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Aroma of Chill™ essential oil blend mitigates psychological and physiological responses to experimentally induced acute stress

Abstract

Objectives

This study investigated the potential for the aroma of an essential oil blend to mitigate psychological, physiological and biological responses to an acute stressor. The blend (Chill™) was created based on evidence of psychological benefits for the component oils, coupled with aromatic hedonics. The potential for stress-buffering effects was compared in a double-blind design to a positive control (pure lavender) and a no aroma control condition.

Methods

Stress was induced using a valid and reliable multitasking paradigm. Ninety participants were randomly allocated to one of the three aroma conditions. Psychological and physiological measures were taken at multiple timepoints and saliva samples collected at the end of the testing period.

Results

As predicted, the multitasking stressor increased heart rate and blood pressure in the control condition. Importantly, the Chill™ blend mitigated these increases and did so to a greater extent than pure lavender. Similarly, psychological measures of stress, mood, and positive and negative affect benefited preferentially from the presence of Chill™ aroma. No differences were found for levels of chromogranin A following the stressor but levels of immunoglobulin A were significantly lower in the Chill™ condition.

Conclusions

These findings demonstrate the benefit of blended essential oils over pure lavender for the mitigation of responses to acute stress and support the argument that essential oil aromatherapy could make a valuable contribution to personal wellbeing and integrated healthcare.

Keywords: essential oils, aroma, stress, multitasking, mood

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Introduction

Globally, record numbers of adults are seeking help for stress and anxiety,[1] and interventions that deliver improved quality of life for sufferers are a focus of psychological research.[2,3] Many pharmacological, psychological and combined treatments are currently employed, but interventions that can be administered by individuals as part of a self-care approach outside clinical settings are increasing in popularity.[4] Aromatherapy is one expanding area of complementary medicine, progressively used alongside conventional medicatiobn.[5,6] The therapeutic use of essential oils extracted from plants has a long history with ancient Greeks, Indians, and Egyptians using aromatherapy for healing purposes.[7] Essential oils were first commercially produced in the early 19th century during the industrial revolution[8] and by the 1960s, the oils were retailed for modern aromatherapy in Britain as the prevalence of holistic treatments spread across Europe.[9]

Review papers have reported the positive benefits of aromatherapy on anxiety levels,[10–13] and have identified oils that have produced anxiolytic benefits such as sweet orange, basil, lavender, sweet marjoram.[14] Further research demonstrated that lavender oil consistently aids in anxiety buffering on both self-report[15] and physiological measures.[16] Similar studies have demonstrated that lavender essential oil aided in the promotion of immunoglobulin A (s-IgA) secretion,[17] a reduction in chromogranin A (CgA) secretion[18] and in blood pressure.[19] Biologists have previously identified that an increase in CgA secretion, blood pressure and depletion in S-IgA secretion are physiological indicators of chronic stress in humans, whereas acute stress leads to an immediate rise in S-IgA.[20] Regarding self-report scales, a systematic review of 37 randomised controlled trials concluded that lavender inhalation reduced anxiety at a significant level on any validated anxiety scale,[21] providing compelling evidence for the psychological and physical influence of inhaling lavender oil aroma and making it an ideal positive control aroma in the current study.

Synergistic effects of blended essential oils have been noted for antimicrobial effects[22,23] and blending is at the heart of aromatherapy[24] with individual therapists developing different blends for individual sessions and clients based on their experience and professional practice.[25] However, the scientific evaluation of the benefits of inhaled blended essential oils is limited, and even when conducted the trials tend not to include comparisons to single oils as positive controls e.g.[26,27] In studies where a direct comparison has been made Lin et al.,[28] reported benefits of blending in an exercise induced stress

scenario whereas Swinburne et al.,[29] found little to suggest a benefit of blending oils for anxiety buffering in healthy participants exposed to an anxiety inducing video. The aim of the current study is to further investigate the potential for blended essential oils to alleviate acute stress responses and whether there is any advantage over treatment with single oil, lavender that has previously been demonstrated to have beneficial effects. The Chill™ essential oil blend employed in the current study has been specifically designed with a view to reduce the stress response based on two principles, evidence of psychological benefits for the component oils, coupled with aromatic hedonics of the final blend. Of the major components in the blend, lavender has been widely investigated as described above. Patchouli has been shown to have anxiolytic effects in children[30] with an animal model suggesting this may be mediated via dopamine levels.[31] Rose geranium has been employed to reduce anxiety and stress in both dental[32] and surgical medicine,[33] and basil has been shown to reduce anxiety in patients with major depressive disorder.[34] Chamomile has been shown to be effective for stress, anxiety and depression in older adults with effect sizes comparable to lavender,[35] and lemongrass has been shown to reduce physiological and self-reported anxiety responses to dental treatment.[36] This study represents a development in the investigation of the potential effect of blended oils on subjective and objective markers of the stress response employing both positive control and no aroma control groups. Although Sathirachawan et al.,[37] report the development of an essential oil blend for stress and sleep problems based on participants scent preferences they do not include any evaluation or evidence of its effectiveness.

Many different approaches have been taken for inducing acute experimental stress in the laboratory and these vary in their ecological validity and the consistency of observed responses.[38] For the current study we employed the Multitasking Framework, a workload stressor that has been demonstrated to mirror the types of simultaneous tasks that might be experienced in a busy working environment, and that elicits acute changes in both physiological and psychological markers of stress.[39–41] Based on previous research findings it is predicted that:

I. The Multitasking Framework will induce physiological and psychological stress responses in healthy adults.

II. Both lavender and Chill™ aroma exposure during completion of the Multitasking Framework will mitigate these responses.

Of principal interest is any difference between the lavender condition and the Chill™ essential oil blend on the variables measured. No a priori prediction is possible based on the available evidence.

Method

Design

A two factor double-blind mixed design was employed in this study. The independent groups factor was the presence or absence of an aroma with three levels, Chill™ aroma, lavender aroma (positive control) or no aroma carrier oil (control). The repeated measures factor was assessment of physiological and psychological variables at multiple time points throughout the testing procedure. Figure 1 presents a schematic of the testing protocol.

Materials and apparatus

Essential oils

The Chill™ blend is a proprietary blend created by Moods Beauty Ltd. The major constituent oils are Patchouli, Basil, Rose Geranium, Lavender, Lemongrass, Jasmine, Chamomile and Vetiver. The exact proportions have not been released. The lavender positive control single essential oil was obtained from Tisserand UK Ltd. Fractionated coconut oil was employed as a no odour carrier oil in the control condition. Each essential oil used was certified with ISO022716 ANS ISO14001, UKAS and EFICI certificates. Research assistants were provided with oils in coloured bottles marked simply A, B or C to use as appropriate for the condition they were testing participants in. Eight drops of the condition appropriate oil were applied to a diffuser pad for a "Tisserand Aroma-stream." The Aroma-stream was placed under the bench in the testing cubicle so as to be out of sight and switched on for 15 min prior to the testing of each participant. The research assistants remained blind to condition until all data had been entered and analysed at which time technical support staff not involved in the study released the blinding codes.

