Coconut Fragrance and Cardiovascular Response to Laboratory Stress

Results of Pilot Testing

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There is preliminary evidence that pleasant fragrances may alter response to stressors in different settings. This pilot study examined the effect of coconut fragrance on cardiovascular response to standard laboratory stressors. While inhaling coconut fragrance (n = 17) or air (n = 15), subjects performed a Stroop color-word task and a mental arithmetic task. Heart rate (HR), heart period variability (HPV) and blood pressure were measured during the 5-minute baseline, the task, and the recovery periods. The results indicated that subjects breathing coconut fragrance had higher HR and lower HPV than those who performed tasks while breathing air. HR response to mental arithmetic seemed to be blunted in the subjects breathing coconut; however, the lack of a difference in HPV seems to indicate that the blunting may be due to decreased sympathetic response, not decreased parasympathetic withdrawal under stress. Blood pressure recovery was slightly enhanced in subjects under coconut fragrance. Thus, the results of this pilot test suggest that coconut fragrance may alter cardiovascular activity both at rest and in response to stressors. Future experimentation should attempt to replicate and extend these findings in larger samples in clinical settings. Key Words: aromatherapy, blood pressure, cardiovascular response, heart period variability, heart rate, stress Holist Nurs Pract 2010;24(6):322–332

There is a popular belief that certain pleasant fragrances are calming and relieve stress. Aromatherapy is the therapeutic use of essential oils (distilled from the leaves, stems, flowers or other parts of aromatic plants) for the purposes of enhancing emotional or physical health or function.1 This effect is thought to occur as a result of the highly complex chemical compounds present in the oils traveling through the nose to the olfactory bulb, and then the limbic system.2

There are a growing number of research studies on the use of essential oils, such as lavender and rose, as well as other pleasant aromas to moderate stress. In particular, lavender scent has been shown to decrease self-reports of stress3 and a synthetic, vanilla-like scent (heliotropin) was associated with significantly decreased self-reported anxiety in the magnetic resonance imaging environment in patients who rated the fragrance as pleasant.4 In addition, fragrances are reported to alter physiological variables thought to reflect stress.3-8 For example, Kikuchi et al investigated the effect of pleasant scents (lemon, rose, or other floral solution) on cardiac response patterns during a simple reaction time task in 18 women. The researchers found that a lemon scent activated the anticipatory/attentional process as indicated by an increased amplitude of heart rate (HR) deceleration just before a stimulus, and that this effect became smaller with decreasing odor concentration. The rose scent resulted in a similar effect that was comparable across all odor concentrations. Subjects described the lemon scent as refreshing and rose as relaxing, and odor effects tended to be stronger when subjects found the scent to be pleasant.

Saeki7 investigated whether the addition of lavender essential oil to a footbath would be associated with increased change in autonomic function beyond the relaxing effects of the footbath alone. Ten healthy female volunteers were assigned to receive 10-minute footbaths with either no oil or the addition of lavender essential oil. Autonomic function was evaluated via...
spectral analysis of heart rate variability (HRV). Heart rate variability provides a noninvasive assessment of the sympathetic and parasympathetic components of the autonomic nervous system through analysis of the variations occurring in the interval from 1 heart beat to the next. Although neither the footbath alone nor with the addition of the essential oil resulted in significant changes in blood pressure (BP), HR, or respiration, parasympathetic activity increased significantly during the footbath in both groups (with and without the addition of lavender oil). In the subjects receiving lavender, shortly after the end of the soaking period, there was a nonsignificant trend toward increased parasympathetic activity indicative of enhanced relaxation.

In a subsequent study, Saeki and Shiohara examined the effect of lavender, rosemary, and citronella fragrances on the autonomic nervous system using blood flow (BF), galvanic skin conductance (GSC), blood pressure (BP), and electrocardiogram (ECG) measurements in 9 female subjects. Each was exposed (in random order) to a control condition without fragrance, and then to lavender, rosemary, and citronella oils that were misted into a room via hot water. Lavender produced an increase in BF and decrease in GSC and BP. Rosemary decreased BF and increased BP immediately after inhalation. Citronella produced an increase in the R-R interval on the ECG and decreased BF and GSC. The authors concluded that lavender produced relaxation by increasing activity in the parasympathetic and decreasing it in the sympathetic nervous system. Rosemary appeared to stimulate the sympathetic nervous systems, and citronella activated both the sympathetic and parasympathetic nervous systems. It is important to note that both of the above studies were limited by their small sample sizes that lacked heterogeneity.

