Exploiting plant adaptations: peppermint makes you hurry whilst lavender helps you linger (a pilot experiment)

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Abstract

The effects of fragrances on humans have received much attention. We hypothesise that fragrances have differing effects due to their different adaptive strategies. In the natural world, peppermint acts as an herbivore deterrent whilst lavender is likely involved in attraction, and potentially, retention of pollinators. We predicted that these strategies would manifest themselves in human subjects as a tendency to hurry when exposed to peppermint fragrance and to linger when exposed to lavender. We tested this hypothesis using a priming paradigm as a novel method to measure the effects of fragrance on human behavior. After reducing the confounds of expectancy and demand characteristics that have impacted previous studies, we showed that, as predicted, lavender fragrance results in a longer time to walk down a corridor compared to peppermint.

Keywords: expectancy characteristics, fragrances , olfaction, priming.

Introduction

Much attention has been afforded to the effects of fragrances on humans; including effects on mood, behaviour, physiology (Herz 2009), and the mechanisms by which these occur (Aprotosoaie et al. 2014; Gostner et al. 2014). However, the question of why fragrances have these properties has received less attention.

Traditionally, the production of secondary metabolites has been considered costly, however, recent evidence suggests that plants exploit multiple strategies to reduce these costs (Neilson et al. 2013). However costly, fragrances must provide an adaptive benefit. Whilst plant fragrances are targeted for defense and pollinator attraction, humans exploit them for activities such as aromatherapy. We hypothesise that the differences in the perceived effects of fragrances may result from the different functions that they perform in their natural environment.

Peppermint leaves produce high levels of monoterpenes (Gershenzon 2000), volatile substances that have been implicated in a variety leaf defense mechanisms (Langenheim 1994). The fragrance produced by peppermint leaves acts as a deterrent to herbivores and has been shown to possess properties that repel the two-spotted spider mite (Momen et al. 2001). It should be noted that a range of essential oils, including peppermint and lavender, have been shown to be effective insecticides against some pest species (Cloyd et al. 2009; Shaaya et al. 1991). However, the concentrations of oils experienced by the insects in this context are much greater than would be experienced by insects in the natural environment.

In humans, peppermint fragrance administered on an adhesive strip under the nose has been shown to increase athletic performance (Raudenbush et al. 2001). Peppermint may also affect physiological measures when participants are not explicitly aware that it is being administered. Sleeping participants displayed increased heart rate and a greater frequency of EEG bursts when exposed to peppermint fragrance (Badia et al. 1990).

Fragrances produced by leaves can be involved in attracting pollinators as well as deterring herbivores. In marjoram the leaves produce fragrance which attracts pollinators from a distance, while the fragrance from the flowers indicates nectar location more precisely (Beker et al. 1989). Lavender plants may use a similar strategy as both leaves and flowers produce fragrance. Linalool is a major constituent of lavender fragrance and has been shown to produce anaesthetic effects by blocking sodium channels (Leal-Cardoso et al. 2010). It is possible that the fragrance reduces activity in pollinators, thus encouraging individuals to visit multiple flowers rather than move to another species or patch. There is some evidence to support this hypothesis: honey bee aggression can be reduced through exposure to lavender fragrance (van der Burg et al. 2014), and a sedative effect of lavender has been reported in mice (Buchbauer et al. 1991) and humans (Aprotosoaie et al. 2014). Lavender fragrance has also been reported to increase the amount of time customers spent in a restaurant (Guéguen and Petr 2006).

Previous fragrance studies involving humans have highlighted the issues of participant expectancies and demand characteristics (Herz 2009; Howard and

Hughes 2008; Ilmberger et al. 2001). In order to reduce these confounds, we piloted a priming paradigm based on a study by Bargh and colleagues (Bargh et al. 1996). Participants were primed with a fragrance and the time taken to walk down the corridor, after leaving the experiment, was measured. This paradigm has the advantage that the participants believe the experiment has finished and are therefore less likely to display demand characteristics.

Participants were exposed to either lavender or peppermint fragrance. We predicted that the time taken to walk down a specified length of corridor would be longer for those participants exposed to lavender than for those exposed to peppermint fragrance.

In order to establish whether fragrance can affect behaviour without participants being aware, half of the participants were explicitly informed that the research study was investigating the effects of fragrance, while the other half were informed that the study was investigating the effects of the time of day. The fragrance to which they were exposed, and any of its associations, were not discussed with participants. It was predicted that the effect of the fragrance on walking time would be enhanced when participants had been made explicitly aware of the fragrance.

