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# Expectancies, not aroma, explain impact of lavender aromatherapy on psychophysiological indices of relaxation in young healthy women

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**Objectives.** In aromatherapy, lavender aroma is reputed to assist with relaxation. However, while there is much anecdotal evidence to that effect, the empirical literature is very inconsistent. Failure to employ adequate placebos, proper blinding, objective measures, or screening of prior beliefs about aromatherapy means that many previous findings could have been influenced by expectancy biases. The present study sought to establish whether lavender aroma and/or expectancies affect post-stress relaxation.

**Design.** A double-blind, 3 (aroma) × 3 (instruction) × 10 (time in minutes) mixed-factorial placebo-controlled trial.

**Method.** In a laboratory, 96 healthy undergraduate women were exposed to lavender, placebo, or no aroma during physiologically assessed relaxation after an arousing cognitive task. Where an aroma was presented, an instructional priming procedure was used to manipulate participants' expectancies about the aroma's likely impact on their ability to relax.

**Results.** Results showed no effect of aroma on galvanic skin response during relaxation. However, the nature of instructional prime was associated with relaxation patterns: when expecting the aroma to inhibit them, participants relaxed more; when expecting facilitation, participants relaxed less. The effect was not seen with regard to self-reported relaxation (as represented by changes in state anxiety) and was independent of ratings of attitudes towards aromatherapy.

**Conclusions.** The findings imply that the previous associations of lavender aroma with assisted relaxation may have been influenced by expectancy biases, and that the relevant expectancies are easily manipulable.

Scented oils have been used as medicinal healing agents for centuries (Allardice, 1998; Damian & Damian, 1995) and aromatherapy is among the most popular contemporary forms of complementary medicine (D'Angelo, 2002). Despite this, neither the biochemical plausibility of aromatherapy (Buckle, 1997) nor its prophylactic efficacy (Cooke &

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Ernst, 2000) has been conclusively determined. While theories of aromatherapy have occasionally invoked the mediation of cognitive variables such as associative memory (Jellinek, 1997), behavioural conditioning (Devriese *et al.*, 2000), and hedonic valence (Ehrlichman & Bastone, 1992), the view presented by majority of proponents is that aromatic oils can exert direct pharmacological effects upon bodily systems. Both conceptual and empirical evidence has been offered in this regard. Conceptually, the proximity of the olfactory and limbic systems has often been cited as indicating the probability that olfactory stimuli might serve to trigger psychosomatic healing mechanisms (Diego *et al.*, 1998), although such collocation might just as easily imply that aromas are liable to have adverse rather than beneficial effects. Empirically, animal studies have suggested that some aromatherapy oils may have sedative effects among guinea pigs (Lis-Balchin, Hart, & Wan Hang, 2002) and mice (Buchbauer, Jirovetz, Jager, Plank, & Dietrich, 1993), but only (a) in large doses and (b) among animals in which states of superphysiological arousal have first been established (e.g. by administration of caffeine or electrical shock). It remains the case that the reputation of aromatherapy among its human consumers largely rests on an extensive pool of supportive but anecdotal testimony.

One of the most common uses of aromatherapy is for the induction, or enhancement, of relaxation (Sanderson & Ruddle, 1992), and perhaps the most widely recommended essential oil for relaxation is that of lavender (*Lavandula angustifolia*; D'Angelo, 2002; La Torre, 2003; Tisserand, 1987). In clinical contexts, lavender-based aromatherapy is commonly recommended for use with clinically hyperaroused populations, such as older adults with dementia (Brooker, Snape, Johnson, Ward, & Payne, 1997). However, the empirical evidence underlying this recommendation is quite modest, and it is difficult to avoid the conclusion that its highly tentative nature is not widely appreciated. For example, in many studies of clinical populations, the administration of aroma is confounded with the simultaneous administration of physical massage (e.g. Kite *et al.*, 1998; Soden, Vincent, Craske, Lucas, & Ashley, 2004; Wilkinson, Aldridge, Salmon, Cain, & Wilson, 1999). Of the two studies of dementia patients to have directly compared aromatherapy in combination with massage against aromatherapy alone or massage alone (Brooker *et al.*, 1997; Smallwood, Brown, Coulter, Irvine, & Copland, 2001), neither found an additive benefit for the administration of aromatherapy.

