

## BRIEF REPORT

# Proust revisited: Odours as triggers of aversive memories

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According to the *Proust phenomenon*, olfactory memory triggers are more evocative than other-modality triggers resulting in more emotional and detailed memories. An experimental paradigm was used to investigate this in aversive memories, similar to those experienced by patients with posttraumatic stress disorder. Seventy healthy participants watched an aversive film, while simultaneously being exposed to olfactory, auditory and visual triggers, which were matched on intensity, valence, arousal and salience. During a second session one week later, participants were randomly exposed to one of the three triggers, and asked to think back about the film and to rate the resulting memory. Results revealed that odour-evoked memories of aversive events were more detailed, unpleasant and arousing than memories evoked by auditory, but not visual, triggers.

*Keywords:* Odour; Proust phenomenon; Aversive memory; Arousal; Detail; PTSD.

The ability of odours to spontaneously trigger autobiographical memories which are highly vivid, detailed, and affectively toned has been widely known as the Proust phenomenon (Chu & Downes, 2000). This phenomenon is named after the famous writer Marcel Proust, who first described in *A la Recherche du Temps perdu* how an emotional and vivid recollection of a childhood experience, which he had not thought about in years, was evoked by the smell of a madeleine biscuit soaked in tea (Proust, 1913). The most important implication of this phenomenon is that odours are more effective triggers of emotional memories than other-modality cues. If this is true,

then odours should also be stronger triggers of traumatic memories, which may have special significance for people with posttraumatic stress disorder (PTSD), who typically experience very detailed and emotional recollections of traumatic events. Clinicians have indeed noted that specific trauma-related smells (e.g., blood, diesel, Old Spice after shave) can be powerful precipitants of traumatic memories for patients with PTSD. Several case reports indicated that odour-evoked memories in PTSD were quite specific, deeply embedded, long lasting and did not extinguish with time (Kline & Rausch, 1985; Vermetten & Bremner, 2003). Still, there are no data on the

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emotionality of trauma memories triggered by smell relative to other sensory modalities.

The notion that odours give privileged access to detailed and emotional memories is intuitively appealing, yet there are few controlled experiments systematically comparing different-modality cues to support the Proust phenomenon. The results from these studies are not unambiguous: for instance, it has been argued that music, too, can evoke intense emotional memories (e.g., Baumgartner, 1992), providing equally powerful cues as odours (Sherer & Zentner, 2001). To the best of our knowledge, only one study demonstrated that odours evoked more emotional arousal, in terms of an increased heart rate, than musical or visual stimuli (Herz, 1998). However, this study did not investigate whether odour-evoked memories were also experienced as more emotional or detailed.

To examine the validity of the Proust phenomenon, the present study investigated whether aversive memories evoked by olfactory cues were more emotional, vivid, detailed and arousing than memories evoked by musical or visual cues. An experimental design was used in which participants were tested on an identical memory created in the lab in the context of olfactory, auditory and visual stimuli matched on intensity, valence and arousal. Because of the alleged importance of olfactory triggers in evoking traumatic memories (Vermetten & Bremner, 2003), combined with the recommendation that clinicians should more routinely inquire about meaningful odours (Kline & Rausch, 1985), the study focused on aversive memories.

The anatomical closeness of the olfactory system to the structures of emotion (amygdala) and memory (hippocampus) has often been proposed as causing the emotional potency of odour-evoked memories (Lombion, Bechetoille, Nezelof, & Millot, 2010).

Previous studies that investigated odour-evoked memories invariably probed autobiographical memories, often going back to childhood. For instance, Herz and Schooler (2002) investigated the Proust phenomenon by using a double-cuing methodology. In Phase 1, participants were asked to recall a personal memory after they were

