alaoui-Ismaïli *et al.* (1997a,b) investigated subjective ratings of emotion in response to odors, as well as six different ANS measures. They found several intercorrelations between the physiological measures and the subjective ratings (in particular pleasantness). Herz (1998b) compared the emotionality of odors, music and paintings, which are often considered to be emotionally laden. She found that although the participants believed that music could affect their emotions and moods more than the other stimulus types, heart rate measures suggested that the odors were more arousing. The participants' emotional ratings of the different stimuli did not differ.

The anatomy of the olfactory system is often brought forward as evidence for the special emotionality of odors. Herz *et al.* (2004) pointed out that the olfactory system is unique among the senses because it has the most direct projection to the amygdala. A recent functional magnetic resonance imaging (fMRI) study demonstrated that amygdala activation is associated with the emotional intensity of odors, but not their valence (Anderson *et al.*, 2003). Odor valence was instead associated with activation in orbitofrontal cortex. Herz *et al.* (2004) presented participants with a personally significant odor (different for each participant) and a control odor of equal intensity, as well as visual representations of the experimental and control odors. An fMRI analysis indicated significantly greater activation in the amygdala and hippocampal regions during recall of a memory triggered by a personally significant odor than by any of the other cues.

Odor identification and confidence

Several studies have demonstrated how difficult it is to identify even common odors without the help of visual or other contextual cues. Naming performance of a set of common odors rarely exceeds 50% and the identification rate of a single item rarely reaches 100% (Desor and Beauchamp, 1974; Cain, 1979; de Wijk, 1994; de Wijk and Cain, 1994; de Wijk *et al.*, 1995; Cain *et al.*, 1998). Recently researchers have begun to study another aspect of odor identification, namely

metamemory judgements about these. Cain (1982) asked a group of participants to (?) judge how easy a set of odors would be to identify (by showing the names of the odors). When comparing their judgements with the actual identification performance of another group, it was evident that the judges were overestimating the performance. Cain *et al.* (1998) had the same participants make both the identification attempts and the confidence judgements, and found that the mean confidence was significantly higher for correctly identified odors than for those being incorrectly labeled. Jönsson and Olsson (2003) further investigated the confidence–accuracy relationship and found that the participants were quite overconfident in their identification performance. Altogether, the research so far points towards some correlation between confidence and accuracy of odor identification, but with an evident overconfidence.

Other researchers have pointed out that the overconfidence often found in empirical studies may just be a product of measurement errors and sample biases rather than a real cognitive phenomenon (see Juslin *et al.*, 2000, for a discussion). There are, however, several reasons why the overconfidence found in Jönsson and Olsson (2003), or at least some of it, may be a valid finding. Jönsson and Olsson related to a further analysis of data by Broman *et al.* (2001) that showed that many odors were rated as very familiar, although these odors were rarely identified (i.e. named). It is thus possible that the high familiarity of some of the incorrectly identified odors could lead the participants to believe that they had in fact identified them correctly.

Another suggestion is that we sometimes misrepresent odors perceptually. Cain and Potts (1996) mentioned that participants sometimes 'misapprehend' the source of an odor (e.g. lemon is perceived as orange), but that their ability to realize this might be compromised. If this confusion hypothesis is true, peoples' confidence in their accuracy may be distorted, that is, people will be overly confident in their answers.

A third possibility is the aforementioned hypothesis proposed by Herz (1998a, 2000). This hypothesis states that people falsely believe that odor-evoked memories are more accurate than memories cued by other sense modalities due to their emotionality. In the current experiment the main aim was to study whether the emotional properties of odors could affect the confidence people have in the correctness of their odor identification attempts. A hypothesis that follows from Herz is that the more arousing an odor is, the higher the overconfidence in the odor name cued by the odor. If supported, this could explain some of the overconfidence found in Jönsson and Olsson (2003). It would also suggest, on a more general basis, that the emotionality of a stimulus could affect metamemory judgements associated to that stimulus. Apart from arousal, which was the focal emotional dimension in this experiment, valence was also investigated. Another aim of the study was to replicate the metamemory accuracy findings in Jönsson and Olsson.