Those studies to have employed aromas alone (without massage) have almost exclusively avoided comparing lavender with a plausible placebo. Holmes *et al.* (2002) used steamed water as a placebo aroma, despite the fact that it is odourless. Similarly, Ballard, O'Brien, Reichelt, and Perry (2002) used sunflower oil as a placebo, despite the fact that its virtually odourless status is recognized within aromatherapy by its classification as a carrier, rather than essential, oil (Quinessence Aromatherapy, 2007). Rather than testing the differential sedative effects of a particular aromatherapy oil, such studies are effectively comparing the presence and the absence of aromas in general. In any event, the very high prevalence of anosmia among dementia populations (Doty, 1989; Knupfer & Spiegel, 1986; Murphy, 1993; Rezek, 1987; Serby, Larson, & Kalkstein, 1991) suggests that such groups may not offer the most convincing test-bed for therapeutic interventions that are reliant on the detection of olfactory stimuli.

Even when anosmia is not expected to be present to a significant extent, further problems can emerge when aromatherapy research is conducted in clinical settings. Often, participants are tested in groups rather than in isolation (e.g. Holmes *et al.*, 2002), samples are very small (e.g. $N = 7$ in Snow, Hovanec, & Brandt, 2004; $N = 4$ in Brooker *et al.*, 1997), *ad hoc* rather than standardized scales are used to measure

outcomes (e.g. Buckle, 1993), a large percentage of clinically aroused participants are taking sedative medication (especially likely when hospitalized; e.g. Itai *et al.*, 2000), and – in repeated measures studies – institution-specific logistical parameters prevent researchers from randomizing the presentation of their experimental conditions, thus elevating the likelihood that observed changes are the result of order effects such as habituation to hospital surroundings (e.g. Itai *et al.*, 2000).

A number of researchers have attempted to examine the effects of aromatherapy among healthy adults in controlled settings, with a number of such studies commonly cited in support of the claim that lavender assists relaxation. It is notable, however, that in much of this research, outcome is measured subjectively by self-report (e.g. Baron & Thomley, 1994) and often among participants whose recruitment was predicated on an explicit prior admission of sympathy towards the claims of aromatherapy (e.g. Edge, 2003). The use of objective measures of outcome has revealed mixed findings. In one study, participants' performance on a battery of cognitive tasks suggested that lavender aroma impinges negatively on working memory when compared with rosemary aroma (Moss, Cook, Wesnes, & Duckett, 2003), although the authors failed to correct for multiple comparisons when establishing statistical significance in their analyses. Using multiple psychometrically validated measures of pain acuity, Gedney, Glover, and Fillingim (2004) found participants in a thermal pain induction experiment to report no differences in ratings of contact heat, pressure, or ischemic pain when exposed to lavender, rosemary, or control aromas. Further, the use of physiological indices of relaxation has failed to demonstrate associations between lavender and cardiovascular functioning following exercise (Romine, Bush, & Geist, 1999), cardiovascular functioning following rumination stress (Motomura, Sakurai, & Yotsuya, 2001), or heart rate or body temperature following a cognitively challenging task (Burnett, Solterbeck, & Strapp, 2004). Lavender aroma has been associated with EEG patterns indicative of relaxation in some studies (Badia, Wesensten, Lammers, Culpepper, & Harsh, 1990; Diego *et al.*, 1998; Field *et al.*, 2005; Lorig, Herman, Schwartz, & Cain, 1990; Lorig & Schwartz, 1987) but of discomfort in others (e.g. Klemm, Lutes, Hendrix, & Warrenburg, 1992; Lee *et al.*, 1994; Lorig & Schwartz, 1988). As with research in applied settings, some laboratory research fails to include non-lavender aroma conditions that would allow for the identification of lavender-specific effects as opposed to effects for odours in general (e.g. Duan *et al.*, 2007). A number of studies comparing different aromas have shown no differential effect for lavender on physiological responses, such as cortisol production or heart rate (Atsumi & Tonosaki, 2007; Kuroda *et al.*, 2005).

Whether outcomes are measured subjectively or objectively, effects of participant expectancy represent a distinct risk to experimental validity. The expectation that the presence of a particular aroma (or of any aroma) is part of an experimental manipulation may affect participants' behaviour or physiological state in ways that have little to do with aromatherapy. Research where the expectation of efficacy is measured in advance demonstrates this risk. For example, in a study where nurses were asked whether they felt the introduction of aromatherapy lavender oil burners would enhance their work environment, the percentage of respondents reporting such an expectation (88%) was virtually identical to that reporting an improvement in environment *after* the burners had been introduced (85%; Tysoe, 2000). Correspondingly, Spector, Carey, Jorgensen, Meisler, and Carnrike (1993) found that aromatherapy scents were ineffective in reducing anxiety arising from a speech task when participants showed little expectation of such efficacy. Such points highlight the need for researchers to seek to control for

expectancy effects through measures such as blinding. Unless some account is taken of expectancy effects, it is difficult to avoid the conclusion that participants may easily surmise the purpose of an aroma-based experimental manipulation (Campenni, Crawley, & Meier, 2004). For example, in the study by Burnett *et al.* (2004), participants had drops of aromatherapy oils applied to their wrists prior to engaging in a laboratory stress task, undergoing physiological monitoring, and completing mood scales. The authors report that they debriefed participants about their hypotheses *ex post facto*, suggesting that they had intended that participants be blind; but, given the salient nature of the aroma manipulation, it seems unlikely that participants would not have inferred the study rationale from this procedure.