Peng et al also examined the effects of an essential oil on HRV with a larger sample of healthy volunteers. In this randomized controlled trial, 114 subjects were randomly assigned to 1 of 4 groups—a music group, an aroma group, a combined music plus aroma group, and a no-treatment control group. In the music group, subjects listened to preselected New Age music for 15 minutes; in the aroma group, they were instructed to inhale a mist containing diluted essential oil of Citrus bergamia over 15 minutes. In the combined group, subjects were exposed to both treatments simultaneously; controls were asked to rest quietly in a recliner for 15 minutes. There were no significant differences across the 4 groups in terms of changes in BP or mean HR. Subjects in all 3 intervention groups experienced increased parasympathetic activity as indicated by the percentage change in the ratio of low-frequency to high-frequency components of HRV as compared to rest alone, however. In addition, the percentage change of normalized low-frequency and high-frequency components of HRV were significantly different between the control and music groups, but not the other groups, another indicator of parasympathetic predominance. There were no significant between-group differences among the intervention groups, which led the researchers to conclude that both music and aroma were similarly relaxing and that there was no additional benefit to combining both treatments.

In addition to the effect of relaxation, some aromas have been shown to improve cognition. Specifically, peppermint and, to a greater extent, lavender oil were associated with improved efficiency among proofreaders. Participants were asked to proofread pages of text and identify the misspelled words while exposed to either lavender or peppermint. Lavender was associated with improved efficiency among women, and peppermint had the greatest effects in men, suggesting essential oils can improve concentration on a mental task.

As described in the Kikuchi study, positive effects of odors may not be restricted to those of essential oils. In 2 published studies using the same sample, an acoustic startle probe paradigm revealed that inhaling a pleasant fragrance (coconut, not an essential oil) was associated with a decreased startle blink magnitude, thus suggesting that exposure to a pleasant scent can decrease sympathetic arousal. Breathing unscented air was not associated with any such reduction, and breathing an unpleasant scent (Limburger cheese) was associated with an augmentation of startle blink response. Subjects’ HRs increased during exposure to the unpleasant aroma but were not affected in the coconut scent group.

Although there is evidence to suggest that inhaling pleasant fragrances during rest might enhance relaxation, little is known about the effects of inhaling fragrances during exposure to a stressor. Romine et al reported diastolic recovery from exercise stress to be enhanced while breathing lavender scent. If in further investigation scents can be shown to buffer physiological responses to stress, these results would provide more support for the hypothesis that pleasant fragrances are stress-reducing.
MATERIALS AND METHODS

Research in psychophysiological reactivity has developed several standardized laboratory stressor paradigms that could be used to evaluate the effects of scents on cardiovascular response to stressors. Therefore, the present study used a standard cardiovascular stress reactivity protocol to test the hypothesis that a pleasant aroma can decrease reactivity to stressors. In this protocol, R-R intervals derived from HR measures were also used to assess heart period variability (HPV) as an index of parasympathetic nervous system activity. In addition to physiological measures, subjective reports of mood and stress were recorded.

Signal acquisition and processing

Electrocardiogram electrodes were placed on the right shoulder, on the left anterior axillary line at the 10th intercostal space, and in the right lower quadrant. Analog ECG signals were digitized at 500 Hz by a National Instruments A/D board and passed to a microcomputer. The ECG waveform was submitted to a specially written R-wave detection routine, resulting in an R-R interval series. Errors in marking of R waves were corrected interactively by research assistants. The root mean square of successive differences (rMSSD) of the R-R intervals served as the measure of HPV. Heart period variability is positively correlated with parasympathetic nervous system activity, thus it is thought to reflect vagal cardiac modulation. An Ohmeda Finapres 2300 monitor was used to measure BP. The finger cuff was placed on the left hand. Finapres measures were calibrated by moving the arm so that readings fell within ±10 mm Hg of a manual BP reading. The servo self-adjustment was disabled except for the last minute of each period, so that the calibration signal would not interfere with the BP measures. The analog BP waveform was digitized at 500 Hz and collected by the microcomputer. Systolic and diastolic pressures were identified on the pressure waveform by a specially written program. Errors in marking systole and diastole were corrected by trained research assistants.