Materials and methods

Participants

Of 46 participants, three participants were excluded from the analysis due to reporting a poor sense of smell and one due to misunderstanding the instructions. The analyses were thus based on 42 participants (34 women) with a mean ± SD age of 25.07 ± 4.33 years (range = 20–38 years). They were all recruited from Uppsala University and participated for course credits or were given a movie ticket voucher (worth ~75 SEK). The 42 participants included in the analyses reported a normal sense of smell.

Stimuli

The 16 odorants used as test stimuli were snuff, tar, lemon, tobacco, orange, soap, soft soap, clove, cigarette butt, vanilla sugar, aniseed, motor oil, gasoline, dill, tea and liquorice. (Table 1) Some odorants (e.g. orange and lemon) were changed regularly to keep them fresh and the odor quality stable. The odorants were all common everyday products (i.e. not artificial odorants). Odorants were presented in 160 ml tinted glass jars with screw lids. Cotton pads prevented visual inspection of the stimulus material in the jars.

Procedure

The participants were tested in small groups in a classroom setting. First they filled in a questionnaire with some background data such as age, sex and whether they considered themselves to have a functional sense of smell or not. Then they read the instructions about the procedure and the different rating scales. The test procedure was as follows: first they wrote down the number that was written on the odor jar they had in front of them. Then they smelled each odor once and rated it on two nine-graded scales, first its valence and finally how arousing it was. The scales used were the self-assessment manikin scales, which is a non-verbal pictorial assessment technique (Bradley and Lang, 1994; Lang *et al.*, 1999) that measures the three emotional dimensions arousal, valence and dominance associated with a person's affective reactions to stimuli. Dominance was not included in this study. In short, the scale consists of five pictures with the possibility for the participants to mark either on the picture or between them, leading to nine possible responses on each scale. The valence scale went from 1 (positive) to 5 (neutral) to 9 (negative). The arousal scale went from 1 (low) to 9 (high).

Immediately after having rated the two emotional aspects, they smelled the odor a second time and tried to name it. If they could come up with a name, they also rated their confidence in that it was the correct one. This was done on a percentage scale ranging from 0 to 100%, with 20% intervals. The scale was explained in the instruction. They were instructed that if, for some odors, they judged that they were,

for example, 40% sure, they should also on average be about 40% correct. The other percentage categories were explained in a similar fashion. A confidence judgement of 100% should reflect a certainty so high that there would be no errors. This method of gathering confidence judgements has been developed and applied in other fields of psychology (for reviews, see Lichtenstein *et al.*, 1982; Yates, 1990; McClelland and Bolger, 1994; Juslin *et al.*, 2000). The presentation order of the odors was fully randomized for each group tested, and each individual in the respective group started with a unique odor. After all the participants had smelled their odor and filled out their questionnaire accordingly, the experimenter instructed them to rotate the odors, giving their odor jar to the participant next in turn (the participants were organized in a circle). When they had done this, the experimenter instructed them to start the next odor trial. This procedure was repeated until everyone had smelled all the odors. The whole experiment took about 30 min to complete, including the instructions.

Results and discussion

An alpha level of 0.05 was used for all statistical tests. The effect sizes Cohen's d and partial eta squared are denoted as d and partial η^2, respectively. All t-tests were two-tailed. On average the participants tried to name and make confidence judgements on 14 (SD = 1.70) out of the 16 odors presented to them. That means that ~88% of the trials led to a naming attempt. Half of the odor naming attempts were correct (M = 0.49; SD = 0.18). If the unnamed odors are included as incorrect answers, the overall proportion correct was slightly lower (M = 0.44; SD = 0.16). The mean confidence was M = 0.63 (SD = 0.14). The correctness scores together with confidence, arousal and valence judgements for the different odors are presented in Table 1.