Only a small number of studies on the effects of lavender have attempted to control for expectancy. Raudenbush, Koon, Smith, and Zoladz (2003) surreptitiously presented different aromas to 20 participants taking part in a large-scale sleep study, but found lavender to have no effect on sleep quality (based on indices such as number of movements during sleep). Fernandez, Hernandez-Reif, Field, Diego, Sanders, and Roca (2004) examined EEG responses to lavender and rosemary aromas in new-born infants (who it can be assumed are not susceptible to expectancy effects), and found no differential effect of aroma on response (cf. Sanders *et al.*, 2002).

In summary, research purporting to test the sedative effects of lavender aromatherapy has been fraught with a number of methodological problems. While several studies have compared lavender to odourless conditions (including odourless placebos), such a design does not allow for the particular effects of lavender (as opposed to odours in general) to be tested. There are many possible explanations as to why participants might respond positively to the presentation of miscellaneous aromas, not least of which relate to expectancy effects. Those studies that have compared lavender to other aromas have tended to employ other essential oils with reputedly beneficial aromatherapeutic effects on mood (such as jasmine or rosemary). Such studies have appeared more likely to demonstrate beneficial effects for some or all of the aromas used than for lavender alone. (In one study, where the effect of lavender on mood was compared to that of a non-aromatherapy alternative (Knasko, 1992), the aroma selected was so unpleasant that an advantage for lavender was almost inevitable: the aroma used was dimethyl sulphide, one of the main odour components of human flatus (Suarez, Springfield, & Levitt, 1998)). Further, the research literature on lavender aroma and relaxation is largely based on the study of non-blinded participants by non-blinded researchers, despite the fact that attitudinal variables appear to be very influential.

The present study sought to investigate the effect of lavender aroma on physiologically assessed relaxation following a laboratory-based cognitive arousal task in healthy adults. The effect of lavender was compared against that of a placebo aroma (not reputed to have sedative qualities) and against an odourless control condition. A blinding protocol was employed to ensure that the researcher administering the experiment was unaware of which aroma was being presented to each participant in the aroma groups. Importantly, two attempts were made to control for the potentially biasing effects of participant expectancies. Firstly, an experimental manipulation was employed where participants were randomly assigned to one of three instructional prime conditions: first in which they were informed that the aroma they are about to be presented with assists relaxation; second in which they were informed it inhibits relaxation; and the last in which they were given no information in this regard. By explicitly drawing participants' attention to the potential for the aroma to affect relaxation, and by attaching an explicit sedation valence to the aroma, the procedure

was intended to offset participants' tendency to draw independent conclusions about the likely effects of the aroma. Secondly, all participants completed a health questionnaire, embedded in which a selection of items intended to assess any positive orientation towards aromatherapy or complementary therapies in general. It was intended that this measure could be used to assess whether prior orientation towards aromatherapy is predictive of relaxation patterns observed in response to aromas.

## Methods

### *Participants*

Participants were 96 healthy female undergraduates (mean age = 20.06 years, $SD = 4.72$ years), recruited through class announcements. The announcements identified that the experiment would comprise a 'study of relaxation and relaxation techniques' and would involve physiological monitoring. All were students of psychology and were rewarded with course credit. All participants were explicitly asked whether they were allergic to any perfumes or scented products; none were. Heterogeneity of physiological factors (such as menstrual phase) was controlled by use of random allocation to groups and conditions. Participants were randomly allocated to one of three aroma groups: lavender aroma ($N = 33$); placebo aroma ($N = 33$); and (no-aroma) control ($N = 30$). Within the lavender and placebo groups, participants were evenly distributed across three instructional prime conditions (facilitation prime, inhibition prime, and no prime).

### *Setting*

Trials took place in a psychophysiology laboratory, measuring $3 \times 4 \times 4$ metres. The room was windowless and thermostatically controlled, and a built-in fan was used for ventilation. Controlled lighting was used throughout the experiment, with the default luminance of 2,300 lux reduced to 470 lux during the relaxation protocol. Participants were seated in a comfortable chair in front of a desk. The researcher was seated at a separate desk 2 metres behind the participant.