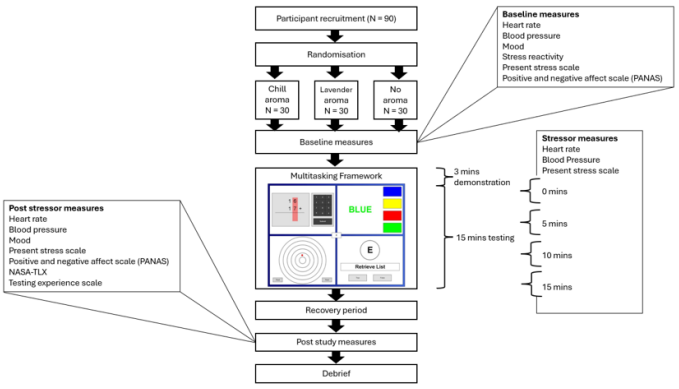

Figure 1 Testing protocol.

GC-MS Analysis

Gas chromatography-mass spectrometry (GC-MS) analysis was performed on the Tisserand® lavender and the Chill™ essential oils using a Thermo Scientific Trace 1300 GC coupled to a ISQ QD single quadrupole mass spectrometer equipped with a AI1310 liquid autosampler (Thermo Fisher Scientific, Hemel Hempsted, UK). Each sample was diluted 1000-fold in methanol and 1 µL was injected into the GC. Chromatographic separation was achieved using a TG5-MS (30 m x 0.25 mm, 0.25 µm film thickness) column (Thermo Fisher Scientific, Hemel Hempsted, UK) using the parameters in Table 1. Data analysis was performed using Xcalibur chromatography data system software (Thermo Fisher Scientific, Hemel Hempsted, UK). The chromatogram shown in Figure 2 (top panel) is consistent with Chill™ essential oil being a blend due to the presence of additional peaks not observed in the chromatogram of the Tisserand® lavender essential oil shown in Figure 2 (bottom panel). The peaks were tentatively identified based on the MS reference NIST 2014 library and the compounds compared against previously published literature. A full table of components and percentage composition and botanical sources is in Table 1.

Biological measures

Blood Pressure & Heart Rate

Systolic and Diastolic blood pressure, and heart rate was measured continuously via the Portapres ambulatory blood pressure monitoring (ABPM) system. Sensors were attached to fingers of the participants' non-dominant hand which was then maintained in a stationary position on the desk during testing to prevent motion artifacts from contaminating the data. Data was stored and retrieved using the BeatScope software and any values more than three standard deviations from the mean were removed as artifacts. Values were split and averaged over seven phases of the study, baseline, practice, four points during the stressor and finally post-stressor.

Table 1 Components, percentage composition and botanical sources of both chill and lavender

		Lavender	Chill	
Ret.Time	**Name**	**% composition**	**% composition**	**Botanical sources**
7.259	α-Pinene	0.32	0.73	Pine, Rosemary, Eucalyptus
8.725	3-Octanone	1.16	0	Lavender
8.463	β-Pinene	0	0.37	Pine, Rosemary, Hops, Cumin
8.854	β-Myrcene	0.54	0.16	Hops, Bay leaf, Lemongrass, Cannabis
8.976	6-Methyl-3-heptanol	0.38	0	Lavender, various essential oils
9.459	Hexyl acetate	0.76	0	Lavender, Apple, Pear
9.81	o-Cymene	0.31	0.26	Cumin, Thyme, Oregano
9.932	D-Limonene	0.6	1.14	Citrus, Caraway, Dill
10.017	Eucalyptol (1,8-Cineole)	1.02	1.68	Eucalyptus, Rosemary, Bay leaf, Tea tree
10.207	β-Ocimene (trans and cis)	7.26	0	Lavender, Basil, Orchids, Hops
11.061	Sabina hydrate	0.12	0	Lavender, Sage, Juniper
11.204	Linalool oxide (cis)	0.38	0.17	Lavender, Tea tree
11.653	α-Terpineol	0.29	0	Pine, petitgrain, Cajuput, Lavender
11.809	Linalool	24.87	5.71	Lavender, Coriander, Rosewood, Bergamot
12.357	1-Octen-3-yl acetate	1.45	0	Mushrooms, Lavender
12.449	exo-Fenchol	0	2.46	Fennel, Basil, Lavender
12.738	Butyl 2-methylvalerate	0	0.66	Valerian root
12.826	Alloocimene	0.54	0	Lavender, hop oils, various essential oils
13.306	L-Camphor	0.52	0.71	Camphor, Rosemary, Lavender
13.673	Isoborneol	0	0.52	Valerian, Ginger, Camphor
13.836	Benzyl acetate	0	0.42	Jasmine, Ylang-ylang, Gardenia
13.99	Lavandulol	2.21	0	Lavender
14.255	Terpinen-4-ol	6.32	0.26	Tea tree, Marjoram, Nutmeg, Lavender
14.639	α-Terpineol	1.14	1.05	Pine, Lavender, Tea tree
15.68	Isobornyl formate	0.07	0.17	Lavender, conifer needles
16.01	Citral	0	0.29	Lemongrass, lemon myrtle, lemon verbena
16.428	Linalyl acetate	24.88	5.25	Lavender, Bergamot, Clary sage
16.483	Phenethyl acetate	0	0.19	Rose, neroli, honey
16.829	Geranial	0	0.46	Lemongrass, lemon myrtle, melissa
17.418	Lavandulyl acetate	5.64	0	Lavender
19.003	α-Terpinyl acetate	0	3.19	Cardamom, Pine, Thyme
19.319	Neryl acetate	0.51	0	Lemongrass, lavender, citronella, neroli
19.788	α-Copaene	0	4.02	Copaiba balsam, Ylang-ylang, black pepper
19.833	Geranyl acetate	1.04	0	Rose, Lemongrass, Lavender
20.108	β-Copaen-4α-ol	0	0.34	Copaiba balsam, various essential oils
20.962	β-Caryophyllene	6.54	7.12	Black pepper, Cloves, Basil, Lavender
21.244	trans-α-Bergamotene	0.26	0	Bergamot, Lavender, Carrot seed
21.768	cis-β-Farnesene	5.94	0.33	Lavender, chamomile, ylang-ylang
22.302	γ-Muurolene	0	0.28	Vetiver, myrrh, cedarwood
22.39	cis-Muurola-3,5-diene	0	0.1	Vetiver, myrrh, cedarwood
22.445	Germacrene D	0.92	0.09	Geranium, ginger, jasmine, lavender
22.741	Nootkatone derivative	0	0.28	Alaska cedar
22.938	α-Calacorene	0	0.28	Vetiver, Calamus root, various woody oils
23.451	Cadina-1,4-diene	0	1.17	Cedarwood oils, various essential oils
23.611	Nerolidol	0	0.32	Neroli, ginger, jasmine, tea tree
24.339	trans-Nerolidol	0	0.84	Neroli, ginger, jasmine, niaouli
24.635	Caryophyllenyl alcohol	0	0.21	hops, citrus fruits, cloves, basil, oregano
24.948	Caryophyllene oxide	1.09	1.43	Lavender, Clove buds, black pepper
25.264	Viridiflorol	0	0.96	Vetiver, various essential oils, sage
25.427	Epicedrol	0	2.08	Patchouli, Cedarwood, various conifer oils
25.604	Isolongifolanone (trans)	0	2.15	Indian sandalwood, Vetiver
26.22	τ-Cadinol	0.19	0	Juniper, Cedarwood, Lavender
26.482	Methyl dihydrojasmonate	0	0.21	Jasmine absolute,
26.58	Cedrene oxide	0	0.96	Cedarwood, Vetiver
26.842	Cadinol	0	14.28	Cedarwood, Patchouli
27.587	Cedrol acetate	0	0.44	Sweet wormwood, Roman Chamomile
27.944	Farnesol	0	1.07	Rose, Rose Geranium, jasmine, ylang-ylang
28.461	Cedrol acetate	0	0.12	Sweet wormwood, Roman Chamomile
28.825	Isolongifolene derivative	0	0.21	Vetiver, Wild carrot,
29.06	Benzyl benzoate	0	9.64	Ylang ylang, Jasmine, Rosewood