Methods

Participants were taking part in an experiment investigating the effects of fragrance on reaction times (not presented here) and the time taken for them to walk down the corridor was included as an extra measure.

Using a similar method to that reported for previous studies (Colzato et al. 2014; Sellaro et al. 2015), fragrance was diffused into the experiment room before testing. The fragrance was dispensed using a Vortex Activ USB (Dale Air, Rochdale, UK), a dispensing system with four independent fans. The room was odour-neutral prior to any fragrance being dispensed. The dispenser was placed on a shelf next to the desk at which the participants completed the computer-based reaction time task. The dispenser was set back on the shelf so as to reduce its conspicuousness. Three drops of pure essential peppermint or lavender oil (Neal's Yard Remedies, Dorset, UK) were placed onto a Vortex cartridge and the cartridge was placed into the dispenser. Separate cartridges were used for the different fragrances to ensure there was no mixing. Each cartridge was used three times and then replaced. The same fan was used for both fragrances to ensure they were dispensed at equal rates. The dispenser was switched on 20 minutes before the start of the experiment to ensure that the fragrance had time to diffuse throughout the room. The machine continued to dispense fragrance throughout the experiment.

Participants completed a computer-based reaction time task, and were informed either that the research was investigating the 'effects of fragrance' or the 'effects of time of day' on reaction times. While participants in the latter condition were still able to perceive the fragrance, their attention was not drawn to its presence and most importantly they were not aware of its relevance to the study. The initial briefing and reaction time task lasted 20 mins in total (a similar amount of time to that required for fragrance molecules to reach the blood stream and produce physiological effects (Herz 2009)). Participants were then thanked and reimbursed for their time. To minimise fragrance diffusion into the corridor, the door from the experiment room remained closed until the participant was ready to leave and was shut again immediately after their departure.

Two motion sensors were mounted on the wall of the corridor outside the experiment room. The first sensor was 0.5m from the door, allowing participants space to turn out of the door before measurements began. The second sensor was 4.55m further down the corridor. The motion sensors were wireless and broadcasted to a receiver. The receiver was connected to an amplifier through which accurate timings could be recorded using the software Spike (CED, Cambridge, UK).

Participants gave written consent in accordance with the Declaration of Helsinki, and the experiment was approved by the Local Research Ethics Committee (School of Biosciences, Cardiff University, UK). Participants were reimbursed for their time. All participants were requested to avoid caffeine for three hours prior to the study. Twenty-six naïve participants completed the experiment. One participant reported having consumed caffeine 30 mins prior to participation and their data was excluded from the analysis.

Results

Participants were assigned to one of four conditions: lavender with fragrance explanation (n=7); lavender with time of day explanation (n=6); peppermint with fragrance explanation (n=5); peppermint with time of day explanation (n=7). Due to the unbalanced data, results were analysed with a model simplification approach using the lme4 package (Bates et al. 2011) in R (R Development Core Team 2011), with the initial general linear model including 'fragrance', 'explanation' and the interaction. Models were compared using the Akaike Information Criterion (AIC), with a lower AIC being more preferable. This approach identified the best model to consist only of the factor 'fragrance' (see Table 1), indicating that there was no interaction between 'fragrance' and 'explanation' and that 'explanation' alone did not significantly affect the time to walk down the corridor. Compared to peppermint fragrance, exposure to lavender fragrance significantly increased time to walk down the corridor ($F(1,23)=4.733$, $p=.040$, see Figure 1).

Table 1. Comparison of GLM models based on the Akaike Information Criterion

Model	AIC
Fragrance + Explanation + Interaction	52.45
Fragrance + Explanation	53.24
Explanation	55.24
Fragrance	50.64