### *Apparatus and materials*

Commercially produced aromatherapy essential oils were used for the two aroma groups. Lavender oil was used for the lavender aroma group. For the placebo aroma group, tea tree oil (*Melaleuca alternifolia*) was used. The selection of tea tree oil as a placebo was intended to offer an advance on previous research. Firstly, unlike placebos such as steam or sunflower oil, tea tree oil is not odourless. Secondly, unlike placebos such as jasmine or rosemary, tea tree oil is not reputed to have sedative or relaxation-promoting properties (its primary use within aromatherapy is as an immunostimulant), and so participants would be less likely to hold such an expectation. Thirdly, unlike placebos such as dimethyl sulphide, tea tree oil does not have a malodorous scent. Overall, it was considered plausible that tea tree oil could be perceived by participants as a potential relaxant, and so would offer a suitable placebo for lavender. Two glass jars with screw-top lids were used to hold the aromas, with cotton wool soaked with three drops of oil placed at the bottom of each jar. Prior to each trial, the jars were marked using a code by an independent research assistant in order to ensure that the researcher dealing directly with participants was blind to aroma during the experiment.

A commercially available odour neutralizer (*Nice 'N' Fresh*, ChemEx, Smethwick, UK) was used to standardize pre-experimental laboratory air odour across participants.

Galvanic skin response (GSR) was assessed by measuring skin resistance using a handheld digital multimeter (DT-830B, Zhanzhou Weihua Electronics, Fujian, China), using electrocardiogram electrodes (*SKINTACT*, Leonhard Lang GmbH, Innsbruck, Austria) applied to the first and second fingers of the participant's non-dominant hand. GSR was quantified in units of 2,000 k ohms. A cosmetic loofah was used to remove dry skin prior to the application of electrodes. To assist in sound attenuation during relaxation, participants were provided with noise-cancelling earmuffs that met safety standards for road construction work.

A version of the Digit Span subtest of the Wechsler Adult Intelligence Scales, third edition (Wechsler, 1997) was used as the arousal task. This subtest requires participants to repeat aloud strings of numbers presented to them orally by the researcher. Participants were presented with seven strings. The first four strings comprised five, six, seven, and eight digits, respectively, and participants were instructed to repeat the digits in their order of presentation. For the final three strings, comprising five, six, and seven digits, participants were instructed to repeat the digits in reverse order. As digits were presented at a rate of one per second, the duration of the arousal task (including instructions) was approximately 2 minutes. Such cognitive tasks have been used in studies of physiological arousal for many years (Hughes, 2001). We collected pilot data from 66 undergraduate women (mean age = 20.18 years, $SD = 5.40$ years) that demonstrated the task to be very effective in precipitating arousal, elevating heart rate by a mean of 10.59 beat/min (SE = 1.10 beat/min), $t(65) = 9.61$, $p < .001$, 95% CI of elevation = [8.39, 12.79].

State anxiety was measured using the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), an inventory of 20 anxiety-related items requiring agreement ratings. It is one of the most utilized psychometric instruments in its area and has repeatedly been confirmed as psychometrically sound (for example, test–retest reliability after 104 days for trait anxiety of .65; Spielberger *et al.*, 1983). Participants were also given a custom-designed health questionnaire, embedded in which were 15 items that described different types of health-related activity. Participants were invited to provide ratings on a 4-point Likert scale of the extent to which they felt each activity to be 'reliable and theoretically sound'. Five of the items described mainstream health-related activities (chemotherapy, daily exercise, cholesterol-lowering foods, gene therapy, vitamin tablets), with the remaining 10 items describing areas of alternative health practices (chiropractic, astrology, reflexology, tarot card reading, aromatherapy, herbal medicine, magnetic therapy, homoeopathy, acupuncture, crystal power). The instrument allowed for a range of computations and cross-comparisons of ratings of perceived reliability of orthodox and alternative health practices.

### *Procedure*

Upon arrival at the laboratory, participants were led to their seats and asked to complete the STAI. Following this, the electrodes were attached by the (female) researcher, who then took her seat and administered the arousal task. After the task, participants in the lavender and placebo aroma conditions were then provided with the relevant glass jar. They were instructed to remove the lid, hold the jar to their noses, take two breaths, and then leave it (opened) on the table in front of them. The researcher then provided the

participant with further instructions, which contained the relevant directive prime. Participants receiving the facilitation prime were told that 'this scent is actually believed to aid in relaxation and relieve anxiety. It should help you feel much calmer.' Participants receiving the inhibition prime were told that 'this scent is actually believed to obstruct relaxation and increase anxiety. It should make you feel less calm.' Participants receiving no prime were given the same overall instructions as others, but with no reference to the hypothesized efficacy of the aroma. In the (no-aroma) control group, participants proceeded directly to the relaxation protocol.