STUDY DESIGN

The intended design was a between-subjects crossover repeated-measures design, where subjects were tested once while exposed to the fragrance condition and once to the control/air-only condition, sequence randomly determined. However, as explained later, the final design presented here was a simple between-subjects study.

SUBJECTS

The university’s institutional review board approved all study procedures related to the ethical conduct of research. Subjects were recruited by flyers posted around the medical center for a study on the effects of fragrance on cardiovascular reactivity. Exclusion criteria were smoking, medical conditions or medications that might affect the cardiovascular system, or conditions that interfered with the olfactory system. No one refused to take part in the study, because they initiated contact for the study: we did not invite/approach them. Subjects gave informed consent prior to any procedures and were paid a total of $80 for the 2 sessions.

Stressors

Two standard laboratory tasks were used as stressors.

Stroop color—word task

Subjects were presented with color names (blue, green, yellow, and red) displayed in colors that were either congruent or incongruent with the names. Subjects pressed a key on a keypad that corresponded to the display color of the letters. The computer paced the task and delivered an error message whenever a subject entered an incorrect response or failed to respond rapidly enough.

Mental arithmetic

Subjects were presented with a 4-digit number on a computer monitor and were instructed to subtract serially by 7s starting with this number, entering their response on a keypad. The first number disappeared after the first answer was entered on the keypad. Subjects received verbal prompts (eg, “please subtract faster”) at random intervals. The computer did not pace this task, but subjects were instructed to subtract as quickly and as accurately as possible.

Fragrance condition

Coconut fragrance was chosen as the pleasant scent on the basis of both previous work and pilot testing on several test subjects. The choice of coconut fragrance over the more researched fragrance of lavender also allowed us to estimate the
generalizability of lavender findings to other pleasant odors. Coconut fragrance was generated using McCormick’s Imitation Coconut Extract.

Air from a standard tank was used in the control/no fragrance condition. Both air and coconut fragrances were delivered under low pressure via nasal cannula. Paper saturated with coconut extract was placed into a small container in the line connecting the tank supplying the air to the nasal cannula.

**STUDY PROCEDURE**

Subjects were seated in a comfortable chair and instrumented for ECG and BP. After instrumentation, they completed the Positive and Negative Affect Scale (PANAS). The PANAS is a widely used 20-item scale that assesses positive and negative affect separately rather than on a unidimensional scale. Subjects rate the degree to which they are experiencing specific mood states at that moment. Ratings of positive mood items were summed to generate a positive mood score, and ratings of negative mood items were summed to generate a negative mood score. The instructions and questionnaire items were presented on a computer and subjects responded using a numeric keypad. Subjects then received instructions about the Stroop and mental arithmetic tasks. They were next fitted with the nasal cannula that delivered either room air or coconut fragrance under low pressure.

The tasks were presented in fixed order. Subjects rested for 5 minutes to provide resting baseline measures. Subjects then performed the 5-minute Stroop task, after which they rested for 5 minutes. Then they performed the 5-minute mental arithmetic task, after which they rested for a final 5-minute rest period. The ECG and BP were recorded continuously. Stress ratings were collected at the end of each of the 5 periods. Subjects were asked to rate their stress at that moment from 1 (“no stress at all”) to 10 (“the most stress ever felt in life”). At the end of the procedure, they completed a second PANAS.

After the instruments were removed, subjects were asked to rate separately the intensity and pleasantness of the fragrance on a scale from 1 (“low intensity/not pleasant at all”) to 6 (“very intense/very pleasant”). They were then paid and released.

**DATA ANALYSES**

Heart rate and BP were recorded during a 5-minute pretask rest period, a 5-minute Stroop task, a 5-minute resting period, a 5-minute mental arithmetic task, and a 5-minute posttask resting period. These dependent measures were analyzed for cardiovascular response to stressors. Before performing analyses to address if exposure to fragrance affects cardiovascular reactivity, we performed a validation of the crossover procedure. This was to verify that repeated-measures analyses could be used on data from both the first and second sessions. To collapse data across both visits to the laboratory, analyses should reveal no difference in response that is affected by order. In other words, the effects of coconut fragrance should not depend on whether subjects received coconut or air during the first session.