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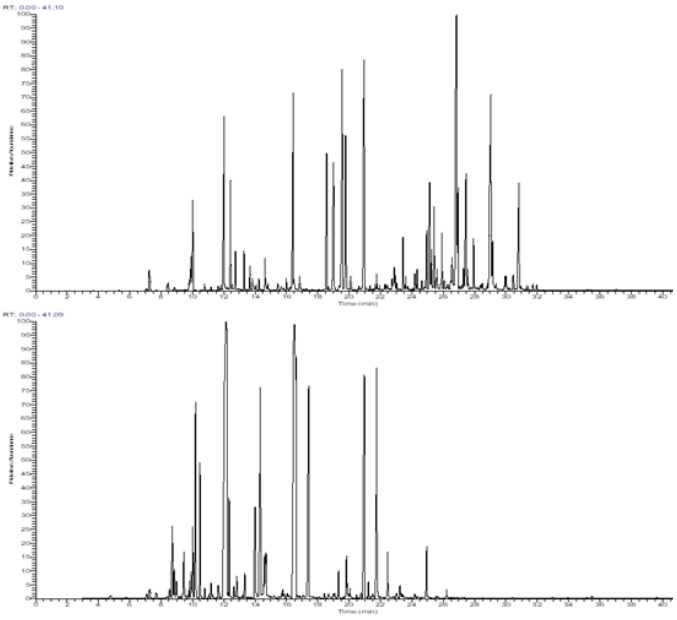

Figure 2 Chromatograms for Chill™ essential oil blend (top panel) and Tisserand pure lavender essential oil (bottom panel).

Salivary markers

Saliva samples were collected using a one-minute passive drool method at the end of the testing period for analysis of salivary immunoglobulin – A (s-IgA) and chromogranin A (CgA). Assays were conducted using Elisa kits obtained from Salimetrics via Stratech Scietific UK Ltd in accordance with the manufacturer's instructions.

Psychological measures

Mood and Affect

Mood and affect were assessed using self-report measures prior to entering the testing room and again at the end of the testing protocol. The Bond-Lader visual analogue scales[42–44] comprise 16 items which as recommended by the authors, are combined to form three mood factors: "alert", "calm" and "content". To calculate the impact of the testing procedure and the aromas, difference scores were calculated by subtracting initial values (pre-) from final values (post-). Positive values therefore indicate an increase in the mood dimension over the test period whereas negative values indicate a decrease in the mood dimension over the testing period. The Positive and Negative Affect Schedule (PANAS) is a well-validated, brief and reliable 20-item questionnaire.[45] For Positive Affect, internal consistency reliabilities are between.73 and.78. For Negative Affect, internal consistency reliabilities are between.72 and.76. The scale was completed at the start and end of the testing protocol.

Stress Reactivity

The Perceived Stress Reactivity Scale (PSRS) is a 23-item questionnaire with 5 subscales and 1 overall scale. Reliability analysis suggests good stability, and validation analysis shows associations with related constructs such as self-efficacy, neuroticism, chronic stress, and perceived stress. Perceived stress reactivity is also associated with depressive symptoms and sleep. The PSRS is considered a useful and easy-to-administer instrument to assess perceived stress reactivity.[46] This scale is a measure of individual's appraisal of how they react to stressful events. The major reason it is included in the study is to ensure that the three groups of participants do not differ systematically at baseline in their susceptibility to stress as this would be a potential confound in the study.

Present Stress

A single item 'How stressed do you feel right now?' was used to evaluate present stress on a ten-point scale at the seven phase time points during the protocol. Single item measures may be preferable as they are quicker to complete at times when other activities are being undertaken, are potentially easier to understand and respond to, may have more face validity and be more flexible as opposed to more complex measures.[47]

Perceived workload

Perceived workload was assessed using the NASA-TLX, which comprises a set of six scales anchored with 'Low' and 'High' at the extreme points.[48] Three of the scales reflect the demand placed upon the respondent by the task (Mental Demand, Physical Demand, Temporal Demand), whereas three reflect the interaction between the respondent and the task (Effort, Perceived Performance, Frustration). The scale was conducted following completion of the stressor.

Testing Experience Scale

This scale assessed participants' experience of the overall procedure in terms of how stressful it had been, how strong and likeable the smell of the room was, and how energising or relaxing participants rated the aroma in the room. All questions were asked irrespective of whether participants had been in the aroma or control condition.

Multitasking Framework

The Multitasking Framework (MTF) computerised battery (Purple Research Solutions) was used to induce acute psychological stress. The Framework consists of four split screen tasks, which are displayed simultaneously (Figure 3) with responses being made via a standard computer mouse. This allows for a multitasking environment where workload intensity can be manipulated by increasing the difficulty of the modules, and permits physiological measurements to be accurately recorded through sensors on the non-dominant hand which is kept still during the procedure. The MTF elicits increase in subjective stress and reductions in positive mood in line with an acute stress experience.[39,41,49] Performance is measured as scores for each of the modules and the total combined score. For the current study the highest task difficulty level was employed for a period of 15 minutes of testing. The stressful nature of the task was increased through the use of social evaluation. All participants were placed in front of a video camera for the duration of the study and were informed that they would be recorded throughout. In fact, no videos were recorded and participants were made aware of this during the debrief. In addition the researcher sat closely observing the participants and commented at three timepoints, saying 'Most people perform better than you', 'You aren't doing very well' and 'I expected you to be scoring higher than you are'. This approach was followed as it has previously been shown to increase psychological and physiological responses to completing the Multitasking Framework.[50]

Participants

Ninety healthy volunteers were each paid £10 to take part in the study. All participants were screened for any olfactory dysfunction or respiratory problems. Thirty were randomly allocated to each of the three conditions. The Chill™ group consisted of 11 males (M_{age}

= 23.82 years, SD = 3.52) and 19 females (M_{age} = 23.53 years, SD = 3.76). The lavender group consisted of 14 males (M_{age} = 23.64 years, SD = 2.87) and 16 females (M_{age} = 25.00 years, SD = 3.29). The control group consisted of 12 males (M_{age} = 24.17 years, SD = 4.00) and 18 females (M_{age} = 21.72 years, SD = 3.43). Ages did not differ between genders across groups F(2, 84) =2.184, p =.119. The number of females and males did not differ across conditions $\chi^2(2)$ =.643, p =.725.