For relaxation, participants were told that when given the appropriate signal, they were to sit back and relax quietly for a period of 10 minutes. The earmuffs were worn to prevent noise interruption and the lights were dimmed to reduce visual distractions. The researcher recorded GSR readings at 20-second intervals throughout the 10-minute period. After this, the researcher raised the lights to their default setting, at which point the participant removed the earmuffs. The participant was then asked to complete the STAI for a second time, and to complete the health questionnaire. All participants were then debriefed as to the true purpose of the experiment.

## Results

Of the 96 participants, a total of three were removed from the sample on the basis of returning outlying or incomplete GSR measures (indicative of equipment failure). A fourth participant was removed on the basis of having an outlying age (>50 years). The remaining 92 participants had a mean age of 19.78 years ($SD = 3.4$ years). Thirty-two participants underwent the procedure in the lavender aroma group, 30 in the placebo aroma group, and 30 in the control (no aroma) group. Among the lavender group, 10 received the facilitation prime, 11 received the inhibition prime, and 11 received no prime. Among the placebo group, the numbers receiving facilitation, inhibition, and no prime were 11, 11, and 8, respectively. (As they were not exposed to an aroma, all participants in the control group ($N = 30$) received no prime.)

The validity of the relaxation protocol was tested by comparing state anxiety scores before the experiment (mean = 41.28, $SD = 9.21$) and after relaxation (mean = 34.21, $SD = 8.97$), which revealed a statistically significant difference, $t(91) = 6.89$, $p < .001$, 95% CI of difference = [5.04, 9.12], suggestive of a decrease in anxiety. A one-way ANOVA revealed no between-group difference in GSR during the first minute of the post-stressor relaxation period, $F(2, 89) = 0.52$, $p = .59$, partial $\eta^2 = .01$ (overall mean GSR = 88.29, $SD = 33.14$), suggesting that between-groups comparisons of changes in GSR over time were justified.

### *Aroma, prime, and GSR*

A mean GSR was computed for each of the 10 minutes of the post-stress relaxation period. In order to investigate the impact of aroma and/or prime on relaxation, taking account of the non-independence of successive GSR measures, data were submitted to a multi-level model analysis using the Mixed Linear Models facility of SPSS 12.0.1. The 10 successive GSR measures were treated as a single (repeated effect) dependent variable, with prime (three levels) and aroma (three levels) treated as fixed-factor independent variables. Scrutiny of covariance parameters confirmed that, across participants, GSR increased over time ($p < .001$ for each increment), implying that as time passed participants became gradually more relaxed. The test of fixed effects on GSR across time

revealed no main effect for aroma, $F(2, 410.75) = 1.52$, $p = .22$, but a near-significant main effect for prime, $F(2, 410.75) = 2.66$, $p = .071$. Scrutiny of mean GSR across time revealed that participants given the inhibition prime tended to relax more over time than those given no prime. Participants given the facilitation prime tended to relax least (see Figure 1). This was confirmed by examination of the estimated marginal means for GSR, which were 123.75 (95% CI = [114.70, 132.80]) in the inhibition prime condition, 118.07 (95% CI = [111.00, 125.13]) in the no-prime condition, and 109.49 (95% CI = [110.22, 118.76]) in the facilitation prime condition.

The aroma × prime interaction was returned as significant, $F(2, 410.75) = 3.48$, $p = .032$. However, for this interaction term two of the available nine cells contained no cases at all (reflecting the fact that participants in the control condition were given neither facilitation nor inhibition primes), meaning that tests of this interaction did not meet cell-size assumptions.

Given that the inclusion of participants in the control group resulted in an uneven distribution of participants across cells in the analysis (with all control participants appearing in the no-prime cell and none appearing in the facilitation or inhibition prime cells), and given that the primary comparisons of interest involved the prime manipulation, the data for the lavender and placebo groups receiving positive and negative primes ($N = 43$) were re-analysed independently. As before, the 10 successive GSR measures were treated as a single repeated-effect-dependent variable, but on this occasion the fixed factors, prime and aroma, comprised two levels each. This had the effect of providing better balance of cases across cells, lending validity to tests of factorial interactions. Once again, the covariance parameters confirmed a consistent increase in GSR over time ($p < .001$ for each increment). Prime was found to exert a significant main effect on GSR across time, $F(1, 170.36) = 4.22$, $p = .042$, with participants given the negative prime exhibiting higher GSR (estimated marginal

