Effects of Peppermint and Cinnamon Odor Administration on Simulated Driving Alertness, Mood and Workload

Bryan Raudenbush¹, Rebecca Grayhem², Tom Sears¹, and Ian Wilson⁴,
¹Wheeling Jesuit University
²Northeastern University

Past research indicates the odors of peppermint and cinnamon (1) enhance motivation, performance, and alertness, (2) decrease fatigue, and (3) serve as central nervous system stimulants. Given these results, it is reasonable to expect that the presentation of peppermint or cinnamon odor while driving may produce a more alert and conscientious driver, and minimize the fatigue associated with prolonged driving. In the present study, participants were monitored during simulated driving under three odor conditions (peppermint, cinnamon, non-odor control). Odors were added to low flow oxygen (1.3L/min) via an oxygen concentrator and presented at the rate of 30 seconds every 15 minutes. Measures of cognitive performance, wakefulness, mood, and workload were also assessed. Both cinnamon and peppermint administration led to increased ratings of alertness, decreased temporal demand, and decreased frustration over the course of the driving scenario. In addition, peppermint scent reduced anxiety and fatigue. Periodic administration of these odors over prolonged driving may prove beneficial in maintaining alertness and decreasing highway accidents and fatalities.

Past research indicates that the presence of peppermint and cinnamon odors during human performance assessment can dramatically influence motivation, task performance, and alertness. In a series of studies, Warm and colleagues investigated the efficacy of certain odors to enhance performance accuracy on a tedious vigilance or sustained attention task. The bulk of these studies (Dember, Warm & Parasuraman, 1996; Jones, Ruhl, Warm & Dember, 1999; Warm, Dember & Parasuraman, 1991) indicate that participants were able to detect more critical signals during the vigil when presented with either muguet or peppermint, than they were with unscented air.

More recently, Raudenbush and colleagues (Raudenbush, Corley, & Eppich, 2001; Raudenbush, Meyer, & Eppich, 2002) examined the effects of odorants on athletic performance. In a series of studies, they...
administered various odors (e.g., peppermint, jasmine, dimethyl sulfide) to athletes performing a modified treadmill stress test. Peppermint odor significantly reduced perceived physical workload, temporal workload, effort, and frustration, as assessed by the Profile of Mood States (POMS; McNair, Lorr & Droppleman, 1971) and the NASA-Task Load Index (NASA-TLX; Hart & Staveland, 1988). Self-evaluated performance was also greater in the peppermint condition, and participants rated their level of vigor higher and their level of fatigue lower. In addition, when assessing performance on specific athletic tasks, those athletes exposed to peppermint odor were found to complete a quarter mile run more quickly, perform more push-ups, and exhibit increased hand dynamometer grip strength.

Zoladz and Raudenbush (2005) have examined the effects of odorant administration on augmenting cognitive performance. Their study was divided into two phases: Phase I investigated the effects of retronasal (i.e., through the mouth) odorants, while Phase II investigated the effects of orthonasal (i.e., through the nose) odorants. During Phase I, participants completed computerized neuro-cognitive tasks under five chewing gum conditions (no gum, flavorless gum, peppermint gum, cinnamon gum, and cherry gum). Assessments included a wide range of cognitive abilities, such as word discrimination, attention, verbal recognition memory, visual recognition memory, visual processing speed, retention memory for novel symbols, reaction time, impulse control/response inhibition, working memory, and visual-motor response speed. During Phase II, participants completed the assessments under four odorant conditions (no odor, peppermint odor, jasmine odor, and cinnamon odor), delivered via low flow (1.3 L/min) oxygen through a nasal cannula. Both cinnamon and peppermint odor, administered either retronasally or orthonasally, improved participants’ scores on tasks related to attentional processes, virtual recognition memory, working memory, and visual-motor response speed. In addition, participants rated their mood and level of vigor higher, and their level of fatigue lower, in the peppermint condition.

Previous studies also indicate that odors have widespread effects on the human central nervous system (Kobal & Hummel, 1988; Lorig & Schwartz, 1988; Van Toller, 1988). These researchers noted substantial changes in EEG activity during the administration of various odors, particularly peppermint. One explanation for the changes noted in EEG activity relates to attentional differences; EEG patterns change predictably when individuals actively attend to stimulus presentations. However, further research suggests that differences occurred even if the individuals were unaware that an odor was being administered (Lorig, Huffman & DeMartino, 1991).
Given the above results, it is reasonable to expect that the presentation of certain odors while driving may produce a more alert and conscientious driver, and minimize the fatigue associated with prolonged driving. Research by Baron and Kalsher (1998) had participants complete a compensatory tracking task where they were to use a joystick to keep a moving stimulus within two vertical lines. During some tracking conditions, a lemon scent was present. Performance was found to be significantly enhanced by the presence of this pleasant fragrance.