given a verbal label of an item, and rate it on several scales: age at encoding, vividness, specificity, emotionality, and feelings of being brought back. Then, in Phase 2, participants were presented with the same item in either a visual or olfactory form, and asked to recall the event again and rate it on vividness, specificity, emotionality, and feelings of being brought back. Results showed that although memories that were accompanied by odours were more emotional and elicited more feelings of being brought back than memories evoked by visual cues, they were not different with respect to vividness or specificity. The same methodology was used by Herz (2004). After Phase 1, participants recalled the same memory three more times with either an olfactory, visual, or auditory cue. She demonstrated that odour-evoked memories were more emotional and evoked stronger feelings of being brought back to the event than memories evoked by verbal, visual or auditory cues. Again, there were no differences in vividness or specificity of the memories. Chu and Downes (2002) also used the double-cuing method, but in Phase 2 memories were cued with either a verbal label, a congruent or an incongruent odour. Results showed that memories of the congruent odour group were more emotional (in terms of pleasantness, painfulness, anxiousness), and more vivid than memories evoked by a verbal label or an incongruent odour. In a second experiment, Chu and Downes (2002) added a visual cue, and analysed level of detail by counting the number of new and previously used sentences to describe the memory. This study demonstrated that memories evoked by the congruent odour included more novel details than did those retrieved in the presence of a word, picture, or incongruent odour.

Finally, Willander and Larsson (2006) randomly cued autobiographical memories with olfactory, verbal or visual stimuli, and asked participants to rate each memory. They found that odour-evoked memories were older, and were associated with stronger feelings of being brought back to the event. However, memories evoked by visual stimuli were the most emotional, and odour-evoked memories were the least emotional.

Thus, findings of previous studies are not consistent. Only one study showed that odour-evoked memories were more vivid and detailed than memories evoked by words or pictures (Chu & Downes, 2002). Additionally, even though two studies demonstrated that odour-evoked memories were more emotional (Herz, 2004; Herz & Schooler, 2002), a more recent study did not support this finding (Willander & Larsson, 2006). Moreover, when looking closer at Herz and Schooler's (2002) findings, both visual- and odour-evoked memories scored below the mid-point of the emotionality scale, which represented the unemotional side of the scale. Thus, odour-evoked memories were less *unemotional* (Gilbert, 2008). Furthermore, an important problem associated with these methodologies is that one cannot control for individual differences between memories in terms of content, affective value, and time past since encoding. Participants were also often asked to recall the same memory multiple times, which could have influenced emotionality and the level of detail of the memory.

The present study controlled for the content of the memory by using an experimental approach in which all participants watched an aversive film used in previous research about PTSD (e.g., Holmes, Brewin, & Hennessy, 2004). The film was watched in the presence of three ambient, contextual stimuli (i.e., olfactory, auditory and visual), which served as potential triggers during a subsequent lab visit. Participants were not made aware of the stimuli, nor of the connection between stimulus and film, to enable a spontaneous connection between the triggers and the film. It was predicted that memories evoked by olfactory triggers would be more emotional, vivid, detailed, arousing and would elicit stronger feelings of being brought back to the event than memories evoked by auditory or visual triggers.

## METHODS

### Participants

Eighty female students participated in exchange for financial remuneration or course credit. We

restricted our study to an all-female population, because there is a sex difference in human olfaction (Brand & Millot, 2001). Females generally have superior olfactory abilities to males. All participants reported to be in good health, to be non-smokers, and not to have asthma. In addition, all participants stated to have normal visual, auditory and olfactory function.

### Material

*Stimulus selection.* Two pilot studies were performed to ensure that the olfactory, auditory, and visual stimuli were similar in terms of valence, intensity, arousal and salience.

In Pilot 1, Cassis (10% Cassifix, IFF, dissolved in isopropyl myristate) was chosen as the olfactory stimulus, because it was previously indicated to be a neutral odour, with moderate ratings on evaluation, potency and activity (Dalton, Mauté, Oshida, Hikichi, & Izumi, 2008). The odour was dispersed through a 1.60 × 2.00 × 2.00 m cabin using a pump-driven odour dispenser (BIOS 200, Betere Lucht BV, the Netherlands) placed behind the computer screen. As visual stimuli, 4 different colours of light were employed, which were projected onto the back wall of the test cabin behind the computer screen by a LED-wash effect lamp (Velleman, 252 × 10 mm LEDs). The distance between the computer screen and wall was 20 cm. As auditory stimuli, 4 different pieces of background music, played through speakers at either side of the computer screen, were employed (see Appendix 1).