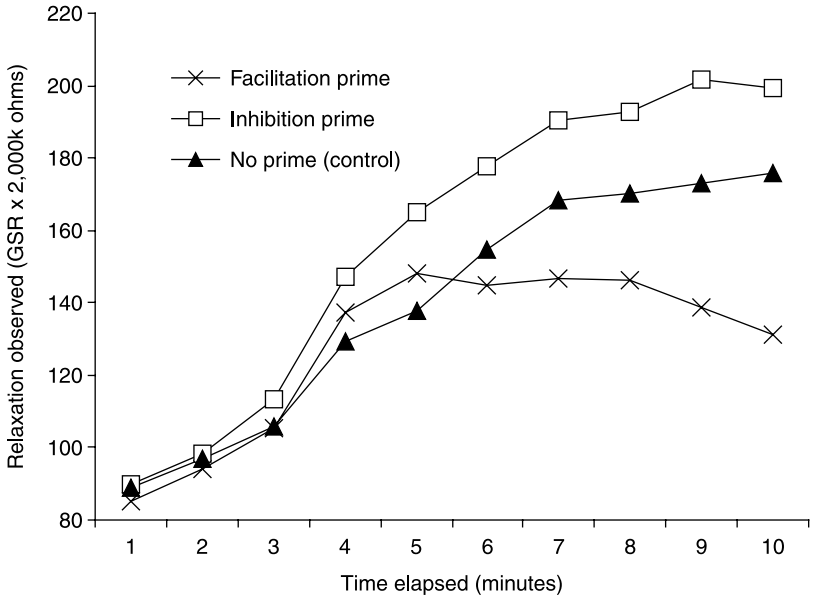


**Figure 1.** Relaxation, measured by skin resistance, across the experiment for participants receiving a facilitation prime ($N = 21$), an inhibition prime ($N = 22$), or no prime ($N = 49$).

mean = 121.73, 95% CI = [112.43, 131.03]) than those given the positive prime (estimated marginal mean = 107.88, 95% CI = [98.35, 117.41]), Bonferroni-adjusted $p = .042$. There was no significant main effect for aroma, $F(1, 170.36) = 0.50$, $p = .48$, nor a significant aroma × prime interaction, $F(1, 170.36) = 1.21$, $p = .27$.

### *Aroma, prime, and state anxiety*

Anxiety was measured before and after the experiment. A mixed, three-factor, time (two levels; within participants) × aroma (three levels; between participants) × prime (three levels; between participants) ANOVA revealed no influence of aroma ($p = .13$) or prime ($p = .79$) on changes in state anxiety. Similarly, there were no significant aroma ($p = .10$) or prime ($p = .63$) effects when control aroma/prime participants were excluded.

### *Perceptions of alternative health practices*

Following the experiment, participants rated orthodox medicines as significantly more 'reliable and theoretically sound' (mean rating = 3.12, $SD = 0.34$) than alternative health practices (mean rating = 2.31, $SD = 0.37$), $t(91) = 16.47$, $p < .001$, 95% CI of difference = [.91, .71]. However, the 10 items used to rate alternative health practices had much better internal reliability (Cronbach's $\alpha = .72$) than the five items used to rate orthodox medicines (Cronbach's $\alpha = .25$; although low Cronbach's $\alpha$ need not be considered problematic for causal, as opposed to effect, indicators; Bollen & Lennox, 1991). Within the context of alternative health practice ratings, it is notable that participants gave significantly higher ratings to aromatherapy (mean = 2.51, $SD = 0.73$) than they did on average to the remaining practices (mean = 2.29, $SD = 0.36$), $t(91) = 3.46$, $p = .001$, 95% CI of difference = [.09, .35]. This may imply that participants were relatively sympathetic to the claims of aromatherapy.

In order to assess whether variations in perceptions of the reliability of alternative health practices contributed to the observed effects of instructions on relaxation, the analyses of experimental relaxation patterns were re-conducted with ratings entered as covariates. While confirming the previously identified effects, none of the re-conducted analyses revealed any main or interaction effects not shown in the original analyses.

