Olfactory Effects on Attention Allocation and Perception of Exertion

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The aim of the current study was to test the effectiveness of pleasant odors on perception of exertion and attention allocation. A secondary purpose was to employ a placebo-control design and measure perceived smell intensity during task performance; methods that have been overlooked in previous olfaction studies in the sport and exercise domain. Seventy-six college students (35 females, 41 males) were recruited to perform a handgrip task. They were randomly assigned to one of 4 groups: control, placebo, lavender odor, and peppermint odor. Adhesive strips were placed under the noses of those in the latter three groups. The placebo group had a strip with no odor. The lavender and peppermint odor groups had a drop of concentration on the strip. After establishing a maximal voluntary contraction (MVC) level, participants performed at 30% of their MVC level for as long as they could tolerate, during which they provided ratings of perceived exertion (or effort; RPE), attention, and smell intensity at 30s intervals, and affect every 60s. MANOVA procedures failed to reveal significant differences among the treatment and nontreatment groups on rate of perceived exertion, attention allocation, and total time duration on the task. However, statistical differences were found between both odor groups and the placebo group on perceived attention diversion. The lavender group reported that the odor diverted attention to a higher degree than both the peppermint and placebo groups. Although nonsignificant, findings revealed a trend suggesting that odors may have an effect on cognitive processes, and on performance. There is a need for additional research to better capture these effects. Directions for further research, with an emphasis on methodological issues are outlined.

Human contact with the external world occurs via sensory channels that enable perception of the environment (Le Magnen, 1998). The senses allow interpretation of events and are often at the crux of an individual’s emotional, psychological, and physiological states. Surprisingly, the effects of manipulating sensory stimuli have only recently been investigated within the sport and exercise psychology domain. Much of this research has been centered on the facilitative
effects of auditory stimuli (i.e., music) during exercise (Karageorghis, et al., 2009). Moreover, with the growing health concerns (e.g., diabetes and hypertension) related to sedentary and over-weight populations (Kallings, Johnson, Fisher et al., 2009), it is necessary to investigate methods of improving exercise habits. Promoting a pleasant exercise environment with the use of appealing stimuli (e.g., video monitors and up-beat music) can increase enjoyment and adherence to exercise (Karageorghis, et al., 2009). One possible way of promoting such an environment is through the use of odors, which may serve to alter exercisers’ perceptions of the exertive task.

Most conscious perceptions are transmitted via the auditory, visual, and tactile systems (Stockhorst & Pietrowsky, 2004). As a result, these systems have received the majority of interest in the current literature. The olfactory system, conversely, has received marginal attention, despite its complexity (Kiecolt-Glaser, et al., 2008). There are nearly 350 functional olfactory receptor cells which allow humans to accurately differentiate between nearly 5000 odors (Shepherd, 2006). In addition to the vast number of olfactory receptors, the olfactory sense is also distinguished from the other senses in that it is processed in a direct path to the brain. Within the olfactory system, only one synapse mediates between the onset of the stimulus and the arrival of the nerve impulse to the cerebral cortex (Shepherd, 2006). Accordingly, there is a direct and rapid flow of olfactory impulses to the brain, which in turn allows for quick sensory recognition. The expansive under workings of the olfactory system, paired with the immediate sensory recognition make olfactory sensations robust and, thus, difficult to ignore.

The relationship between olfactory stimuli (e.g., odors and aromas) and performance on cognitive and physical tasks (e.g., treadmill, typing, pain perception and alphabetization) has been increasingly studied in recent years (Raudenbush, Corley & Eppich, 2001). The majority of these findings revealed that odors influence affective (e.g., emotions, mood, and anxiety), physiological/biological (e.g., brain activity, chemical changes, arousal levels), cognitive (e.g., memory, processing speed and pain perception), and behavioral (e.g., speed, accuracy and duration of performance) variables (Barker, et al., 2003; Marchand & Arsenault, 2002; Simpson, Coady, Osowski, & Bode, 2001). Moreover, aromatherapy has been used for centuries to facilitate well-being by reducing anxiety, decreasing pain, and controlling arousal levels (Moss, Hewitt, Moss, & Wesnes, 2008).