Semantic differential scaling (Osgood, 1962; Osgood, Suci, & Tannenbaum, 1957) was used for matching of the sensory stimuli. This measure has been widely used for evaluating affective responses to stimuli of various sensory modalities. Dalton et al. (2008) recently demonstrated the suitability of semantic differential scaling for capturing the multidimensional nature of odour representations. Based on 50 semantic differential scales describing sensory attributes from 30 distinct odorants three general dimensions were found, which matched those found by Osgood

et al. (1957) for other modalities: evaluation (valence), potency (intensity), and activity (arousal). From the original set, 17 semantic pairs of polar adjectives representative of the three general dimensions (Dalton et al., 2008), and also applicable to the visual and auditory modality were selected. Each adjective pair was rated on a 7-point bipolar scale (see Appendix 2).

Fifteen female participants ( $M_{\text{age}} = 23.20$  years,  $SD = 2.73$ ) rated all nine stimuli in counterbalanced order using the 17 different semantic adjective pairs. All scores were converted into factor scores by assigning numerical values to the scale positions (-3 to +3 for the seven scale positions). For all stimuli, mean factor scores were computed (see Figure 1). Music 1 and Light 3 best matched the context odour: dependent samples  $t$ -tests indicated that only Music 1 did not differ significantly from the odour on evaluation,  $t(14) < 1.0$ , potency,  $t(14) = -1.86$ ,  $p = .084$ , and activity,  $t(14) < 1.0$ . Also, Light 3 was the only visual stimulus that did not differ significantly from the odour on evaluation,  $t(14) = 1.02$ ,  $p = .326$ , potency,  $t(14) < 1.0$ , and activity,  $t(14) < 1.0$ . Last, Music 1 and Light 3 also did not differ significantly from each other on evaluation,  $t(14) < 1.0$ , potency,  $t(14) = -1.49$ ,  $p = .160$ , and activity  $t(14) < 1.0$ . Hence, these

three stimuli were selected as memory triggers for the main study.

In Pilot 2, the three selected triggers were compared on salience. Ten female participants ( $M_{\text{age}} = 21.1$ ,  $SD = 1.97$ ) watched 11 minutes of a nature film (Meerkat Manor, Season 4, Episode 1, Part 2; <http://www.youtube.com/watch?v=TEWRCnKzy8o>) while simultaneously being exposed to the olfactory, auditory and visual triggers. After the film participants filled out a questionnaire on whether they noticed an odour/colour of light/music, intensity of odour/colour of light/music, and level of distraction by the odour/colour of light/music while watching the film. All questions were rated on a 7-point Likert scale (1 = *not at all*, 7 = *very much*). A dependent samples  $t$ -test on the mean score from the three questions indicated no significant difference in salience of the olfactory trigger ( $M = 2.93$ ,  $SD = 1.84$ ) and auditory trigger ( $M = 4.60$ ,  $SD = 1.70$ ),  $t(9) = 1.72$ ,  $p = .120$ , or the visual trigger ( $M = 2.77$ ,  $SD = 0.88$ ),  $t(9) < 1.0$ .

*Triggers.* Participants were exposed to the olfactory, visual and auditory triggers as described in Pilot 1.

*Aversive film.* A 12-minute aversive film of real-life footage was shown on a computer. The film contained several scenes of dreadful road traffic accidents, live human surgeries, part of a documentary about the Rwandan genocide, and a video about a terrible accident in the circus about an elephant breaking loose, and stepping on people. Regarding ethical issues, it was noted that previous research showing the same film (Holmes, James, Coode-Bate, & Deeprose, 2009), as well as studies using a different film with traumatic content (e.g., Hagenars, van Minnen, Holmes, Brewin, & Hoogduin, 2008; Holmes et al., 2004), found that no participants reported ongoing distress after the study had ended. In addition, although the film is momentarily distressing, the content of the film is similar to that witnessed by television viewers watching programmes such as news coverage of traffic