However, given that the health questionnaire was administered at the end of the experiment, it is possible that participants' ratings of aromatherapy were influenced by the aroma (if any) to which they were exposed or by the prime (if any) given to them. In order to investigate whether this was the case, a two-way aroma (three levels; between participants) × prime (three levels; between participants) ANOVA was conducted, using ratings of aromatherapy as the dependent variable. This analysis revealed a main effect for aroma, $F(2, 85) = 4.11$, $p = .020$, partial $\eta^2 = .09$, but no main effect for prime, $F(2, 85) = 0.79$, $p = .46$, partial $\eta^2 = .02$, or aroma × prime interaction, $F(2, 85) = 0.57$, $p = .57$, partial $\eta^2 = .01$. *Post hoc* Bonferroni tests revealed that participants in the control group gave significantly lower ratings to aromatherapy (mean = 2.17, $SD = 0.70$) than those in either the lavender (mean = 2.63, $SD = 0.71$), $p = .037$, or placebo (mean = 2.73, $SD = 0.69$), $p = .008$, groups, with no difference in ratings of aromatherapy between the lavender and placebo groups, $p = 1.0$. One interpretation of this is that exposure to aromas (of any description) raised participants' ratings of aromatherapy, independently of prime and notwithstanding the fact that there was no main effect for aroma on relaxation.

An equivalent ANOVA using the ratings of other alternative health practices as the dependent variable showed no main or interaction effects.

## Discussion

The present data suggest that, in a sample of healthy adults, post-arousal relaxation patterns were not influenced by aromatherapeutic lavender oil but were very much influenced by participant expectancies. While there were no differences in relaxation among groups exposed to lavender aroma, a placebo aroma, or no aroma, there was a distinct difference among participants given a facilitation prime, an inhibition prime, or no prime. Specifically, participants reached greater levels of relaxation when they were led to believe that the aroma presented to them would inhibit their efforts, and reached lesser levels of relaxation when they were led to believe that the aroma would facilitate them. This pattern is consistent with the interpretation that participants moderated their efforts to achieve relaxation in line with their expectancies about how much help they would receive from the aroma. When they believed that the aroma would inhibit their efforts, they tried harder to relax (and succeeded); when they expected the aroma to facilitate relaxation, they did not try as hard. In the absence of an actual aroma effect, the levels of relaxation that were reached reflected the relative efforts made to relax. Consistent with this explanation, when no aroma was presented (and no priming instructions given), the levels of relaxation reached by participants lay in the mid-range: participants neither bolstered nor attenuated their efforts to relax.

This interpretation could imply that previous research should also have found a negative effect for lavender aroma on relaxation, in that participants' expectancies (of a positive effect) should have resulted in their making less effort to relax. However, it is notable that previous research using physiological indices of relaxation has been truly equivocal, with a mixture of positive (e.g. Diego *et al.*, 1998), negative (e.g. Klemm *et al.*, 1992), and null (e.g. Burnett *et al.*, 2004) findings. The variation in findings may be related to differences not only among physiological indices, but also in the salience of participants' expectancies about outcome as might result from variations in methodologies. The novel instructional priming procedure used in the present study, by manipulating and thus drawing participants' attention towards their own expectancies, may have elevated the salience of expectancies such that they directly influenced relaxation in the manner described. Indeed, the critical nature of the phrasing used in the instructional primes (i.e. their description as constituting belief rather than fact) may have stimulated participants to reflect on the validity of their expectancies. If so, then the impact of these externally precipitated expectancies may not be directly comparable to the internally developed expectancies of participants in past research (or of consumers of aromatherapy). However, the present findings do suggest that expectancies, however tentative or sceptically held, can exert a significant effect on relaxation.

Thus, the present findings illustrate the importance of considering participant expectancies in studies of aromatherapy interventions for relaxation. In previous research, it has probably been assumed that participants held no prior expectations about the nature of aromatherapy. Although the findings of such research have been equivocal in many ways, when results have been consistent with the hypothesized relaxant effects of lavender, researchers have tended to infer therapeutic efficacy rather than participant expectancy. Some authors have noted the apparent correlation between measured expectancies and outcomes (Spector *et al.*, 1993; Tysoe, 2000).

However, the present study is the first to explicitly manipulate participant expectancies, with the findings suggesting that such expectancies are: (a) indeed manipulable and (b) the only factor to influence relaxation outcomes in this case. It appears clear, therefore, that in research on aromatherapeutic lavender and relaxation, expectancy effects must first be accounted for before the efficacy of lavender can be inferred.