In all analyses of odor emotionality, we assigned the odors to arousal and valence categories based on the mean of the participants' ratings for each odor (see Table 1). The five most negative odors were labeled as negative (M = 6.96; SD = 1.12), the five most positive were labeled as positive (M = 2.95; SD = 0.73) and the six odors in between were labeled as neutral (M = 4.65; SD = 1.05). All three valence categories were significantly different from each other as shown by t-tests (all Ps < 0.001). Concerning arousal, the eight most arousing odors were labeled as high-arousing (M = 5.50; SD = 1.23) and the other eight as low-arousing [M = 4.35; SD = 1.07; t (41) = 6.38; P < 0.0001; d = 1.00].

Confidence–accuracy relationship

The mean Goodman–Kruskal gamma (G) correlation (Nelson, 1984) between confidence and correctness of identification was high and significantly different from zero [G(41) = 0.66; t(40) = 14.07; P < 0.001]. This is close to the correlation (G = 0.64) found in Jönsson and Olsson (2003).

Table 1 Mean arousal and valence for the odorants based on the participants' subjective ratings

Odorant	Arousal Mean (SD)	Arousal category	Valence Mean (SD)	Valence category	Proportion correct	Confidence Mean (SD)
Tar	6.07 (2.06)	high	5.98 (2.50)	neutral	0.60	0.57 (0.33)
Snuff (Swedish tobacco)	5.95 (2.02)	high	7.12 (1.98)	negative	0.69	0.77 (0.27)
Cigarette butt	5.81 (1.99)	high	7.93 (1.24)	negative	0.73	0.85 (0.22)
Motor oil	5.69 (2.16)	high	6.90 (2.10)	negative	0.31	0.47 (0.32)
Pipe tobacco	5.61 (1.79)	high	6.76 (1.89)	negative	0.16	0.43 (0.33)
Cloves	5.05 (1.82)	high	2.69 (1.49)	positive	0.60	0.79 (0.28)
Petrol	5.02 (2.20)	high	6.05 (2.25)	negative	0.37	0.51 (0.30)
Soft soap	4.76 (1.83)	high	3.50 (1.74)	positive	0.21	0.69 (0.30)
Anis	4.62 (1.91)	low	4.38 (2.13)	neutral	0.24	0.57 (0.33)
Liquorice	4.62 (1.67)	low	4.07 (2.00)	neutral	0.51	0.51 (0.33)
Tea (Earl Grey)	4.45 (1.63)	low	3.79 (1.94)	neutral	0.30	0.42 (0.31)
Dill	4.45 (1.64)	low	5.45 (1.64)	neutral	0.29	0.38 (0.27)
Soap	4.40 (2.08)	low	3.69 (1.73)	positive	0.92	0.81 (0.23)
Vanilla	4.38 (1.68)	low	2.07 (1.05)	positive	0.74	0.76 (0.27)
Lemon	4.00 (1.77)	low	4.24 (1.81)	neutral	0.38	0.56 (0.31)
Orange	3.85 (1.81)	low	2.78 (1.47)	positive	0.76	0.88 (0.18)

The proportion of correct naming and mean confidence for each odorant is also presented. The standard deviations (SD) are presented in parentheses. The odorants are ordered according to their level of arousal. The arousal and valence scales were both from 1 to 9. See text for further details.

We also analyzed the *O*/*U* index, which is a directional measure of the appropriateness of assigned confidence levels. It is simply the difference between the confidence and proportion correct (Yates, 1990). If the participants on average are more confident than correct, they are said to be overconfident. If they are less confident than correct, they are underconfident. If the confidence ratings equal the proportion correct they are instead perfectly calibrated, that is, their confidence ratings are perfectly accurate. The participants showed a clear overconfidence in their odor identifications. The mean of all participants' individual *O*/*U* indexes was significantly different from zero [*O*/*U* = 0.14; SD = 0.17; 95% confidence interval (CI) = 0.09–0.19]. This replicates the overconfidence finding of Jönsson and Olsson (2003), but the overconfidence of that study (*O*/*U* = 0.26) was higher than in the present study. This difference is not due to differences in naming difficulty, because the proportion correct naming is almost identical in the two studies (0.49 and 0.51). Since all odors in the current study were also included in the previous, we could do a direct comparison between the studies. The overconfidence of this subset of odorants in Jönsson and Olsson (*O*/*U* = 0.15; SD = 0.20; 95% CI = 0.09–0.21) showed to be non-significantly different from that of the current study [$t(80) = 0.39$; $P = 0.70$]. This observation suggests that the two studies concur more than they disagree.