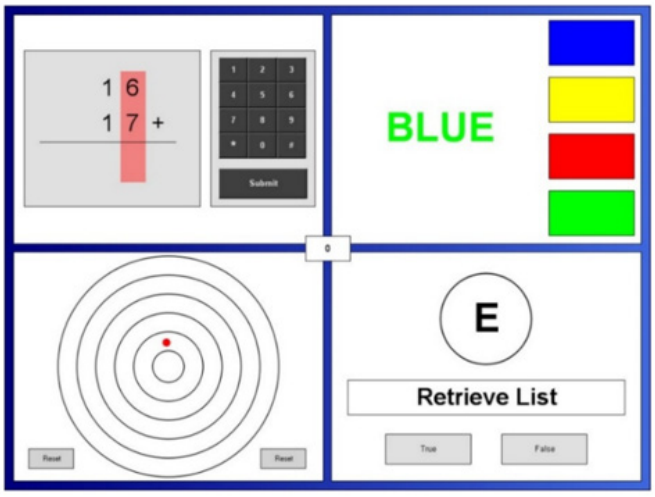

Figure 3 Multitasking framework computer screen layout.

Testing Room

The testing room measured 2.4 m long × 1.8 m wide × 2.4 m high and was maintained at a temperature between 18 and 22 degrees Celsius throughout the testing sessions.

Ethics

All procedures performed in this study involving human participants were in accordance with the ethical standards of the Northumbria University research ethics committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Before recruitment and data collection commenced, the study gained full approval from the Department of Psychology ethics system, Faculty of Health and Life Sciences at Northumbria University, submission #8213. All participants provided informed consent to participate prior to the start of data collection.

Procedure

Participants were tested individually and all provided written informed consent prior to any data collection. In order to avoid cross contamination of conditions, participants were allocated days and times to attend the lab such that all control and aroma testing sessions occurred in different weeks with the testing room window left open over the weekend to permit full ventilation. All testing took place between 8:00 and 12:00 to avoid time of day effects and to minimise the impact of food and drink intake without applying proscriptive regimes. On arrival at the lab, participants provided informed consent to take part in the study and completed the pre-test questionnaire evaluations. Baseline assessments of physiological measures were recorded once they entered the testing room and continually thereafter throughout the testing procedure. The present stress scale was completed orally at regular time points throughout the study. Once the fifteen minute framework task was completed a five-minute recovery period ensued during which final physiological and questionnaire assessments were completed. The entire testing process took about 30 minutes per participant. On completion of the study all participants were fully debriefed as the initial information did not indicate the research was investigating the effect of aromas. This economy of pre-trial information was employed to remove the possibility of expectancy effects from contaminating the data and is usual in this field of research.

Data Analysis Strategy

For variables measured at multiple timepoints (blood pressure, heart rate, present stress) a mixed 3 (condition) by 7 (timepoint) factorial multivariate analysis of variance (Manova) was applied. The significance of the interaction effect was employed as a gatekeeper to consideration of the univariate analyses of variance. Any significant interaction effects for the univariate Anovas were then followed up with Bonferroni corrected simple main effects analyses between conditions at each timepoint.

Variables measured at the start and end of the study (Mood, PANAS) were treated in a similar manner following a 3 (condition) by 2 (timepoint) Manova. Any significant interaction effects for the univariate Anovas were then followed up with Bonferroni corrected simple main effects analyses between conditions at each timepoint.

Variables measured just once at different points in the study (Stress reactivity, NASA-TLX and testing experience scale) were analysed using individual independent groups Manovas. Any significant effects of condition were followed up with univariate Anovas and Tukey pairwise comparisons.

Results

Stress reactivity

An independent groups Manova was applied to the scores from the five subscales and the omnibus test of the combined dependent variable considered. Participants in the three conditions did not differ in stress reactivity Wilks' lambda =.864, F(10, 166) = 1.260, p =.257. Stress reactivity was therefore not considered to be a confound in the study.

Blood pressure, heart rate, present stress

The multivariate condition*timepoint interaction effect was significant, Wilks' lambda =.233, F(48, 128) = 2.854, p<.001. Each of the dependent variables was then considered individually.

Systolic blood pressure

Mauchly's test of sphericity was significant, W =.165, $\chi^2(20)$ = 152.830, p<.001. As a consequence a Greenhouse-Geisser correction was applied to the Anova. The corrected condition*timepoint interaction was significant, F(8.128, 353.567) = 3.758, p<.001, η^2_p =.080 (a medium effect size). Bonferroni corrected pairwise comparisons indicated that the Chill condition led to lower systolic blood pressure than the control condition at the demonstration phase, p =.033 and after fifteen minutes of multitasking. P =.016. No other significant differences were found (see Figure 4).

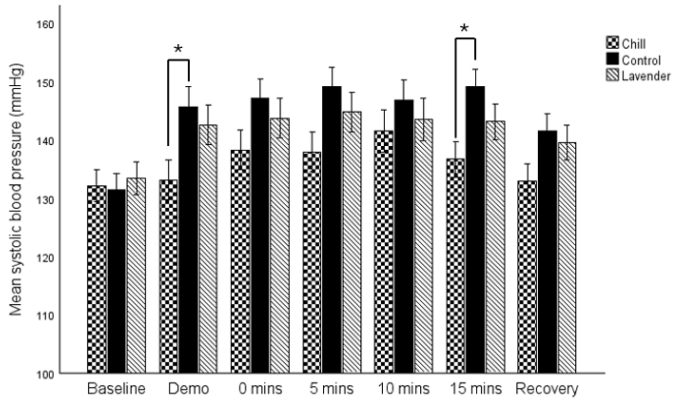

Figure 4 Mean systolic blood pressure values (mmHg) for all conditions at all timepoints in the study. Error bars represent standard errors, * indicates p<.05.

Diastolic blood pressure

Mauchly's test of sphericity was significant, W =.145, $\chi^2(20)$ = 163.741, p<.001. As a consequence, a Greenhouse-Geisser correction was applied to the Anova. Once corrected the condition*timepoint interaction was no longer significant F(7.061, 307.157) = 1.781, p =.090, η^2_p =.039 (a small to medium effect size). See Figure 5.