Olfactory research within the sport and exercise domain, however, is scarce. Only recently have researchers begun to investigate the role of the olfactory system in performing physical tasks. For example, Raudenbush et al. (2001) examined the effect of olfactory stimuli on a battery of physical tasks (e.g., running, handgrip, push-ups and basketball free throws). Participants performed the tasks under two conditions: peppermint odor and no odor. Results revealed that performance on the running, handgrip, and push-up tasks improved under the odor condition. A similar study examined the effect of aromatherapy in an exercise setting (Simpson et al., 2001). During a 15-min bout of exercise, no significant effects of odor (i.e., lavender, peppermint, and placebo) on physiological measures (e.g., Oxygen uptake ($VO_2$), pulmonary ventilation during exercise (VE) and respiratory exchange rate (RER)) or cognitive measures (i.e., RPE) were found. Nevertheless, the authors suggested that further effort is required to explore the effects of olfactory stimuli in alternative exercise settings (Simpson et al., 2001).
Although there is an increasing body of research investigating the utilization of olfactory stimuli while performing a physical task, no studies have examined attention strategies (i.e., association and dissociation), and the relationship between attention strategies and exertion as a function of olfactory stimuli presentation. Findings indicated that the presentation of other forms of sensory stimuli (i.e., auditory and visual) is effective in reducing perceived levels of exertion (Karageorghis, et al., 2009; Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006), and is related to changes in attention allocation (Razon, Basevitch, Land, Thompson & Tenenbaum, 2009). Thus, there is a need to further investigate the effect of olfactory stimuli on cognitive variables such as attention focus and perceived exertion.

Attention strategies (i.e., association and dissociation) and their effect on exertion have been topics that have received a great deal of attention within the past 25 years (Hardy & Nelson, 1988; Hollander & Acevedo, 2000; Hutchinson, 2004; Hutchinson & Tenenbaum, 2006, 2007; Morgan & Pollock, 1977; Tenenbaum, 2001, 2005; Tenenbaum & Connolly, 2008). Associative strategies help direct an individual’s focus internally, and toward somatic cues, while dissociative strategies direct one’s focus externally (Masters & Ogles, 1998, Scott, Scott, Bedic, & Dowd, 1999; Tenenbaum, 2005). Across physical activity contexts, individuals tend to shift attention as a function of increased physical workload (Tenenbaum, 2001). Specifically, as the intensity of the physical workload increases, individuals tend to alternate their attentional focus from a dissociative style (e.g., daydreaming, random or intentional thoughts) to an associative one (e.g., attending to breathing, increasing efforts to cope with pain and exhaustion). Thus, shifting attentional focus toward environmental stimuli (dissociation), such as olfactory stimuli, instead of toward emerging somatic cues (association) can promote positive psychological outcomes, and alleviate physiological stress inherent to physical activity.

The purpose of the current study is to further examine the role of the olfactory system while performing a strength-endurance squeezing task. Specifically, the current study examines the effect of lavender and peppermint odors on attention allocation and perceived exertion while performing a handgrip task. Moss, Cook, Wesnes and Duckett (2003) investigated the effect of lavender odor on cognitive performance and mood. Results supported the notion that relaxing odors, such as lavender, produce decrements in memory and attention. In addition, Barker et al. (2003), examined the effect of peppermint odor during performance of motor and cognitive tasks (i.e., typing, memorization and alphabetization). Findings indicated that peppermint odor improved performance overall, as it served to focus the participants attention to the task. Accordingly, the odors used within the current study were selected based on the notion that relaxing olfactory stimuli (i.e., lavender) divert attention (Moss et al., 2003) and stimulating olfactory stimuli (i.e., peppermint) increase attention to the task at hand (Barker et al., 2003; Kimura, Mori, Suzuki, Endo & Kawano, 2001). In addition, findings in the sport and exercise domain highlight the strong link between arousal level, exertion, attention and performance (Janelle & Hatfield, 2008; Pesce, Tessitore, Casella, Pirritano, & Capranica, 2007; Singer, 2002). Given the evidenced effect of auditory and visual stimulation on attention allocation and perceived exertion during exercise, and the effect of olfactory stimulation on cognitive, affective, and behavioral variables, it is our contention that the presentation of odors will show an affect on perceived exertion during an exertive task. Specifically, we are
 interested in examining the effect of the presentation of lavender and/or peppermint odors on RPE, task duration, and the shift from dissociative to associative attention relative to the control and placebo conditions in which no olfactory stimulus is presented.