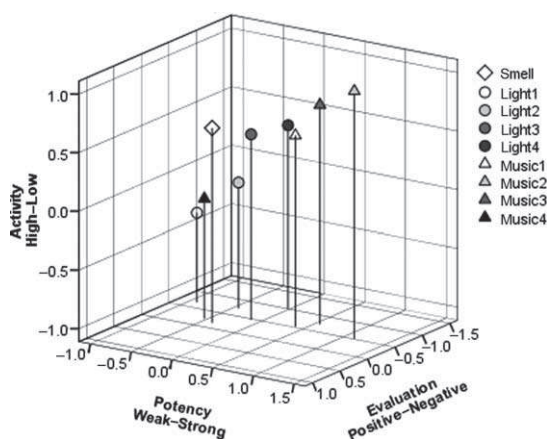


Figure 1. Three-factor plot of olfactory, musical and visual triggers, illustrating the mean score of each trigger on activity, potency and evaluation.

accidents or programmes about medical surgeries or ambulance service work (Holmes et al., 2004).

### Experiential ratings

After watching the aversive film during Session 1, participants rated the film on the following four dimensions:

1. How emotional do you feel now, after watching the film?
2. How vivid would you rate the film?
3. How pleasant would you rate the film?
4. How arousing would you rate the film?

All dimensions were rated on a 9-point Likert scale (1 = *not at all*, 9 = *very much*), except Question 3 for which a different 9-point Likert scale (1 = *very unpleasant*, 5 = *neutral*, 9 = *very pleasant*) was used. These ratings were obtained in order to compare the groups on how the film was experienced.

During the second session participants first wrote down their memory of the aversive film. Then participants rated this memory on six dimensions:

1. How emotional do you feel now, as you recall the memory of the film?
2. How vivid is your memory of the film?
3. As you think back about the film, to what degree do you have the feeling of being brought back to the moment you watched the film?
4. How detailed is your memory of the film?
5. How pleasant would you rate the film, as you think back about it?
6. How arousing would you rate the film, as you think back about it?

Again, all dimensions were rated on a 9-point Likert scale (1 = *not at all*, 9 = *very much*), except Question 5 for which a different 9-point Likert scale (1 = *very unpleasant*, 5 = *neutral*, 9 = *very pleasant*) was used.

Participants were also asked whether they had noticed a colour of light, music, and/or an odour when watching the film (Did you notice an odour/colour of light/music while watching the film during the first session?), and they rated the intensity of these triggers (How intense would you rate the odour/colour of light/music while

watching the film during the first session?) on a 9-point Likert scale (1 = *not at all*, 9 = *very much*).

Finally, participants self-rated their sense of smell, hearing and vision compared with others, varying from "Much better than that of others" to "Much worse than that of others" on a 5-point scale.

### Procedure

All participants were tested individually in a soundproof laboratory cabin equipped with a one-way screen. The study was conducted in two sessions. During Session 1 participants were first informed about the content of the aversive film and signed informed consent. Participants were instructed to watch the film with great attention, because they were told that they would be asked to answer questions about content afterwards. Participants were seated in front of a 19-inch computer screen at a distance of approximately 70 cm. While watching the film, participants were simultaneously being exposed to the auditory, visual and olfactory triggers, without explicitly drawing their attention to these. After watching the film, participants rated the film on emotionality, vividness, pleasantness, and arousal. Then, participants were told they would again watch a different film one week later and fill out questions afterwards.

During the second session, approximately one week later (6–8 days), participants were randomly assigned to the olfactory, visual or auditory condition, in which they were exposed to one of the triggers in the same fashion as during Session 1. Participants were told they did not have to watch another film, but that they had to think back about the film they watched during the first session. Participants then received the following instruction:

Try to think back as best as you can to the film you watched here during the first session one week ago, and write down everything you remember about the film as exactly and completely as possible. After you have written down your memory of the film you will be asked to fill out several questionnaires which relate to your memory of the film and how you experience this memory now.