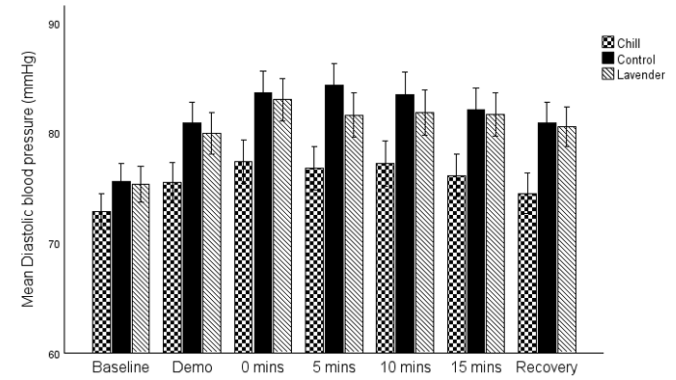

Figure 5 Mean diastolic blood pressure values (mmHg) for all conditions at all timepoints in the study. Error bars represent standard errors.

Heart rate

Mauchly's test of sphericity was significant, W =.152, $\chi^2(20)$ = 159.611, p<.001. As a consequence a Greenhouse-Geisser correction was applied to the Anova. The corrected condition*timepoint interaction was significant, F(7.385, 321.261) = 2.936, p =.005, η^2_p =.063 (a medium effect size). Bonferroni corrected pairwise comparisons indicated that the Chill condition led to lower heart rate than the control condition at the 5 minute timepoint, p =.045. no other significant differences were found (Figure 6).

Present stress

Mauchly's test of sphericity was significant, W =.256, $\chi^2(20)$ = 115.615, p<.001. As a consequence a Greenhouse-Geisser correction was applied to the Anova. The corrected condition*timepoint interaction was significant, F(8.272, 359.849) = 2.582, p =.009, η^2_p =.056 (a medium effect size). Bonferroni corrected pairwise comparisons indicated that present stress was significantly lower in the Chill condition than the control condition at 0 min, p =.006, 5 min, p =.002, 10 min, p =.002, 15 min p =.001 and during recovery, p<.001. Chill was also significantly lower than lavender during recovery, p<.001 (Figure 7).

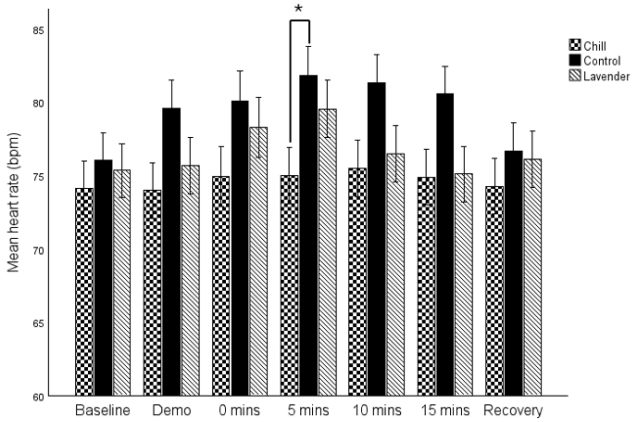

Figure 6 Mean heart rate values (bpm) for all conditions at all timepoints in the study. Error bars represent standard errors, * indicates p<.05.

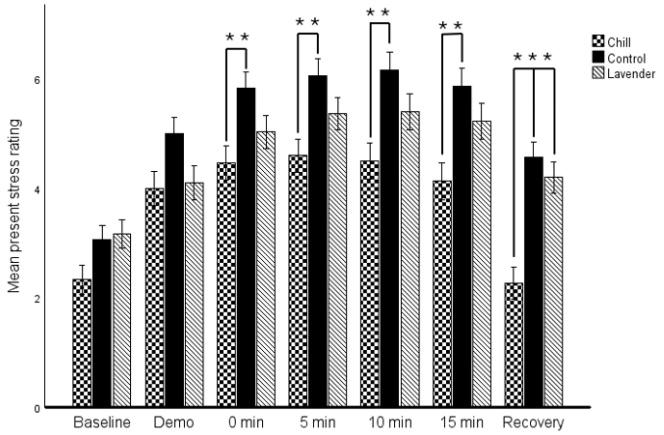

Figure 7 Mean present stress ratings for all conditions at all timepoints in the study. Error bars represent standard errors, * indicates p<.05, **p<.01, ***p<.001.

Mood, positive and negative affect

The multivariate condition*timepoint interaction effect was significant, Wilks' lambda =.625, F(10, 168) = 4.399, p<.001. Each of the dependent variables was then considered individually.

Alert

The condition*timepoint interaction was not significant F(2, 87) = 1.781, p =.640, η^2_p =.010 (a small effect size).

Content

The condition*timepoint interaction was significant F(2, 87) = 3.097, p =.050, η^2_p =.066 (a medium effect size). Bonferroni corrected pairwise comparisons indicated that no differences existed between conditions at baseline, but that at recovery participants in the chill condition were significantly more content (M = 72.26) than those in the control condition (M = 64.23), p =.037 (Figure 8a).

Citation: Moss M, Longmuir G, Cowper G, et al. Aroma of Chill™ essential oil blend mitigates psychological and physiological responses to experimentally induced acute stress. *Int J Complement Alt Med.* 2026;19(4):178–189. DOI: 10.15406/ijcam.2026.19.00783

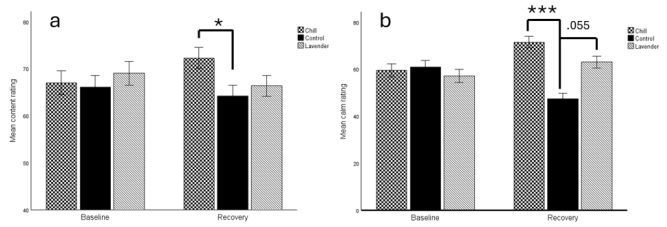

Figure 8 Mean content (a) and calm (b) ratings for all conditions at baseline and during recovery. Error bars represent standard errors, * indicates p<.05, *** indicates p<.001.

Calm

The condition*timepoint interaction was significant F(2, 87) = 14.596, p<.001, η^2_p =.251 (a large effect size). Bonferroni corrected pairwise comparisons indicated that no differences existed between conditions at baseline, but that at recovery participants in the chill condition (M = 71.47) and the lavender condition (M = 63.01) were significantly more calm than those in the control condition (M = 47.35), p<.001. The difference between the chill condition and the lavender condition approached but did not quite reach significance, p =.055 (Figure 8b).

Positive affect

The condition*timepoint interaction was significant F(2, 87) = 3.541, p =.033, η^2_p =.075 (a medium effect size). Bonferroni corrected pairwise comparisons indicated that no differences existed between conditions at baseline, but that at recovery participants in the chill condition possessed significantly greater positive affect (M = 34.57) than those in the control condition (M = 28.83), p =.001 (Figure 9a).