The present study also attempts to answer certain methodological concerns that have not been fully addressed by previous olfactory studies. A major limitation within the previous literature on olfactory effects in the exercise and sport domain is the absence of a placebo and/or control group. The absence of a placebo-control design limits the experimental strength of the studies, and consequently, restricts the potency of the conclusions yielded from such studies. Another major limitation inherent to the design of previously conducted olfactory studies is the lack of measurement of the perceived intensity of olfactory stimuli. The significance of this limitation is made clear when considering the propensity for sensory adaptation and the subjectivity of odor sensitivity (Dalton & Wysocki, 1996). With constant exposure to a smell, peripheral receptors adapt to olfactory stimuli, and as a result, perceived intensity decreases over time (Dalton, 2000). In addition, there are differences of perceived odor intensity between and within individuals (Ayabe-Kanamura, et al., 1998; Larsson, Finkel & Pedersen, 2000). As a result of sensory adaptation to odors and individual differences in sensory sensitivity, it is important to measure each participant’s perceived intensity of smell to ensure that effects can be attributed to the presentation of the olfactory stimuli. Thus, in the current study perceived intensity of the olfactory stimuli was measured during the task and both placebo and control groups were included within the experimental design.

Method

Participants

Seventy-six participants (females = 35; males = 41) were recruited from two US South-Eastern universities to participate in the study. Participants were randomly assigned to four conditions: (a) control (n = 17), (b) placebo (n = 19), (c) lavender (n = 20), and (d) peppermint (n = 20). Participants’ mean age was slightly above 24 years old (M = 24.1, SD = 7.54).

A shortened version of the General Health and Life type questionnaire (GHLQ; British Colombia Department of Health, 1975), including questions regarding allergies and olfactory concerns, were administered before task performance to assure healthy status of the participants. Only healthy participants who did not indicate any olfactory concerns or allergies related to the olfactory system were included in the study. Human Subjects Committee approval was obtained before the initiation of the data collecting process.

Apparatus and Handgrip Task

Handgrip capacity was measured using a calibrated Lafayette TM handgrip dynamometer Model 78010 (Lafayette instrument company, Lafayette, Indiana). The device included an adjustable hand bar connected to a steel spring that, when compressed, moved a pointer. Applied force was recorded in kilograms by the pointer on the face of the device. The testing range for the dynamometer was 0–100kg.
Although the handgrip task itself is not a component of many sporting or exercise activities, it does provide an efficient method of inducing exertional symptoms (e.g., muscular fatigue, and discomfort) which are germane to many physical tasks. The handgrip dynamometer is also easily transported and only poses very minimal risk to participants. Accordingly, it was deemed as an appropriate task in testing the tenets of the current study and can be related to other exercise and sport related contexts.

Participants were asked to squeeze the handgrip dynamometer for as long as they could at 30% of their baseline MVC (measured before the onset of the experimental task). They were instructed to use their dominant hand and remain seated while performing the task. In addition, participants were required to turn the indicator face of the device to the researcher. Thus, they were not able to watch and monitor their ongoing task performance. This was done to ensure that the researcher could accurately gauge if the participants were maintaining 30% of their MVC during the task and provide feedback when necessary. This method is consistent with previous studies which implemented a handgrip task (Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008; Razon et al., 2009).