The deleterious effects of prolonged driving and fatigue on driving performance are frequently noted in scientific literature. Driving over long periods of time has produced visual tracking and driving speed variations of the same magnitude as 0.08 blood alcohol concentration (Arnedt, Wilde, Munt, & MacLean, 2001; Lenne, Triggs, & Redman, 1998), a safety-critical decline in lane-keeping performance (Fairclough & Graham, 1999), and progressive losses in overall driving performance (Herbert & Jaynes, 1963).

Based on police crash report data, the U.S. National Transportation Association and Department of Transportation estimate that about 100,000 crashes and 1,500 fatalities each year result from drivers falling asleep at the wheel. About 1 million crashes annually are attributed to driver inattention or lapses of attention. A Gallup poll conducted for the National Sleep Foundation reported that 31% of adults said they had fallen asleep at the wheel. Such detrimental effects are even more pronounced for those individuals whose profession is driving, with research showing that one out of four truck drivers’ self-ratings of fatigue are in the “tired” range, with 24% of such drivers failing a simple psychomotor performance test (Charlton & Bass, 2001). In the year 2000, there were 5,362 truck-driver related fatalities in the U.S., with approximately 800 of those fatalities being related to driver fatigue. Taking all of these factors into consideration, The U.S. Department of Transportation has estimated that the total societal annual cost of motor vehicle accidents is $150 billion.

The following study was designed to investigate whether the presence of either peppermint or cinnamon affects driving alertness and associated driving measures. Participants will be monitored during simulated driving under three conditions. These conditions will consist of the presentation of peppermint and cinnamon, and a non-scent control condition. While driving, measures of alertness, mood, and task workload will be assessed.

Previous research with peppermint and cinnamon odors has shown effects on an individual’s mood, attention, and ability to perform cognitively- and physically-based tasks. Thus, it is reasonable to expect that the presentation of these odors will result in a general stimulation of
the central nervous system. If so, participants should be able to maintain attention and motivation to the driving task, have decreased workload demands, and show decreased fatigue and increased alertness while driving.

METHOD

Participants
Twenty-five individuals (16 females, 9 males, mean age = 19.7 years), all current drivers (mean number of years of driving experience = 3.4) participated. Each participant was compensated $40.

Stimuli
Stimuli consisted of pharmaceutical grade peppermint oil and cinnamon oil (Sigma Aldrich Company).

Fragrance Equipment
The scent conditions were maintained by aerating 50 ml of peppermint or cinnamon oil into tubing containing low flow (1.3 L/min) oxygen produced by an AirSep® NewLife Oxygen Concentrator. The oxygen concentrator is a portable device for producing low flow oxygen on demand, which provides for greater control of oxygen flow rate than conventional oxygen tanks. Participants wore nasal cannulas through which either low flow oxygen (control condition) or oxygen plus odorant was administered. Participants were told that they may or may not perceive a scent through the cannula, but were not informed as to what that scent might be. Scent administration was superthreshold.

Driving Simulation System
The driVR system (Imago Systems, Inc) and VR driving software (Sierra®), which use virtual reality technology to create interactive driving scenarios, were employed for the driving simulations. The user is prompted to drive on a particular route by visual cues, but is not limited to following the prescribed route. Driving conditions are modeled accurately to give realistic vehicle responses to driver inputs, and the simulation environment is crafted to provide realistic surroundings that are sufficient to suspend disbelief that the activity is merely a simulation. Thus, the user becomes immersed in the virtual surroundings and performs as if he or she was driving in the real world. Driving scenarios are modeled to allow the user to interact with the virtual world and experience the consequences of their actions. Every action has an effect, and these effects in turn serve to initiate the driver's next action. The motion of the car corresponds to the driver's input to the steering wheel, accelerator pedal, and brake pedal (Saitek Ltd, Model R100).
Inventories
To assess workload demands of prolonged driving, participants completed the NASA-Task Load Index (NASA-TLX; Hart & Staveland, 1988). This is a multi-dimensional scale which measures specific components of workload in a given task along three dimensions related to demands imposed on the participant by the task (mental, physical, temporal) and three dimensions related to the interaction of the participant and the task (effort, frustration, performance). Based on the recommended measurement procedure of Hart and Staveland (1988), participants were presented with a 12 cm line with the endpoints of the line marked “low” and “high” for each of the six aspects of workload. They were then asked to place a hash mark on the line to indicate their level of workload. The distance of their hash mark from the left (beginning) of the 12 cm line is measured in millimeters, and that number is taken as a numeric indication of workload.