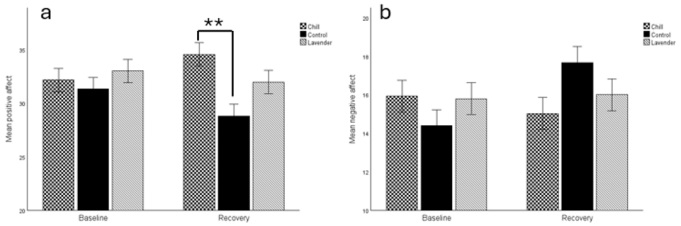

Figure 9 Mean positive (a) and negative (b) affect scores for all conditions at baseline and during recovery. Error bars represent standard errors, ** indicates p<.01.

Negative affect

The condition*timepoint interaction was significant F(2, 87) = 4.826, p =.010, η^2_p =.100 (a medium to large effect size). Bonferroni corrected pairwise comparisons indicated that no differences existed between conditions at baseline. During recovery participants in the chill condition reported negative affect levels (M = 15.03) that were lower than those in the control condition (M = 17.67) although this difference did not reach statistical significance, p =.087 (Figure 9b).

Salivary immunoglobulin-A

A significant difference was found between conditions F(2, 87) = 3.216, p =.045, η^2_p =.069 (a medium effect). Tukey pairwise comparisons revealed that the chill condition (M = 151.95) was significantly lower than the control condition (M = 180.93) (Figure 10a).

Salivary chromogranin A

The difference between the three conditions approached but did not quite reach significance F(2, 87) = 2.686, p =.074, η^2_p =.058 (a medium effect) (Figure 10b).

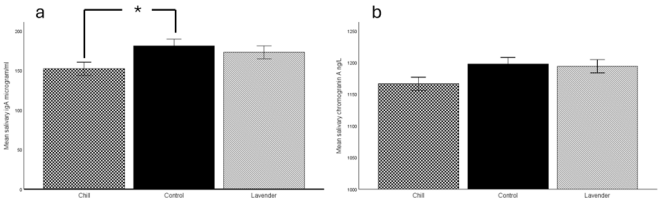

Figure 10 Mean salivary immunoglobulin A values in µg/ml (a) and salivary chromogranin A in ng/L (b) for all conditions. Error bars represent standard errors. * indicates p<.05.

NASA-TLX and testing experience scale

The one way multivariate analysis of variance revealed a significant difference between conditions for the compound dependent variable, Wilks' lambda =.504, F(22, 154) = 2.863, p<.001. Each of the dependent variables was then considered individually using univariate Anovas. See Table 2 for descriptive statistics.

Table 2 Mean (SD) values for the subscales of the NASA task load index for all conditions

Condition	Mental demand	Physical demand	Temporal demand	Performance	Effort	Frustration
Chill	68.67 (16.0)	29.67 (20.2)	81.83 (13.7)	63.50 (14.4)	59.43 (16.7)	42.33 (15.2)
Control	78.00 (12.9)	32.93 (17.7)	80.43 (13.5)	50.83 (14.2)	74.23 (23.1)	60.77 (25.6)
Lavender	71.50 (16.5)	36.50 (26.4)	79.17 (16.1)	53.83 (16.7)	63.67 (18.0)	48.33 (24.1)

NASA-TLX mental demand

The difference between conditions for the mental demand subscale approached but did not quite reach statistical significance, F(2, 87) = 2.961, p =.057, η^2_p =.064 (a medium effect size)

NASA-TLX physical demand

No difference was found between the conditions for the physical demand subscale F(2, 87) =.740, p =.480, η^2_p =.017 (a small effect size).

NASA-TLX temporal demand

No difference was found between the conditions for the temporal demand subscale F(2, 87) =.255, p =.776, η^2_p =.006 (a very small effect size).

NASA-TLX performance

A significant difference was found between conditions for the performance subscale F(2, 87) = 5.129, p =.008, η^2_p =.105 (a large effect size). Tukey post hoc comparisons revealed that the chill

condition possessed higher performance ratings (M = 63.50) than the control condition (M = 50.83), p =.008. The difference between the chill condition and the lavender condition (M = 53.83) approached but did not reach significance, p =.056.

NASA-TLX effort

A significant difference was found between conditions for the effort subscale F(2, 87) = 4.002, p =.022, η^2_p=.084 (a medium to large effect size). Tukey post hoc comparisons revealed that the chill condition possessed lower ratings of effort (M = 59.43) than the control condition (M = 74.23), p =.020.

NASA-TLX frustration

A significant difference was found between conditions for the frustration subscale F(2, 87) = 5.419, p =.006, η^2_p=.111 (a large effect size). Tukey post hoc comparisons revealed that the chill condition possessed lower ratings of frustration (M = 42.33) than the control condition (M = 60.77), p =.005.

Testing experience scale

The descriptive statistics for the testing experience scale are presented in Table 3.

Table 3 Mean (SD) values for the subscales of the testing experience questionnaire for all conditions

Condition	Stressful	Temperature	Lighting	Aroma strength	Likeable
Chill	5.33 (1.6)	5.23 (1.1)	5.40 (0.9)	5.10 (2.4)	7.07 (1.6)
Control	6.43 (2.1)	5.53 (1.3)	5.20 (0.7)	3.77 (2.3)	5.40 (1.7)
Lavender	5.47 (2.2)	5.40 (0.9)	5.37 (0.7)	5.43 (2.3)	5.87 (2.0)

Testing experience scale - stressful

The difference between conditions for how stressful they found the study experience approached but did not quite reach statistical significance, F(2, 87) = 2.722, p =.071, η^2_p=.059 (a medium effect size).

Testing experience scale - temperature

No difference was found between the conditions for the temperature of the test room F(2, 87) =.567, p =.569, η^2_p=.013 (a small effect size).

Testing experience scale - lighting

No difference was found between the conditions for the lighting of the test room F(2, 87) =.612, p =.545, η^2_p=.014 (a small effect size).

Testing experience scale – aroma strength

A significant difference was found between the conditions for the aroma strength in the test room F(2, 87) = 4.217, p =.018, η^2_p=.088 (a medium to large effect size). Tukey post hoc comparisons revealed that the lavender aroma (M = 5.43) was rated as stronger than the control condition (M = 3.77), p =.020. The difference between the chill aroma (M = 5.10) and the control condition approached but did not reach significance, p =.078.

Testing experience scale – aroma likeable

A significant difference was found between the conditions for how likeable the aroma in the test room was F(2, 87) = 6.977, p =.022, η^2_p=.138 (a large effect size). Tukey post hoc comparisons revealed that the chill aroma (M = 7.07) was rated as more likeable than both the lavender aroma (M = 5.87), p =.032, and the control condition (M = 5.40), p =.001.