A repeated-measures multivariate analysis of variance (MANOVA) was performed on HR reactivity to both tasks with fragrance (coconut vs air) as the within-subjects factor and order (coconut followed by air vs air followed by coconut) as the between-subjects factor. A significant fragrance by order interaction for both Stroop and mental arithmetic indicated that the crossover manipulation had failed. The results indicated that there were significant differences between measures of the first and second sessions. The most likely reason was because the prior experience with the laboratory tasks in the first session altered stress responses for the second session, regardless of whether there was aroma present or not. These results meant that the data could not be analyzed by a repeated-measures method.

Therefore, we present results generated from the first session only. This choice was based on the assumption that stress responses would be less robust during the second session than during the first session due to habituation, thus decreasing the chance of detecting the expected buffering effect of coconut aroma exposure. Data analyses were restricted to a subset of 20 women and 12 men. Seventeen participants completed tasks while exposed to fragrance, and 15 performed the tasks under normal room air conditions. The mean age of the subjects was 33.72 ± 8.60 years; 6.3% were of mixed ethnicity, 9.4% were Latino, 18.8% were African American, and 65.6% were white.

**HEART RATE**

Baseline, task, and recovery measures of HR were analyzed in repeated-measures MANOVA. Separate
multivariate analysis of covariance was conducted for each task. Condition (coconut/air) was the between-subjects factor and period (pretask rest/task/posttask rest) was the within-subjects factor. Wilks lambda (Λ) criterion was used for the multivariate significance testing. Univariate ANOVAs of simple contrasts were also conducted with the pretask rest as the comparison period. Similar repeated-measures MANOVAs were conducted on diastolic blood pressure (DBP) and systolic blood pressure (SBP). Please note that because the Stroop was always performed before the mental arithmetic test, the posttask rest after Stroop is also the pretask rest before mental arithmetic. This means the numbers will be identical for these variables and the actual time period could be called by either name.

Mood

Change in positive mood was computed by subtracting the positive mood score prestress from the positive mood score poststress. Change in negative mood was computed by subtracting the negative mood score prestress from the negative mood score poststress. Group differences in change in positive and negative mood were analyzed by t test.

STRESS

Ratings of stress were analyzed in a repeated-measures MANOVA with condition (coconut/air) as the between-subjects factor and period (pretask rest/Stroop/post-Stroop rest/mental arithmetic/post–mental arithmetic rest) as the within-subjects factor. Post hoc univariate ANOVAs of simple contrasts (Pretask rest vs the other periods) followed the multivariate analysis.

RESULTS

The use of a repeated-measures MANOVA analyses requires a normal distribution of data. The distribution of the variables of rMSSD and SBP were significantly skewed; therefore, the data was transformed prior to analyses using a standard log transformation mathematical process to achieve a normal distribution of these data (lnrMSSD and lnSBP respectively).

Pleasantness and intensity ratings

The coconut fragrance was rated somewhat more pleasant than the control air (P = .07). There were no differences in the group on intensity of fragrance.

CARDIOVASCULAR RESPONSE TO STROOP

Figures 1 and 2 present the means and standard errors for lnrMSSD, and HR during the pretask rest, Stroop, and posttask recovery periods. A 2 (condition) by 3 (period) MANOVA of these lnMSSD and HR revealed a significant effect of condition, Λ = 0.77, F_{2,29} = 4.26, P < .05, and period, Λ = 0.26, F_{4,27} = 18.68, P < .0001, and a trend toward a significant condition by period interaction, Λ = 0.73, F_{4,27}
FIGURE 2. Means and standard errors for heart rate during the pretask rest, Stroop, and posttask recovery periods.