Participants also completed the Profile of Mood States (POMS; McNair, Lorr & Droppleman, 1971). This contains a list of 65 adjectives concerning current mood. Participants indicate the extent to which each adjective describes them at a particular moment using a 5-point scale. Sub-scales of the questionnaire include anxiety, anger, vigor, confusion, fatigue and depression.

Finally, prior to beginning the protocol, and at 1-hour increments, participants rated their level of alertness on a 0-10 scale, with a higher rating indicating a greater level of alertness.

Procedure
Participants were tested individually in an 8’ x 8’ room in which the driVR system was housed. After positioning of the nasal cannula, they were instructed as to the use of the driving simulator and, prior to driving, indicated their level of alertness. After one hour, and at the completion of the driving task, participants completed both the POMS and the NASA Task Load Index. A researcher was present in the testing room only during the time when the POMS and NASA Task Load Index were being completed; during simulated driving, the participant was alone.

Participants performed the protocol three times, each time in a different scent condition, with the conditions separated by at least 48 hours to control for fatigue effects. These conditions consisted of peppermint scent plus oxygen, cinnamon scent plus oxygen, and a no-scent, oxygen only control condition. A within-subjects design was used to minimize individual differences and to provide a control condition for each participant. Scent was delivered at a rate of 30 seconds every 15 minutes during the course of the protocol, including questionnaire
assessments. The order of the conditions was counterbalanced. Each driving condition was performed for two hours.

RESULTS

Assessment measures were subjected to a two-within analysis of variance. The within factors were the scent condition (peppermint, cinnamon, no-scent control) and time period (two times for the POMS and NASA-TLX; three times for the level of alertness). Tukey post-hoc contrasts were employed when significant effects were noted. Tables 1 and 2 represent the means and standard deviations among the scent conditions for the mood and workload measures, respectively. In preliminary data analyses, no significant sex differences were noted for the dependent variables listed below, thus they were omitted from the result.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>POMS Means (Measured at 2 Time Intervals) and SDs Among the Scent Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONTROL</td>
</tr>
<tr>
<td></td>
<td>1 Hour</td>
</tr>
<tr>
<td>Anxiety</td>
<td>8.68 (1.0)</td>
</tr>
<tr>
<td>Anger</td>
<td>6.10 (1.4)</td>
</tr>
<tr>
<td>Vigor</td>
<td>13.75 (1.4)</td>
</tr>
<tr>
<td>Confusion</td>
<td>6.57 (0.7)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>8.60 (1.4)</td>
</tr>
<tr>
<td>Depression</td>
<td>6.58 (1.9)</td>
</tr>
</tbody>
</table>

Note: SDs are rounded to one decimal place.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>NASA-TLX Means (Measured at 2 Time Intervals) and SDs Among the Scent Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONTROL</td>
</tr>
<tr>
<td></td>
<td>1 Hour</td>
</tr>
<tr>
<td>MD</td>
<td>67.1 (4.2)</td>
</tr>
<tr>
<td>PD</td>
<td>35.8 (5.5)</td>
</tr>
<tr>
<td>TD</td>
<td>62.7 (4.4)</td>
</tr>
<tr>
<td>Effort</td>
<td>61.2 (5.3)</td>
</tr>
<tr>
<td>Frustration</td>
<td>60.7 (5.0)</td>
</tr>
<tr>
<td>Performance</td>
<td>48.6 (6.3)</td>
</tr>
</tbody>
</table>

Note: MD = Mental Demand; PD = Physical Demand; TD = Temporal Demand. Means and SDs are rounded to one decimal place.

POMS Mood Measures

Anxiety: A significant effect was found for scent condition ($F_{2,36}=3.53$, $p<.05$). Ratings of anxiety were lower in the peppermint condition as compared to both the control and cinnamon conditions. No
significant effect for time period \( F_{1,18}=0.55, p>.05 \), or the interaction between scent condition and time period \( F_{2.38}=0.82, p>.05 \), was found.

Anger: No significant effect was found for scent condition \( F_{2,38}=0.21, p>.05 \), time period \( F_{1,19}=3.48, p>.05 \), or the interaction between scent condition and time period \( F_{2.38}=2.30, p>.05 \).