### Task Conditions

The study included four conditions: control, placebo, peppermint odor and lavender odor. Participants in the control condition were not administered any olfactory stimuli or adhesive strip while performing the task. Participants in the placebo group were provided with a nonodor adhesive strip under the nose. In the two experimental conditions an odorized adhesive strip was placed under each participant’s nose. Two different odors (i.e., peppermint, and lavender) were used to differentiate the two experimental conditions. Odors can be rated on different dimensions; a dimension that is deemed relevant to attention is arousal level. Thus, peppermint and lavender odors were chosen because they represented an arousing and a relaxing odor, respectively (Kiecolt-Glaser et al., 2008; Moss et al., 2008). In addition, olfactory studies have frequently used the two odors (Ho & Spence, 2005; Moss et al., 2008). Based on previous research, the odors consisted of one drop of fragrance oil placed on an adhesive strip under the participant’s nose (Raudenbush et al., 2001). For the current study, one drop was measured to contain approximately 50 mL of the oil. Aveda essential oils (Aveda Corp., Dist, Minneapolis, MN, 55449) of lavandula angustifolia (i.e., lavender) and menthe piperita (i.e., peppermint) were used. The strip was not changed throughout the task.

### Instrumentation

**Informed Consent.** This form described the study’s procedures, the risks and benefits associated with the study, and ensured the confidentiality of the information obtained.

**Demographic Information.** Participants provided basic demographic information including age, gender, and physical activity habits.

**General Health and Life Type Questionnaire (GHLQ; British Columbia Department of Health, 1975).** A shortened version of the GHLQ was used in the study. More specifically, participants responded to items related to coronary and
cardiovascular conditions to ensure they did not present any health concerns. Additional questions were added to the questionnaire to ensure that the participants did not present any olfactory concerns and allergies.

**Ratings of Perceived Exertion (RPE; Borg, 1982).** The scale measures perceived exertion during the task. The RPE is a 10-point category-ratio scale ranging from 0 (nothing) to 10 (extremely strong). The higher the RPE score, the higher the rating of perceived exertion. The scale was shown to have high intratest \((r = .93)\) and retest \((r = .83–.94)\) reliabilities, and to be a reliable measure of physical discomfort. RPE has been extensively used in previous research due to its strong correlation with a number of physiological and chemical indices of exertion including lactic acid (LA), heart rate (HR), VO\(_2\) and VE (Borg, 1982; 1998).

**Attention (Tammen, 1996).** A 10-point scale ranging from 0 (external thoughts, daydreaming, environment) to 10 (internal thoughts, how body feels, breathing technique) was used to measure attention throughout the task performance. The scale was originally designed to represent the continuum of attention strategies ranging from 0 (pure dissociation) to 10 (pure association). Tammen (1996) found the one-question scale to be an effective and valid measure of attention strategies during physical exertion. Other researchers have also used a one-question scale to investigate the percent of time allocated to association or dissociation during physical activity (Baden, McLean, Noakes, & St. Clair Gibson, 2005).

Major findings stemming from these studies indicated that participants’ use of association and dissociation varied along a continuum, and the one-item measure was in fact an effective measure in capturing participants’ attention focus. Lending further support to the previous findings, Masters and Ogles (1998) reported that the use of one-item measurements remains effective in encapsulating participants’ attention immediately following the experimental task. Other research based on similar measures have also shown that during physical effort attention shifts from dissociation to association as a function of the workload intensity (Hutchinson & Tenenbaum 2007; Tenenbaum & Connolly, 2008).

**Perceived Diversion of Smell.** Participants were asked to respond to the following statement, “to what degree did the smell divert your attention to other things rather than the physical effort itself?” Participants then rated the item on a scale ranging from 0 (not at all) to 10 (very much).