Confidence–accuracy relationship as a function of emotionality

The mean *O*/*U* index was also calculated across participants as a function of valence category (positive, neutral and negative) and arousal (high and low). A repeated measures analysis of variance (ANOVA) with valence category as within-subject factor, showed that although people were slightly more overconfident in the positive ($M_{positive}$ = 0.14; SD = 0.24) and negative ($M_{negative}$ = 0.15; SD = 0.22) odor trials compared with the neutral trials ($M_{neutral}$ = 0.12; SD = 0.22), this difference was clearly non-significant ($F < 1$). An analysis between levels of arousal, on the other hand, showed that the high arousing odors (*O*/*U* = 0.18; SD = 0.20) led to significantly higher overconfidence, than the low arousing odors [*O*/*U* = 0.10; SD = 0.21; $t(41) = 2.26$; $P = 0.03$; $d = 0.39$]. In Figure 1, the *O*/*U* index calculated as a function of each level of arousal is presented. It can be seen that the higher the arousal the higher the overconfidence. The relationship is close to linear with a high Pearson correlation between arousal and *O*/*U* index [$r(9) = 0.92$; $P < 0.001$].

The above analyses showed that the overconfidence increases as a function of arousal, but not valence. A further analysis investigated whether arousal interacted with confidence. This is central, because if such an effect could be shown, independent of changes in memory, it would support the conclusion that it is indeed a metamemory effect, rather than a memory effect. For this purpose, we analyzed the mean confidence as a function of arousal category (high and low) separately for incorrectly and correctly identified (named) odors. Proportion correct was thus held constant for the two arousal categories. A repeated measures ANOVA with response type (correct or incorrect) and arousal category (high or low) as within-subject variables was used. As expected, correctly named odors were associated with a significantly higher confidence (M = 0.80; SD = 0.13) than incorrectly named odors [M = 0.49; SD = 0.19; $F(1,37) = 84.31$; $P < 0.001$; partial $\eta^2 = 0.69$]. This is

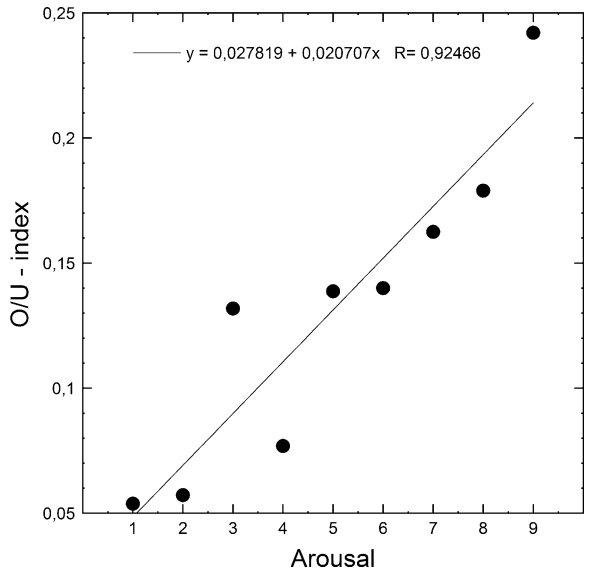

Figure 1 O/U index is plotted as a function of the individuals' arousal ratings. That is, the O/U index was calculated for all odor's given an arousal rating of 1, and so forth for the other ratings up to 9. The regression line is inserted.