Univariate analyses indicated that the multivariate group effect was primarily due to depressed lnrMSSD, $F_{1,30} = 8.17$, $P < .01$, and to a somewhat elevated HR, $F_{1,25} = 5.41$, $P < .05$, in subjects in the coconut condition compared with those in the air condition. The multivariate period effect was due to significant differences between pretask and task lnrMSSD, $F_{1,30} = 30.12$, $P < .0001$, pretask and posttask lnrMSSD $F_{1,30} = 8.73$, $P < .01$, pretask and task HR, $F_{1,30} = 21.15$, $P < .0001$, somewhat due to a trend toward a significant difference in pretask and posttask HR, $F_{1,30} = 3.83$, $P = .06$. As Figures 1 and 2 depict, HPV was lower and HR was higher during Stroop than during baseline and recovery.

Cardiovascular response to mental arithmetic

Data from 2 coconut subjects were dropped because of signal loss. Figures 3 and 4 present the means and standard errors for lnrMSSD and HR during the pretask rest, mental arithmetic, and posttask recovery periods. A 2 (condition) by 3 (period) MANOVA of these measures revealed a significant effect of condition, $\Lambda = 0.78$, $F_{2,27} = 3.72$, $P < .05$, and
period, $\Lambda = 0.55$, $F_{4,25} = 5.20$, $P < .005$. Univariate analyses indicated that the multivariate group effect was primarily due to depressed lnMSSD, $F_{1,28} = 5.83$, $P < .05$, and to an elevated HR, $F_{1,28} = 6.24$, $P < .05$, in subjects in the coconut condition compared with the air condition. The multivariate period effect was due to significant differences between pretask and task lnMSSD, $F_{1,28} = 14.74$, $P < .001$, and pretask and task HR, $F_{1,28} = 18.20$, $P < .0001$. As Figures 3 and 4 depict, HPV was lower and HR was higher during Stroop than during baseline. In addition, within-subjects contrasts revealed a significant condition by period interaction in HR response to mental arithmetic, $F_{1,28} = 4.37$, $P < .05$. As Figure 4 shows, HR response to mental arithmetic was greater in subjects breathing nonfragrant air compared with those breathing coconut fragrance.

### Blood pressure response to Stroop

Data from 1 air subject were dropped because of signal loss. Figures 5 and 6 present the means and standard errors for DBP and SBP during the pretask rest, Stroop, and posttask recovery periods.
A 2 (condition) by 3 (period) MANOVA of these measures revealed a significant effect of period, $\Lambda = 0.50$, $F_{4,26} = 6.43, P < .001$. Univariate analyses indicated that the multivariate period effect was due to significant differences between pretask and task DBP, $F_{1,29} = 28.17, P < .0001$, pretask and posttask DBP, $F_{1,29} = 19.64, P < .0001$, and pretask and task lnSBP, $F_{1,29} = 19.64, P < .0001$, and somewhat due to a trend toward a significant difference in pretask and posttask lnSBP, $F_{1,29} = 3.82, P = .06$. As Figures 5 and 6 depict, both DBP and SBP were higher during Stroop than during pre- and posttask rests. In addition, within-subjects contrasts revealed a nearly significant condition by period interaction in DBP response to Stroop, $F_{1,29} = 3.26, P = .08$. As Figure 5 shows, compared with subjects breathing coconut fragrance, subjects breathing air had greater increases in DBP from pre- to posttask.

**Blood pressure response to mental arithmetic**

Data from 2 coconut subjects and 1 air subject were dropped because of signal loss. Figures 7 and 8 present the means and standard errors for DBP and SBP during the pretask rest, mental arithmetic, and posttask recovery periods. A 2 (condition) by 3
(period) MANOVA of these measures revealed a significant effect of period, $\Lambda = 0.35, F_{4,24} = 11.15, P < .001$. Univariate analyses indicated that the multivariate period effect was due to significant differences between pretask and task DBP, $F_{1,27} = 41.48, P < .0001$, and pretask and task lnSBP, $F_{1,27} = 26.95, P < .0001$. As Figures 7 and 8 depict, both DBP and SBP were higher during mental arithmetic than during pre- and posttask rest. In addition, within-subjects contrasts revealed a nearly significant condition by period interaction in DBP response to mental arithmetic, $F_{1,27} = 3.08, P = .09$. As Figure 7 shows, compared with subjects breathing coconut fragrance, subjects breathing air had greater increases in DBP from pre- to posttask.

**CHANGE IN MOOD**

There were no differences between the conditions on positive or negative mood change from pre to poststressors as indexed by the PANAS.