Testing experience scale – aroma relaxing

A significant difference was found between the conditions for how relaxing the aroma in the test room was F(2, 87) = 17.848, p <.001, η^2_p=.291 (a large effect size). Tukey post hoc comparisons revealed that the chill aroma (M = 6.63) was rated as more likeable than both the lavender aroma (M = 5.70), p =.023, and the control condition (M = 4.57), p <.001. In addition the lavender aroma (M = 5.70) was rated as significantly more relaxing than the control condition (M = 4.57), p =.004.

Testing experience scale – aroma energising

No difference was found between the conditions for the ratings of how energising the aroma of the test room was perceived to be F(2, 87) =.554, p =.577, η^2_p=.013 (a small effect size).

Effect size comparison of Chill™ vs lavender

The multiple tests included in the analysis reduces the likelihood of significance and as an alternative approach the Cohen's d measures of effect size for the Chill vs Lavender comparisons are presented in Tables 4 and 5. The values clearly indicate consistent small to medium effect sizes demonstrating a beneficial effect of the Chill™ aroma over pure lavender for the physiological and psychological measures employed here.

Table 4 Mean (SD) and Cohen's d effect sizes for comparisons between the Chill and lavender conditions for physiological variables

Variable	Chill M (SD)	Lavender M (SD)	Cohen's d [95% CI]
Systolic BP baseline	132.16 (13.56)	133.47 (19.21)	-.079 [-.585, .428]
Systolic BP Demo	133.15 (16.15)	142.59 (20.15)	-.517 [-1.029, .000]
Systolic BP task	138.32 (15.87)	143.79 (18.59)	-.316 [-.824, .194]
Systolic BP 1st Interval	137.98 (16.22)	144.84 (18.41)	-.395 [-.905, .117]
Systolic BP 2nd Interval	141.52 (19.42)	143.52 (19.26)	-.103 [-.609, .403]
Systolic BP 3rd Interval	136.75 (14.09)	143.16 (18.89)	-.385 [-.894, .128]
Systolic BP Recovery	132.90 (12.04)	139.59 (19.61)	-.411 [-.921, .102]
Diastolic BP baseline	72.86 (7.37)	75.36 (11.18)	-.263 [-.770, .246]

Table 4 Continued..

Diastolic BP Demo	75.49 (9.29)	79.96 (12.02)	-.417 [-.927, .097]
Diastolic BP task	77.39 (10.35)	83.01 (11.53)	-.513 [-1.026, .004]
Diastolic BP 1st Interval	76.79 (10.79)	81.62 (11.94)	-.425 [-.935, .089]
Diastolic BP 2nd Interval	77.25 (10.10)	81.83 (12.72)	-.400 [-.909, .113]
Diastolic BP 3rd Interval	76.14 (9.53)	81.71 (12.22)	-.509 [-1.021, .008]
Diastolic BP Recovery	74.49 (8.54)	80.56 (12.30)	-.574 [-1.088, -.055]
HR baseline	74.15 (7.55)	75.36 (10.67)	-.131 [-.637, .376]
HR Demo	73.99 (9.16)	75.69 (9.71)	-.179 [-.686, .329]
HR task	74.92 (10.66)	78.28 (11.09)	-.309 [-.817, .202]
HR 1st Interval	75.01 (10.93)	79.56 (10.08)	-.433 [-.943, .081]
HR 2nd Interval	75.47 (10.92)	76.49 (10.85)	-.094 [-.600, .413]
HR 3rd Interval	74.89 (10.50)	75.12 (10.44)	-.022 [-.528, .484]
HR Recovery	74.27 (10.45)	76.12 (9.71)	-.183 [-.680, .321]
S-CgA	1166.45 (44.95)	1193.93 (72.30)	-.456 [-.967, .058]
S-IgA	151.95 (45.21)	172.78 (44.90)	-.462 [-.973, .053]

Table 5 Mean (SD) and Cohen's d effect sizes for comparisons between Chill and lavender conditions for self-report variables

Variable	Chill M (SD)	Lavender M (SD)	Cohen's d [95% CI]
Present stress baseline	2.33 (1.23)	3.17 (1.64)	-.568 [-1.082, -.049]
Present stress Demo	4.00 (1.31)	4.10 (1.88)	-.062 [-.568, .445]
Present stress task	4.47 (1.63)	5.03 (1.79)	-.331 [-.839, .180]
Present stress 1st Interval	4.60 (1.22)	5.37 (1.83)	-.493 [-1.005, .023]
Present stress 2nd Interval	4.50 (1.74)	5.40 (1.83)	-.504 [-1.017, .012]
Present stress 3rd Interval	4.13 (1.72)	5.23 (1.65)	-.653 [-1.170, -.130]
Present stress Recovery	2.27 (1.14)	4.20 (1.71)	-1.329 [-1.885, -.764]
Positive affect CFB	2.37 (6.70)	-1.03 (5.57)	.537[.020, 1.051]
Negative affect CFB	-.90 (5.96)	.20 (4.10)	-.215 [-.722, .293]
Alertness CFB	2.13 (8.54)	.20 (11.02)	.196 [-.312, .703]
Contentment CFB	5.25 (15.37)	-2.65 (11.96)	.573 [.054, 1.088]
Calmness CFB	11.90 (13.68)	5.94 (21.62)	.329 [-.182, .838]
Mental demand	68.67 (16.03)	71.50 (16.51)	-.174 [-.680, .334]
Performance	63.50 (14.21)	53.83 (16.95)	.618 [.097, 1.134]
Effort	59.43 (23.13)	63.67 (21.17)	-.191 [-.697, .317]
Frustration	42.33 (15.24)	48.33 (24.12)	-.297 [-.805, .213]
Stressful	5.33 (1.63)	5.47 (2.18)	-.169 [-.575, .437]
Likeable	7.07 (1.60)	5.87 (1.98)	.668 [.145, 1.185]

Discussion

The current study investigated the effects of essential oil aroma inhalation on psychological and physiological responses to experimentally induced acute stress in a sample of healthy adults. The main focus of the study was the relative potential for stress buffering from the two aromas compared to a no aroma control group. In particular, whether the Chill™ blend may offer greater buffering potential than a single essential oil. The data analysis revealed that in support of hypothesis one, the Multitasking Framework induced psychological stress in healthy participants and that this was mirrored in physiological responses. Hypothesis two was also supported with the impact of the Multitasking Framework mitigated by the inhalation of the aroma of essential oils. Of particular importance here is the comparison between the single essential oil of lavender with the blended essential oils in the Chill™ formula and the observation that the blended Chill™ aroma had a greater effect than the lavender aroma positive control.