**Table 1.** Means (SDs) for each rating directly after watching the film during the first session per condition

Scale	Condition		
	Odour	Auditory	Visual
Emotionality	6.79 (0.78)	6.33 (0.76)	6.68 (0.99)
Vividness	7.17 (1.40)	6.63 (1.53)	6.68 (1.55)
Pleasantness	2.00 (1.02)	2.54 (1.18)	2.05 (1.00)
Arousal	6.33 (2.08)	6.29 (1.83)	6.09 (2.07)

Hereafter, participants were debriefed and paid for their participation.

## Results

A total of 10 participants were excluded in the analysis. Seven participants were excluded, because immediately after watching the film, these participants reported a score of 4 or less on a 9-point Likert scale (1 = *not at all*, 9 = *very much*) on the question: “How emotional do you feel now, after watching the film?” Two participants were excluded because they did not show up for Session 2, and one participant was excluded due to technical problems. The final analysis consisted of 70 female participants ( $M_{\text{age}} = 21.32$ ,  $SD = 2.69$ ). Specifically, 24 participants were randomly assigned to the odour condition, 24 participants to the auditory condition, and 22 participants to the visual condition.

First, a one-way between-subjects analysis of variance (ANOVA) tested whether the three groups differed in how they experienced the film

during the first session. Table 1 shows the means and standard deviations of the ratings.

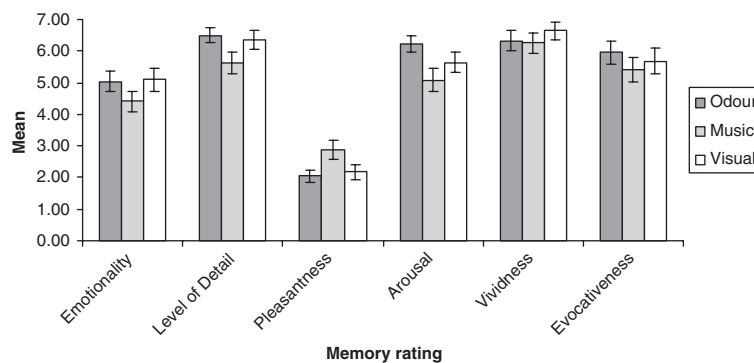
There were no differences in emotionality,  $F(2, 67) = 1.91$ ,  $p = .157$ , vividness,  $F(2, 67) < 1.0$ , pleasantness,  $F(2, 67) = 1.87$ ,  $p = .162$ , or arousal,  $F(2, 67) < 1.0$ , between the three conditions during Session 1.

To determine whether memories of the film evoked by an odour differed from memories evoked by an auditory or visual stimulus another one-way ANOVA was conducted. Figure 2 depicts the mean ratings of the memory of the film for each condition.

There was a significant difference across conditions on the pleasantness of the memory,  $F(2, 67) = 3.50$ ,  $p = .036$ , and also on arousal,  $F(2, 67) = 3.24$ ,  $p = .045$ . There was a trend in subjective level of detail,  $F(2, 67) = 2.63$ ,  $p = .080$ . On the other three ratings, no differences across conditions were encountered.

Regardless of the statistical trend in subjective level of detail, we proceeded to conduct post hoc test for the pertinent comparisons, i.e., odour–auditory and odour–visual trigger. Post hoc Fisher LSD test revealed that memories evoked by an odour were significantly less pleasant ( $p = .016$ ), more arousing ( $p = .013$ ) and experienced as more detailed ( $p = .036$ ) than memories evoked by music. Memories evoked by a visual trigger did not differ significantly from memories evoked by an odour or by music.

To check whether participants actually noticed all three triggers, and to investigate perceived



**Figure 2.** Means of each memory rating of the film by cue-condition. Error bars represent one standard error of the mean.

intensity, dependent samples *t*-tests were conducted. Results showed that participants had noticed the visual trigger significantly less frequently ( $M=0.31$ ,  $SD=0.47$ ) than either the olfactory trigger ( $M=0.64$ ,  $SD=1.02$ ),  $t(69) = -2.70$ ,  $p = .009$ , or the auditory trigger ( $M=0.86$ ,  $SD=0.35$ ),  $t(69) = -8.34$ ,  $p < .001$ . However, the olfactory and auditory triggers were noticed equally often,  $t(69) = 1.69$ ,  $p = .096$ . Additionally, when the visual trigger was noticed (only 15 participants noticed both the olfactory and the visual trigger, and only 20 participants noticed both the auditory and the visual trigger) it was also experienced as less intense ( $M=4.93$ ,  $SD=2.12$ ) than the olfactory trigger ( $M=6.93$ ,  $SD=2.49$ ),  $t(14) = -3.13$ ,  $p = .007$ , but did not differ from the auditory trigger ( $M=5.45$ ,  $SD=2.70$ ),  $t(19) = -0.51$ ,  $p = .61$ .