**Affect Grid (Russell, Weiss, & Mendelsohn, 1989).** The affect grid was used to measure overall pleasantness and arousal throughout the task. The scale was designed to measure affect for the components of pleasure-displeasure and high arousal-sleepiness. The pleasantness dimension was measured on a scale ranging from 1 (unpleasant) to 9 (pleasant). Likewise, the arousal dimension was measured on a scale ranging from 1 (sleepiness) to 9 (high arousal). Earlier evidence has supported the independence of the two dimensions and the validity of the grid itself (Russell et al., 1989). Particularly, Russell and Mehrabian (1977) studied 42 self-report affect scales and showed that affect could be predicted on nearly all scales by the subjects’ scores on the dimensions of pleasure-displeasure, arousal-sleepiness, and dominance-submissiveness. The last dimension counted for the least amount of variance, thus supporting the use of only two dimensions in the affect grid.
Perceived Intensity of Smell (Cameron, 2007; Larsson et al., 2000). A one-item scale, ranging from 0 (not at all) to 10 (very much), was used to measure perceived intensity of smell during task performance. Participants were instructed to report on the following item: “To what degree did you perceive the intensity of the smell?”.

Duration of Task. A standard stopwatch was used to record the amount of time each participant endured throughout the isometric handgrip task (i.e., maintained 30% max ± 5%). Time was measured to the nearest second.

Procedure

Each potential participant was verbally asked whether he/she would be willing to participate in a study of an isometric handgrip task. Upon agreement, a detailed explanation of the study was provided and participants signed the informed consent sheet. In addition, the participants responded to the demographic information form and the GHLQ.

MVC was measured for each participant. Specifically, each participant was instructed to squeeze the handgrip of the dynamometer maximally in one explosive effort. Each participant was given three consecutive attempts, and the highest grip value (in kg) among the three attempts was recorded as the participant’s MVC.

Following the establishment of the MVC, 30% of the maximal capacity was computed for each participant using a standard calculator to the nearest decimal point. The use of 30% of maximal grip pressure was based on similar rates (e.g., 20–50%) used in previous studies that made use of an isometric handgrip task to examine exercise-related cognitive and affective components (Hutchinson et al., 2008; Koltyn & Umeda, 2007).

At this point, RPE, the affect grid, perceived intensity of smell, and the attention scales were explained to each participant. RPE instructions were given following Borg’s guidelines (1998) in that participants were given simple examples of intensities, and asked to confirm their understanding. Following this familiarization procedure, each participant was randomly assigned to one of the four conditions. In the odor and placebo conditions, the adhesive strip was placed under the nose, before task performance. The researchers did not inform the participants on the specific condition (lavender, peppermint or placebo). Next, participants were instructed to squeeze the dynamometer at their 30% max (as set by the researcher) until volitional fatigue. RPE, perceived intensity of smell, and attention ratings were collected from participants at 30s intervals throughout the task performance based on the one item RPE, smell intensity, and attention allocation scales that were placed within their view at eye level. In addition, every minute, data pertaining to affective state were collected using the affect grid. The 30s interval was chosen based upon previous research, which implemented a similar design and obtained ratings at 30s intervals (Razon et al., 2009). Upon the completion of the task, participants were administered the commitment check and were debriefed concerning relevant research questions.

Statistical Analyses

Manipulation checks of smell ratings, perceived diversion of smell, intensity of smell, and affect were completed using one-way ANOVAs and repeated measure ANOVAs. Repeated measure ANOVA was also used to test RPE and attention strategies through increment of physical effort expenditure. The 4 conditions (i.e., control, placebo, lavender odor and peppermint odor) were considered between
Manipulation Checks

Smell Check. A one-way ANOVA pertaining to the pleasantness and relaxing/arousing dimensions of each smell (e.g., placebo, lavender, peppermint) indicated significant differences on smells’ pleasantness, $F(2, 56) = 6.10, p < .05$. As predicted, the placebo condition ($M = 4.37, SD = 2.99$) was the least pleasant, and was significantly less pleasant compared with both peppermint ($M = 7.70, SD = 2.58$) and lavender ($M = 6.25, SD = 3.34$). There were no significant differences between peppermint and lavender on this dimension. In addition, no significant difference was indicated among groups as to the ratings of relaxing/arousing dimensions of either smell, $F(2, 55) = .99, p = .38$.