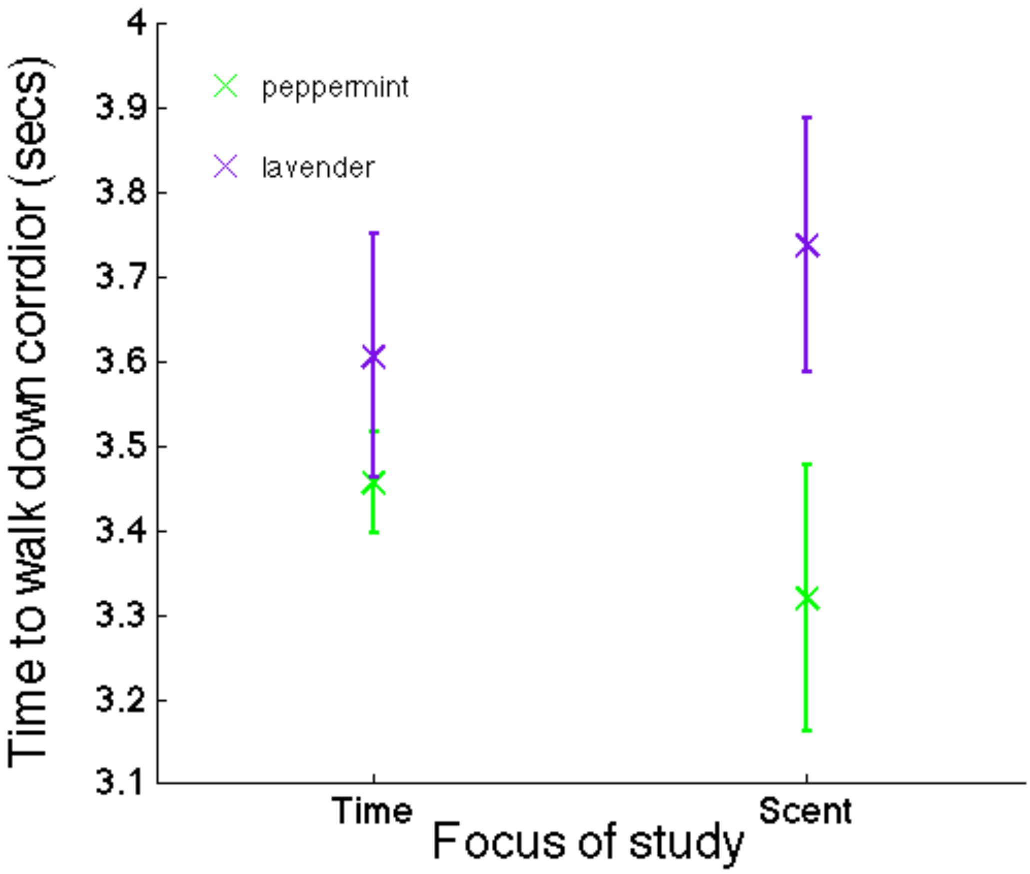

Figure 1. Mean (± standard error) time to walk down the corridor was longer when participants were exposed to lavender fragrance compared to peppermint fragrance.

Discussion

It was hypothesised that peppermint and lavender fragrances have differing effects on humans due to their different adaptive strategies. Peppermint is derived from monoterpenes which act as herbivore deterrents (Gershenzon 2000; Langenheim 1994) whilst lavender is likely involved in attraction, and potentially, retention of pollinators. We predicted that these strategies would manifest themselves in human subjects as a tendency to linger when exposed to lavender fragrance and to hurry when exposed to peppermint.

As predicted, humans that had experienced peppermint fragrance took less time to walk down the corridor than those that experienced lavender. This is consistent with previous studies where peppermint has been shown to have energising properties (Badia et al. 1990; Raudenbush et al. 2001; Raudenbush et al. 2009) and lavender has been shown to have sedative effects (Aprotosoaie et al. 2014; Buchbauer et al. 1991; van der Burg et al. 2014), most likely due to its constituent, linalool, which blocks sodium channels, producing an anaesthetic effect (Leal-Cardoso et al. 2010). However, this is the first evidence that exposure to these fragrances could actively modify walking behaviour after exposure has finished, and when participants are unaware that their activity is being monitored. It is not possible to tell whether one or both of the fragrances drove the difference between the walking speeds for the two fragrances. This research was designed as a pilot experiment to test the paradigm and a future experiment involving a greater number of participants could also include a non-odour control to assess the magnitude of the modification to walking speed for the different fragrances.

Previously expectancies and demand characteristics have been found to play a significant role (Howard and Hughes 2008) in studies investigating fragrances, however we found no significant effect of participants knowing that the fragrance in the room was relevant to the study . We suggest that by taking measurements after participants believed the study was finished, we substantially reduced the level of demand characteristics that would otherwise be displayed.

In conclusion, the priming paradigm provides a novel way to measure the effects of fragrance on human behaviour whilst reducing the confounds of expectancy and demand characteristics that can have a large impact on fragrance studies. We provide evidence that lavender fragrance may result in longer walking times, compared to peppermint, and relate this effect to the differing adaptive strategies of these fragrances in the natural world.

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