Finally, to investigate whether the memory performance of participants who noticed the trigger in Session 1 differed from those that did not notice this, independent samples *t*-tests were conducted. It was indicated that there were no significant differences in emotionality,  $t(68) = 0.62$ ,  $p = .55$ , vividness,  $t(68) = 1.01$ ,  $p = .32$ , evocativeness,  $t(68) = 0.95$ ,  $p = .35$ , level of detail,  $t(68) = 0.85$ ,  $p = .40$ , pleasantness,  $t(68) = 1.1$ ,  $p = .28$ , and arousal,  $t(68) = -0.78$ ,  $p = .44$ , of the memories of the aversive film between participants who noticed or did not notice the trigger during the first session of the experiment. Thus, there were no differences in implicit versus explicit encoding of later memory cues.

## DISCUSSION

The present study demonstrated that aversive memories evoked by olfactory triggers were more detailed, arousing and unpleasant than memories evoked by auditory triggers. However, odours were not more evocative or emotive than visual triggers. It could be argued that a necessary implication of the Proust phenomenon is that odours are more effective triggers of emotional memories than other-modality triggers. Under such strong assumptions the results reported

here do not confirm the Proust phenomenon. Nonetheless, our findings do extend previous research by demonstrating that odour is a stronger trigger of detailed and arousing memories than music, which has often been held to provide equally powerful triggers as odours (Sherer & Zentner, 2001). It should be noted, however, that the present results cannot be generalised to the whole human population, because only female participants were included. However, since more women than men suffer from PTSD (Tolin & Foa, 2006), results can be meaningful for this particular population.

There was no difference between the odour and the auditory condition in how emotional people felt when thinking back about the film. Possibly, it was difficult for people to indicate which general emotional feelings were evoked by the memory of the film, because we did not differentiate between specific emotions in the question asked. In addition, we did not control for how people felt when entering the lab, which could also have influenced how emotional people felt when thinking back about the film. Mood can be divided into two central dimensions: arousal and hedonic valence (Lang, Bradley, & Cuthbert, 1990). The finding that participants did experience odour-evoked memories as more arousing and unpleasant may still indicate that odours did evoke more emotional memories than auditory triggers.

In addition to the analyses on the memory ratings, we conducted an analysis on recorded memories of the participants about the aversive film. However, no differences were encountered between conditions in how many scenes from the film they remembered nor in how many words they used to describe these scenes as an indication of objective level of detail. We wish to point out that it was not our original intention to use the recorded memories for qualitative/quantitative analysis, and that these analyses were conducted on a post hoc basis. However, if we had intended to investigate these recorded memories for objective level of detail, we should have stated the instructions differently and we should have set a specific time for them to write down as much as they remembered. Specifically, instructions should

have stated that participants had to write down their memory of the film in as much detail as possible, using complete sentences, not keywords, during a predetermined time window of, e.g., 5 minutes. Future research should take this into account.

No differences between the three modalities were found on vividness and evocativeness of triggered memories. A possible explanation could be that the time between the inducement of the memory—one week—and thinking back about it was too short. Note, however, that although people often experience odour-evoked memories to be highly vivid, there is not much empirical support for this. That is, the only study showing that odour-evoked memories were experienced as more vivid had no experimental design (Chu & Downes, 2002), and therefore odour superiority in this study may have been accounted for by the memories that were selected or by the specific qualities of the trigger.