An interesting finding is that although the content of instructional primes appeared to be associated with post-experiment ratings of aromatherapy, the observed ratings were not (upon initial consideration) clearly congruent with the primes given. Participants given *either* facilitation *or* inhibition primes rated aromatherapy as more 'reliable and theoretically sound' than participants given no prime. This was despite the fact that these participants had experienced the opposite physiological change to that of which they had been forewarned. Such findings may reflect the widespread belief that, regardless of the *nature* of the information that is available, simply a greater *amount* of information about a therapy makes it appear more plausible to observers. The finding also demonstrates the extent to which many people are poor at judging their own inner physiological states (Pollatos, Kirsch, & Schandry, 2005). This is further demonstrated in the present study, where the effects of participant expectancies were seen only at a physiological level (i.e. in terms of changes in GSR) and not with regard to changes in (self-reported) state anxiety. In addition, it is notable that participant perceptions about the soundness of aromatherapy did not account statistically for the observed effects on relaxation, insofar as the effects remained significant after ratings of soundness were included as covariates. In essence, participants' retrospective reports about the effects of aromas were dissociated from their actual physiological effects. Parallels can be drawn with previous studies where participants' post-experiment ratings of aromatherapy efficacy were incongruent with their own behaviours and cognitions during the experiment itself (Gedney *et al.*, 2004).

One of the main reasons why a placebo aroma group was included in the present study was to address the concern that previous findings for lavender could be accounted for by olfactory stimulation alone (as opposed to lavender-specific effects). In terms of physiological arousal, the findings were consistent with a number of previous studies that have failed to establish lavender-related relaxation (Burnett *et al.*, 2004; Klemm *et al.*, 1992; Lee *et al.*, 1994; Lorig & Schwartz, 1988; Motomura *et al.*, 2001; Romine *et al.*, 1999). However, in terms of self-report indices of relaxation, the present findings are inconsistent with those studies where aroma-related relaxation has been reported. This inconsistency might be related to the fact that most such previous research has employed *ad hoc* measures of relaxation, whereas in the present study a psychometrically validated measure of state anxiety was employed.

When assessing the implications of the results of the present study, some methodological limitations should be considered. Firstly, it might be argued that the procedures used are not representative of the way in which aromatherapy is administered outside the laboratory. A variety of measures were taken to ensure standardization (e.g. the formal arousal task, the configuration of the laboratory furniture, the delivery of aroma via cotton wool placed in jars, the use of dimmed lighting and ear muffling), which may somehow detract from the potency of lavender's effects on relaxation. Similarly, the homogenous age, gender, and educational background of the participants might mean that the observed effects are not generalizable to other members of the population. However, in response to such criticisms it could be argued that: (a) the use of procedural standardization should in fact serve to minimize the role of extraneous factors and so enhance the core effect under scrutiny, if it exists, and (b) by focusing on a large sample

of healthy adults, the present study possesses more external validity than those several previous studies to have focused on small clinical samples. Indeed in one sense, the present procedure could have created a bias *in favour* of aroma-related effects on relaxation, in that the control group participants were not presented with the an equivalent aroma-related manipulation as that presented to other participants. Experimental control would have been enhanced had these participants been given a jar containing odourless cotton wool, rather than no jar at all. It is notable that even with this procedural deviation the present study nonetheless detected no difference between the control and aroma (either lavender or placebo) groups.

Future research in this area may wish to explore precisely how participants feel about the manipulations they are exposed to. For example, in the present study, participants were not asked whether they believed the instructional prime that was presented to them. As such, whether the primes were perceived as credible by all participants is unknown. However, the fact that there was a clear effect for group on physiological relaxation suggests that the various primes were systematically infused with a particular meaning by at least a critical mass of participants in each group. This being the case, it is difficult to envisage how participants in general might have disbelieved the primes presented to them. For example, if participants in the inhibition group had disbelieved their prime, then their expectancies (and relaxation patterns) should have ended up being *congruent* with those of participants in the facilitation group, not diametrically incongruent. The same principle would apply (in reverse) if participants in the facilitation group had disbelieved their prime. If disbelief was widespread then the pattern of the present findings could only emerge if participants in both the facilitation and the inhibition groups symmetrically disbelieved what they were told. It is submitted that, given the repeated demonstration of participant compliance in psychological research (Cialdini & Goldstein, 2004), this pattern would be somewhat unlikely.

In conclusion, the findings of the present study raise further questions about the precise way in which lavender aromas (and, by extension, other aromas) impinge on psychological relaxation. While the practices of many conventional aromatherapists include procedures that are in themselves potentially relaxing (e.g. massage and/or emotional counselling), the research literature to date has not conclusively established the independent additive relaxant effect of lavender aroma as administered therapeutically. It appears that client expectations regarding likely efficacy may well have influenced the outcomes that have been reported. The findings of the present study highlight the extent to which expectancies can impact on arousal, and the ease with which such expectancies can be manipulated. The findings suggest that future research in aromatherapy should explicitly seek to control for expectancy biases; and that the widespread advocacy for, and incorporation of, aromatherapy practices in mainstream healthcare (e.g. Lewith, Hyland, & Gray, 2001) should be critically reassessed.

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