Previous research with the Multitasking Framework has identified it as a useful technique for modelling acute stress and workload in the laboratory with consistent increases in heart rate and blood pressure coupled with negative impact on mood being reported following a ten minute engagement with the parallel tasks.[39,50] Here, the no aroma control participants showed similar small to medium sized effects for increased heart rate and blood pressure that were mitigated to some extent by aroma inhalation, although the correction for violation of sphericity left the condition by timepoint interaction for diastolic blood pressure just short of statistical significance. Inhalation of aromas is known to directly stimulate the limbic system in particular the olfactory amygdala that shares connectivity with brain areas involved in autonomic functions such as respiration, heart rate, and blood pressure.[51] Similar beneficial effects of a sandalwood-lavender blend beyond those for pure lavender have been reported in an exercise-based stress protocol which the authors attribute to the combined advantages of the blends two pure essential oil components.[28] The complex blend employed in the current study extends considerably the constituent compounds compared to pure lavender as evidenced by the chromatogram and it seems likely that this accounts for the superior impact of the Chill™ blend.

Considering the effect of the Multitasking Framework on mood, previous reports have identified pre to post testing reductions in

calmness and contentment[50] and increases in alertness[52] and perceived stress.[53] Data from our control condition showed no effect for alertness, a small decline in calmness and a larger one for contentedness. Importantly, the Chill aroma not only mitigated these declines but actually led to increases in both calmness and contentedness resulting in participants in this condition being significantly more calm and content than control participants during the recovery phase. Lavender aroma had a smaller, non-significant effect on mood and this is in keeping with a previous study that investigated the effect of lavender on mood during completion of the Multitasking Framework where no impact on the same mood variables was observed.[54] Typically, positive affect decreases and negative affect is maintained or increases during a multitasking procedure.[55,56] Such a pattern was observed here for the control and lavender conditions, but the Chill™ aroma reversed this with an increase in positive affect and a decrease in negative affect from baseline to recovery. Mindfulness meditation has been shown to lessen the effect of multitasking on negative affect but no effect was seen for positive affect.[56] In the same study Levy and colleagues reported significant increases in self-reported stress as a consequence of multitasking. The present stress scale we employed here has previously been used with the Multitasking Framework with large effects observed from baseline to framework completion.[57] In the current study we observed consistent, significant reductions in self-reported stress in the Chill™ condition during the framework completion when compared to the control condition. The scores for lavender on this variable falling between the Chill™ and control conditions.

The NASA-TLX has been used in a number of previous investigations employing the Multitasking Framework[39,40,58] and other multitasking paradigms[59–61] with consistent increases in total workload and across the subscales being reported. In the current study we found that the Chill™ aroma significantly improved ratings of performance and reduced effort and frustration compared to the control condition. Previous aroma studies employing the NASA-TLX have shown decreases in temporal demand and frustration in a driving simulation[62] and contrasting increases in perceived effort and mental demand during a cognitive video game.[63] Driving based studies might be considered to include multitasking aspects and as such the findings reported by Raudenbush and colleagues align comfortably with ours. The cognitive video game required focussed attention and McCombs and colleagues argue that the self-reported increases in effort and demand reflect increased engagement with the task as a consequence of the presence of an aroma. By comparison the multitasking framework we employed required divided attention and attentional switching rather than focussed attention. This difference may underpin the inconsistent findings when compared to McCombs et al[63]. Alternatively, the use of arousing peppermint aroma by McCombs and colleagues compared to the sedative Chill™ blend we tested might be a reasonable explanation.

The Multitasking Framework has also been shown to increase salivary IgA secretion in healthy adults and this has been linked to perceived workload and psychological experience of completing the framework.[41,52] Here, although baseline levels were not recorded we observed that the Chill™ aroma delivered lower S-IgA levels at the end of the testing period. Previous research has shown that S-IgA levels increase immediately following acute stress[20] and we suggest that the difference between conditions observed here reflects a general reduction in the level of sympathetic arousal as a consequence of inhalation of the Chill™ aroma. However, no correlations were found between S-IgA levels and measures of stress, mental demand, effort or frustration completed during the recovery period. Salivary chromogranin-A has been reported to be elevated by exam stress,[64] orthodontic treatment[65] and noise exposure.[66] No data have been reported previously for a Multitasking paradigm of the kind employed here although the CogScreen-AE test battery has been employed as a psychological stressor and led to significant increases in CgA.[67] The current study again lacked a pre to post stressor comparison but the recovery period assays were suggestive of the Chill™ aroma buffering CgA secretion although the medium sized effect just fell short of statistical significance. Again we would contend that the effect may be related to sympathetic arousal, but accept that because salivary biomarkers possess high inter-individual variability, the independent groups analysis limits the interpretability of the intervention's true efficacy without baseline measurements being taken.

A key aspect of interest in the current study was the comparison between the two aroma conditions. There has been very limited research comparing individual oils with blends specifically designed to have a particular effect based on evidence of psychological benefits for the component oils, coupled with aromatic hedonics of the final blend. One recent study did find potential benefits of blending over a single positive control essential oil previously identified as a cognitive enhancer.[68] Given the large number of pairwise comparisons in the current study's analysis, Bonferroni corrections meant that many failed to reach statistical significance. It was considered prudent to evaluate the effect sizes for each comparison to identify if effects of value were at risk of being overlooked through the simple hypothesis testing procedure.[69] For the physiological variables consistent small to medium sized effects were present for systolic and diastolic blood pressure across the procedure. These suggest that inhalation of the Chill™ blend aroma was more effective than lavender essential oil in buffering the response to the stressful multitasking.

Two aspects warrant consideration when designing future research in this area. Firstly, the sample employed here were all healthy young adults and it is noted that and middle-aged and older adults exhibit different olfactory sensitivity[70] and stress responses.[71] Therefore the generalisability of the current findings is limited and future studies should aim to employ a wider age range in sufficient numbers to allow for age effects to be investigated. Secondly, future studies should aim to incorporate measures of volatile organic compounds (VOCs) in the test rooms to try to provide data regarding dosing. This is an aspect of aroma based research that consistently falls short of standardisation and one that is essential to address in order to move the application of aroma inhalation interventions forward. Although a measure of VOCs alone is not sufficient to establish dosing, as breath depth and frequency are also important variables, it will represent a step in the right direction. A final point that is difficult to reconcile in future research is that the results from the Testing Experience Scale indicate that the lavender aroma was rated as significantly stronger than the control condition, and that the chill aroma was more pleasant than both lavender and the control. These perceptual differences could induce expectancy effects or allow participants to deduce their condition, potentially compromising the double-blind design. The very nature of aromas makes double blinding difficult but we argue that it is essential to try in order to maintain the integrity of the study.

Conclusion

In conclusion, the data presented here clearly add to a growing body of evidence supporting the beneficial properties of essential oil aroma inhalation on psychophysiological responses to acute stress. More pertinently the demonstration that Chill™ aroma outperformed pure lavender aroma supports the use of blended oils in aroma-based interventions. We argue that the potential benefits of essential

oil inhalation aromatherapy have been widely overlooked and that their inclusion in a fully integrated healthcare model would be of considerable value

Acknowledgements

None.

Conflicts of interest

The authors declare there are no conflicts of interest.

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