Perceived Diversion of Smell. A one-way ANOVA on the rating of the distractive properties of each smell indicated significant differences, $F(2, 55) = 10.21, p < .05$. LSD post hoc test indicated that lavender ($M = 5.20, SD = 2.74$) diverted attention more than the placebo ($M = 1.22, SD = 2.53, p < .05, ES = 1.52$), and peppermint conditions ($M = 3.25, SD = 2.83, p < .05, ES = .70$; see Figure 1).

Intensity of Smell Check (During task). A repeated measure ANOVA with task conditions as a between subjects factor was conducted to determine differences on the perception of intensity of each smell across 6 time intervals (i.e., the first 3 min; see attrition). The results revealed a significant time effect on the intensity levels...
associated with each smell, Wilks’s $\lambda = .64$, $F(5, 30) = 3.39$, $p < .05$, $\eta_p^2 = .36$. In addition, a significant group effect was revealed, $F(2, 34) = 4.93$, $p < .05$, $\eta_p^2 = .23$. LSD post hoc test revealed no significant difference between the lavender and peppermint conditions ($p = .74$). However, placebo’s intensity was rated significantly lower than both lavender ($p < .05$; $ES = 1.30$), and peppermint, ($p < .05$; $ES = 1.16$). A nonsignificant group by time interaction effect was also indicated by repeated measure ANOVA, Wilks’s $\lambda = .63$, $F(10, 60) = 1.55$, $p = .14$, $\eta_p^2 = .21$.

**Affect Check.** A repeated measure ANOVA on the perception of pleasantness and relaxing/arousing dimensions of affect across the first three minutes of the task revealed a significant time effect on the pleasantness dimension, Wilks’s $\lambda = .56$, $F(2, 43) = 17.07$, $p < .05$, $\eta_p^2 = .44$. Specifically, pleasantness ratings decreased with time. In addition, neither group, nor group by time effects were significant, $F(3, 44) = .63$, $p = .60$, $\eta_p^2 = .04$, Wilks’s $\lambda = .90$, $F(6, 86) = .79$, $p = .58$, $\eta_p^2 = .05$, respectively. No significant differences were indicated for either time, group, and time by group effects for the arousal dimension of affect; Wilks’s $\lambda = .89$, $F(2, 43) = 2.65$, $p = .08$, $\eta_p^2 = .11$, $F(3, 44) = .24$, $p = .87$, $\eta_p^2 = .02$, and Wilks’s $\lambda = .82$, $F(6, 86) = 1.51$, $p = .19$, $\eta_p^2 = .10$, respectively.

**Task Analyses**

**Attrition and Duration.** Descriptive examination indicated high participant attrition rate (i.e., cessation of task participation) following the 6th interval. Following the 6th interval a substantial number of control participants dropped out (e.g., approximately half of the control participants). Thus, the 6th interval was set as the cut-off point and the present analysis included data up until the 6th time interval (e.g., three minutes).

In addition, to assess the extent to which the odorants affected task adherence, a one-way ANOVA was performed. Results revealed non- significant differences ($p = .65$) between the lengths of time the four groups adhered to the handgrip task. Specifically, the mean time duration (in seconds) for each group was: control—$M = 218.06$, $SD = 123.28$; placebo—$M = 254.16$, $SD = 133.83$; lavender—$M = 274.15$, $SD = 141.65$ and, peppermint—$M = 251.40$, $SD = 132.41$.

**Ratings of Perceived Exertion.** To examine the influence of differential impact of each condition RPE, a 6 (time intervals) by 4 (control, placebo, lavender, peppermint) mixed model RM ANOVA consisting of time intervals as within subject factor and conditions as between subject factor was performed. The analysis indicated a significant main effect for time; $GG_{ms} = 386.81$, $F(1.84, 80.83) = 77.10$, $p < .001$, $\eta_p^2 = .64$. This suggests that as the task duration increased RPE also increased steadily until the cessation of performance (see Figure 2). In addition, neither group nor group by time effects were significant, $F(3, 44) = .81$, $p = .50$, $\eta_p^2 = .05$, and $GG_{ms} = 6.39$, $F(5.51, 80.83) = .42$, $p = .85$, $\eta_p^2 = .03$, respectively.