**STRESS RATINGS**

Figure 9 depicts mean stress ratings and standard errors from across the session. Data from 2 coconut
subjects were missing because of experimenter error. There were no significant effects on the multivariate and univariate analyses. From analyses of within-subject contrasts, there was a significant condition by period interaction in the comparison of the baseline versus final rest period $F_{1,28} = 7.00, P < .05$. As can be seen from Figure 9, stress ratings of the subjects in the coconut condition increased more than those of subjects in the air condition.

**DISCUSSION**

The main result from this experiment was that subjects breathing coconut fragrance had higher HRs than subjects who performed tasks while breathing air. The results of analyses of the HPV suggest that this effect was due to decreased parasympathetic cardiac modulation. In addition, cardiovascular response to the stressor tasks was altered under coconut fragrance. Specifically, HR response to mental arithmetic seemed to be blunted; however, the lack of a difference in HPV seems to indicate that the blunting may be due to decreased sympathetic response, not decreased parasympathetic withdrawal under stress. If the blunting was due to decreased parasympathetic withdrawal under stress, the analyses would show a different HPV between the 2 conditions. Finally, there was slight evidence that BP recovery after both psychological stressors was enhanced in subjects who were inhaling coconut fragrance.

These findings are consistent with several earlier reports, such as Motomura et al., who showed that exposure to pleasant odors increased arousal and Romine et al., who showed that diastolic recovery from exercise stress was slightly altered while breathing lavender scent. Our results showed that pre- to postincreases in diastolic pressures were slightly attenuated when subjects were inhaling coconut fragrance. Finally, the blunting of HR response to stressors that appear to be attributable to decreased sympathetic response is consistent with the earlier findings, in which exposure to coconut fragrance attenuated startle blink response.

It is unlikely that the decrease in HR reactivity is due to a ceiling effect subsequent to an elevated baseline HR under coconut fragrance because these mean resting HRs were far below maximal (air, 65.6 beats per minute, and coconut, 73.5 beats per minute).

Although coconut fragrance appears to affect physiological measures, there was little evidence of an effect on subjective mood and stress ratings. In fact, coconut subjects reported greater increases from the first to last reports of stress. While this may be interpreted as an exacerbation effect, an inspection of Figure 9 supports the notion that during pretask rest, coconut fragrance decreases stress, but this effect disappears through the course of the protocol, perhaps because of perceptual habituation.

One interpretation of these findings is that breathing a pleasant scent while undertaking a task increases the general arousal level (as evidenced by the increased HR) while attenuating responses to stressors (as evidenced by the blunted HR reactivity) and possibly enhancing recovery after stressors (as evidenced by increased BP recovery). One might then propose that pleasant odors in the environment may enhance task performance and possibly cardiovascular health. It is possible that inhaling a pleasant aroma prior to and during an invasive medical procedure such as cardiac catheterization might reduce the level of stress experienced by the patient.

A limitation of the work is that only 1 commercially available fragrance—coconut—was used. However, this is one of the few studies that has explored a commercially available fragrance, rather than an essential oil as used in aromatherapy. This is the first study to explore the effect of a synthetic aroma on the cardiovascular system while under stress. While results from within-subjects analyses would be more reliable, our findings are preliminary evidence of the beneficial effects of coconut fragrance on cardiovascular reactivity. Further work is warranted.

**REFERENCES**


Erratum

An Integrative Review of the Concept of Well-being: Erratum

In the article that appears on pages 244–252 in the September/October 2008 issue of the journal, the following text should have been attributed to Stanley and Cheek (Can J Occup Ther. 2003;79(1):51–59). This error is noted in the online version of the article, which is available at www.hnpjournal.com.

Well-being is thus an important concept in the philosophy underpinning social support and the clinical practice on which it is built. It is important for those individuals who are part of the social support network addressing the needs of the elderly population to consider what understandings of well-being are in play in the way that they construct their practice and explore whether there is congruence between understandings of well-being held by health care practitioners and the clients with whom they deal. If the concept is not well understood and incongruence exists, then well-being may be an elusive goal of clinical practice. Health care professionals need to be clear about what well-being is, before they can effectively enable their clients to work toward it. Furthermore, given the increasing numbers of elder individuals, it is even more imperative to understand what well-being is for older people.

Reference