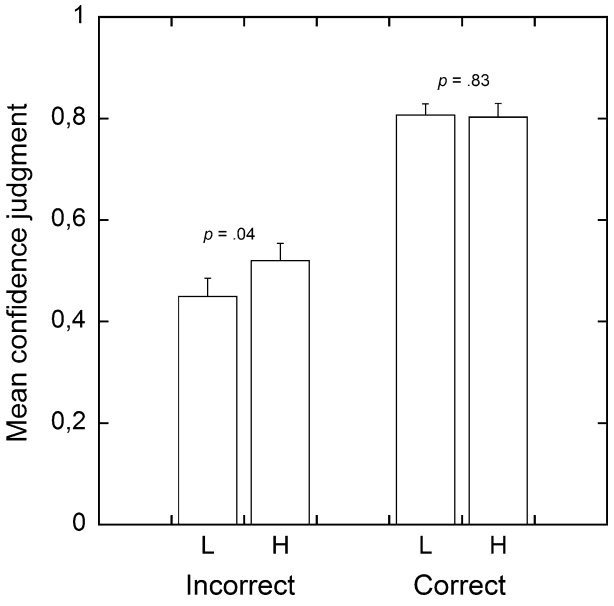

Figure 2 Mean confidence judgments for correctly and incorrectly named odors, as a function of low (L) and high (H) arousal.

consistent with previous findings (Cain *et al.*, 1998; Jönsson and Olsson, 2003). There was no main effect of arousal category on the confidence ratings [M_{high} = 0.66; SD_{high} = 0.15; M_{low} = 0.63; SD_{low} = 0.15; $F(1,37) = 1.75$; $P = 0.19$; partial $\eta^2 = 0.05$]. There was a tendency towards an interaction between response type and arousal category [$F(1,37) = 2.86$; $P = 0.10$; partial $\eta^2 = 0.07$]. An analysis of the simple effects showed that there was no difference in confidence between high and low arousing odors when the participants named them correctly [M_{high} = 0.80; SD_{high} = 0.17; M_{low} = 0.81; SD_{low} = 0.14; $t(38) = 0.21$; $P = 0.83$; $d = 0.06$]. However, as can be seen in Figure 2, following incorrect naming attempts the participants were significantly more confident in the high, than in the low arousing odors [M_{high} = 0.53; SD_{high} = 0.22; M_{low} = 0.46; SD_{low} = 0.23; $t(40) = 2.07$; $P = 0.04$; $d = 0.31$]. To conclude, when the participants in fact knew the correct answer, their confidence was not affected by how arousing the odor was. However, when they named the odors incorrectly, their confidence judgements were higher for high-arousal odors.

Concluding remarks

The gamma correlation showed that there is a good agreement between the confidence people have in their odor identifications and how correct these are. Moreover, analyses of an over-/underconfidence index showed that participants were overconfident in their odor identifications. The experiment thereby replicated the findings of Jönsson and Olsson (2003).

The analyses of arousal demonstrated that the participants were more overconfident if they considered the odor to be highly arousing than if it was less arousing. Further analyses suggested that when the participants knew the correct answer, their confidence was not affected by how arousing the odor was. However, when they named the odors incorrectly, their confidence judgements were higher for high-arousal odors. The results thus indicate that at least a part of the overconfidence repeatedly observed in odor identification may be due to their emotional intensity.

The results are of importance because they implicate that emotional variables can indeed affect peoples' metamemories, and should be taken into account when researching metamemory for other sense modalities. It is at present unclear why arousal should have this effect. Research is, as noted, scarce. Overconfidence has been observed (e.g. Talarico and Rubin, 2003) in studies of emotional memory, although the reason is still unknown. In the case of olfactory memory, Herz (1998a, 2000) proposed that people are overly confident in memories cued by odors due to the emotionality of odors. The current study provided support for this notion. In order to pin down the effects of emotions in metamemory, future studies should differentiate between effects of emotional states during encoding and recall, on the one hand, and emotional properties of the contents of memory at these stages on the other.

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