**Attention.** A 6 (time intervals) by 4 (control, placebo, lavender, peppermint) mixed model RM ANOVA on attention allocation indicated a significant main effect for time; $GG_{ms} = 50.59$, $F(2.23, 98.02) = 3.57$, $p < .05$, $\eta_p^2 = .08$. This suggests that as the task duration increased attention shifted from dissociative to associative steadily until the cessation of performance (see Figure 3). In addition, neither group nor group by time effects were significant, $F(3, 44) = .48$, $p = .70$, $\eta_p^2 = .03$; $GG_{ms} = 53.17$, $F(6.68, 98.02) = 1.25$, $p = .28$, $\eta_p^2 = .08$, respectively.
Figure 2 — Ratings of perceived exertion across time and conditions.

Figure 3 — Attention ratings across time and conditions.
Discussion

The purpose of the current study was to examine the effect of presenting lavender and peppermint odors on attention allocation and perceived exertion while performing a handgrip task. Olfactory stimuli have been found to exert influence over affective, physiological, biological, cognitive, and behavioral variables (Barker et al., 2003; Marchand & Arsenault, 2002; Simpson et al., 2001), but the presentation of olfactory stimuli in the current study appeared to have only minimal attentional and perceptual effects during the handgrip task. There were no significant relationships between olfactory stimuli presentation, attention focus, RPE and task duration. It is worth noting that while nonsignificant, an examination of the plotted data revealed a trend in terms of odorant presentation and attention allocation during task performance, indicating that lavender was associated with attention diversion.

The presence of sensory stimuli (i.e., auditory and visual) has been found to be effective in diverting attention and maintaining dissociative patterns of attention throughout an exertive task (Karageorghis et al., 2009; Razon et al., 2009; Yamashita et al., 2006). Thus, it was expected that differences would be observed in terms of delayed attentional shifting from dissociative to associative focus as exertion increased between conditions. However, the current findings failed to reveal any significant group differences in the shift of attention from dissociative to associative focus. As this is the first study exploring the effect of olfactory stimuli on attention allocation it is possible that olfactory stimulation does not produce similar effects as auditory or visual stimulation. Yet, upon examination of the descriptive data, it appears that participants in the lavender group exhibited different attention allocation characteristics throughout the task, as predicted. In addition, when asked retrospectively to rate the effectiveness of the odor in diverting their attention from the task, participants in the lavender group indicated that they were diverted by the smell to a greater degree than both the peppermint and the placebo conditions. Thus, there seems to be a degree of support suggesting that lavender odor diverts attention and delays the shift from dissociative to associative attention during an exertive task.

Although certain studies have reported relationships between RPE and the presentation of olfactory stimuli (Raudenbush, 2000), this relationship could not be established in the current study. Previous research findings, however, have been equivocal on this account; while various studies found peppermint to be associated with increased performance (Barker et al., 2003; Raudenbush et al., 2001), and lavender to be associated with decreased pain perceptions (Marchand & Arsenault, 2002), other findings indicated that neither olfactory stimuli was associated with differential performance or RPE ratings (Simpson et al., 2001). The literature on olfactory sensation and exercise performance lacks details concerning the amount (or percent of concentration of solution) of odorant given to participants. This provokes speculation about the reproducibility of previous results, and is considered a major reason for the equivocal findings.