In the present study, visual triggers appeared to evoke memories that were rated in between the odour- and auditory-evoked memories on level of detail, pleasantness and arousal, although not significant. Possibly the visual trigger was not strong enough, because based on questions asked during the second session of the experiment participants reported that they noticed the visual trigger less frequently during the first session of the experiment, and that they also experienced it as less intense than the olfactory trigger. However, in the pilot studies participants reported *during* the exposure to the sensory triggers that they experienced the three triggers to be equally intense. A pertinent difference between the pilot studies and the proper experiment is that reports were based on ongoing experience in the former type of studies as opposed to memory (of the previous session) in the latter type of study. It is unclear which results—either those from the pilot studies showing no difference in salience and intensity between the visual and olfactory triggers or those from the main study that in fact did show such differences—most accurately reflect the actual state of affairs. Furthermore, the fact that the visual trigger was as effective at evoking emotionality as the odour

trigger, even though the visual trigger was perceived at lower intensity and noticed less often, suggests that the purple hue of light was processed automatically and implicitly. Future studies could perhaps be designed to match triggering stimuli on nature of cognitive processing.

The present study differs from previous studies in two important ways: First, we controlled for the content of the memory that was experimentally induced. Second, we carefully matched the olfactory, auditory and visual triggers on valence, intensity and arousal. The findings from our study suggest that, while odours are evocative and emotive triggers of memory, they are not superior to visual triggers. Future research may further elucidate similarities and differences between these modalities. Additionally, future research may include objective measures, such as heart rate frequency or the physiological startle reflex, as converging evidence of the emotionality of odour-evoked aversive memories.

It could be argued that a memory of watching an aversive film created in the laboratory is not a truly autobiographical memory in the sense that the events happened to the people filmed, not to the individual watching them. However, a memory about an (aversive) film is considered autobiographical in the sense that the individual truly watched the film. Moreover, the trauma film paradigm has been used excessively in research on PTSD, and has been shown to induce negative mood, distress, dissociation, and other PTSD-like symptoms such as fear, avoidance and arousal (Holmes & Bourne, 2008). Additionally, intrusions of the film that were reported in previous research were experienced as unwanted, and the nature was similar to intrusions described by patients with PTSD (Holmes et al., 2004). This indicates that the trauma film does provide a useful paradigm to study traumatic experiences and memories.

Taken together, the present study replicated and extended results of previous research by demonstrating that odour-evoked memories of aversive events are more detailed and emotional than memories evoked by auditory stimuli. However, whether odours are also more effective than



visual triggers in evoking emotional memories has not been resolved.

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APPENDIX 1

*Musical and visual stimuli used in Pilot study 1 to select stimuli that were similar in valence, intensity and arousal as the olfactory stimulus*

<i>Stimulus</i>	<i>Composer: title</i>	<i>Red/Green/Blue intensity</i>
Music 1	M. Simmonds: Flowing streams	—
Music 2	M. Simmonds: Natural power	—
Music 3	M. Simmonds: Leaves in the wind	—
Music 4	Ricardo Villalobos: Mecker	—
Light 1 (red/pink)	—	R:255 G:0 B:11
Light 2 (purple/pink)	—	R:255 G:0 B:48
Light 3 (purple)	—	R:255 G:0 B:92
Light 4 (blue/green)	—	R:0 G:255 B:52

APPENDIX 2

*Adjective pairs used for semantic differential scaling for each dimension*

<i>Factor 1: Evaluation</i>	<i>Factor 2: Potency</i>	<i>Factor 3: Activity</i>
Fresh–Stale	Strong–Weak	Ordered–Chaotic
Good–Bad	Powerful–Powerless	Quiet–Noisy
Happy–Sad	Harsh–Mild	Relaxing–Stimulating
Harmonious–Inharmonious		Wet–Dry
Healthy–Unhealthy		Muddy–Clear
Beautiful–Ugly		
Smooth–Rough		
Clean–Dirty		
Safe–Dangerous		

*Note:* From Dalton et al. (2008).

**Example of question of semantic differential scaling to rate a stimulus**

I experience the odour as:

1	2	3	4	5	6	7
Polar term X						Polar term Y

- (1) Very X
- (2) Quite X
- (3) Slightly X
- (4) Neither X, nor Y
- (5) Slightly Y
- (6) Quite Y
- (7) Very Y