For the current study we used one drop (approximately 50 mL) of the odorant, however this may not have been a sufficient amount to evoke significant effects. It is important to note, that at the beginning of the task, the intensity of smell was rated significantly higher for both odor conditions compared with the placebo condition. However, the ratings for the odors were still low. In addition, results from the current
study suggested that, over time, the intensity of the smell decreased within the peppermint and lavender conditions, while staying relatively constant for the placebo condition (i.e., odors: from $M = 4.73$, $SD = 3.00$, to $M = 2.96$, $SD = 2.02$ and placebo: $M = 1.01$, $SD = 1.35$, to $M = .96$, $SD = 1.93$, on a 10 point scale). Therefore, the effectiveness of the olfactory stimuli may have been lessened with time. Perhaps by presenting increased amounts of the odorant, the intensity of the smell would have been more pronounced throughout the task and may have led to more fruitful findings. Moreover, when odorants are presented continuously, sensory adaptation can occur (Dalton & Wysocki, 1996). It is likely that the habituation to the odor may have contributed to the decrease in smell intensity throughout the task. As such, it is important to maintain smell intensity throughout the task. Administering the smell intermittently throughout the task may be one method of reaching this end. Regardless of the potential outcomes, it is apparent that identifying the amount of odorant used within the experimental design, or measuring the perceived intensity of the odor, is crucial to furthering this area of research.

Future studies should be aimed at studying the effect of olfaction on exercise performance using varying intensities to determine how much odorant is needed to produce effects, and to determine if the ambiguous nature of previous studies can possibly be attributed to the variable degree of odorant presentation. In addition, it would be interesting to examine the effect of presenting olfactory stimuli variably throughout the exercise task, as opposed to continuously, in terms of odorant intensity and effectiveness. Further, although previous research has identified the arousing nature of the peppermint odor, as well as the relaxing nature of the lavender odor (Kiecolt-Glaser et al., 2008; Moss et al., 2008), participants within the current study did not distinguish between the odorants in this regard. It is likely that the amount of odorant provided was not sufficient to produce the arousing or relaxing effect. More salient findings may have been obtained if the odorants were perceived as arousing or relaxing to a greater degree. Subsequent studies should implement a design in which participants are presented with a range of odorants, and are then matched according to their perceptions of arousal. Thus, the effect of truly arousing or relaxing odorants on an individual basis can be ascertained.

Another plausible explanation for the nonsignificant differences might be related to a measurement issue. Specifically, participants were asked to rate the arousing/relaxing dimension of the odors after completing the task, which might have influenced their reply. Thus, perhaps asking participants to submit their perceptions before and/or during the task might be a more accurate method of measuring this dimension.

Furthermore, since this investigation merely looked into the effects of arousing (i.e., peppermint) and relaxing (i.e., lavender) olfactory stimuli, it may be important to look into other characteristics of smell (e.g., aversive vs. pleasant) and test their effects on RPE and attention allocation. Finally, it is important to explore the mechanisms by which olfactory stimuli affect cognitive and/or physiological processes.

One reason individuals often provide for not exercising is the discomfort experienced during exercise (Canadian Fitness and Lifestyle Research Institute, 1996; Wankel, Yardley, & Graham, 1985). If the presentation of a pleasant odorant can be used to effectively divert individuals’ attention from the effort sensations, they will be more likely to enjoy exercise and adhere to it. Thus, it is important to extend research in this field to determine if the presentation of olfactory stimuli
truly has an effect on performance and if so, how much odorant is necessary to elicit this effect. Although the current study failed to show any decisive effect of odorant presentation on RPE and attention allocation, it has been intimated within the findings that the presentation of olfactory stimuli may have an effect on attention and sensation throughout an exercise task if a greater dose had been used and more familiarity with it was achieved.

Odorants can be presented with relative ease throughout most exercise and sport endeavors. The use of nasal strips for both athletes and exercisers may serve to divert attention from the task, and if provided at the correct intensity, may also influence task performance. Perhaps nasal strips of different odorants can be used to effectively manage relaxation and arousal throughout the task. In addition, just as exercisers and runners use portable music devices, it is possible that a similar device for smell can be developed and used in the same way as audio stimuli. Further research is necessary to identify the utility of such strips and odor devices. Moreover, it may be interesting to identify the salience of the odorant in terms of the regulation of emotions before a competitive task. The presentation of an odorant may be beneficial in “psyching-up” or relaxing the participant. Future research should investigate this potential, and the subsequent effect it may have on performance and enjoyment. In addition, a more detailed report of methods is required in future studies to fully capture the effectiveness of olfactory stimulation during exercise.

References


Olfactory Effects on Attention Allocation and Exertion