Vigor: No significant effect was found for scent condition \( F_{2,38}=0.02, p>.05 \), time period \( F_{1,19}=3.48, p>.05 \), or the interaction between scent condition and time period \( F_{2,38}=2.30, p>.05 \). There was a significant effect for time period \( F_{1,19}=9.32, p<.01 \). Vigor significantly declined over time.

Confusion: No significant effect was found for scent condition \( F_{2,40}=0.02, p>.05 \), time period \( F_{1,20}=0.73, p>.05 \), or the interaction between scent condition and time period \( F_{2,40}=2.15, p>.05 \).

Fatigue: A significant effect was found for scent condition \( F_{2,38}=3.74, p<.05 \). Level of fatigue was lower in the peppermint condition as compared to both the control and cinnamon conditions. There was no significant effect for time period \( F_{1,19}=1.42, p>.05 \). A significant interaction was found between scent condition and time period \( F_{2,38}=3.42, p<.05 \). Ratings of fatigue decreased over time for the cinnamon scent condition.

Depression: No significant effect was found for scent condition \( F_{2,36}=0.38, p>.05 \), time period \( F_{1,18}=0.49, p>.05 \), or the interaction between scent condition and time period \( F_{2,36}=1.72, p>.05 \).

NASA TLX Workload Measures

Mental Demand: No significant effect was found for scent condition \( F_{2,40}=0.20, p>.05 \), time period \( F_{1,21}=0.73, p>.05 \), or the interaction between scent condition and time period \( F_{2,40}=1.38, p>.05 \).

Physical Demand: No significant effect was found for scent condition \( F_{2,40}=0.59, p>.05 \) or the interaction between scent condition and time period \( F_{2,40}=0.72, p>.05 \). A significant effect was found for time period \( F_{1,21}=0.72, p>.05 \). Physical demand increased over time.

Temporal Demand: A significant effect was found for scent condition \( F_{2,40}=3.39, p<.05 \). Both peppermint and cinnamon scents produced the perception of a faster testing session time in relation to the control condition. There was no significant effect for time period \( F_{1,21}=0.09, p>.05 \), or interaction of scent condition and time period \( F_{2,40}=0.10, p>.05 \).

Effort: No significant effect was found for scent condition \( F_{2,40}=0.41, p>.05 \), time period \( F_{1,21}=0.69, p>.05 \), or the interaction of scent condition and time period \( F_{2,40}=0.52, p>.05 \).

Frustration: A significant effect was found for scent condition \( F_{2,40}=4.14, p<.05 \). Ratings of frustration were lower in both the peppermint and cinnamon scent conditions in relation to the control
condition. There was no significant effect of time period ($F_{1,21}=0.79$, $p>.05$), or the interaction of scent condition and time period ($F_{2,42}=0.61$, $p>.05$).

Performance: No significant effect was found for scent condition ($F_{2,42}=1.60$, $p>.05$), time period ($F_{1,21}=2.54$, $p>.05$), or the interaction of scent condition and time period ($F_{2,42}=1.33$, $p>.05$).

**Alertness Measure**

A significant scent condition effect was found ($F_{2,42}=4.14$, $p<.05$). Ratings of alertness were higher in both the peppermint and cinnamon conditions in comparison to the control condition. A significant time effect was found ($F_{2,42}=6.11$, $p<.01$). Level of alertness decreased over time. There was no significant interaction between scent condition and time ($F_{4,84}=1.21$, $p>.05$). See Figure 1.

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**DISCUSSION**

The present study investigated whether the administration of an odorant during virtual reality driving affects factors related to mood, task workload, and alertness. The deleterious effects of prolonged driving and fatigue on driving performance are frequently noted in the scientific literature. Driving over long periods of time has produced visual tracking
and driving speed variations of the same magnitude as 0.08 blood alcohol concentration (Arnedt, et al., 2001; Lenne, et al., 1998), a safety-critical decline in lane-keeping performance (Fairclough & Graham, 1999), and progressive losses in overall driving performance (Herbert & Jaynes, 1963).

The U.S. Department of Transportation reports the average commute distance to be 74 miles per day (DOT HS 809 702), and modern society imposes increasing cognitive demands and distractions on drivers. Such distractions consist of attending to roadside advertisements (Crundall, van Loon & Underwood, 2006), interacting with in-vehicle technologies (Horrey, Wickens & Consalus, 2006), cellular phone use (Hutton & Rose, 2005; Strayer, Drews & Johnson, 2003), and passenger conversations (Amando & Ulupinar, 2005). Hanowski, Perez and Dingus (2005) examined the accident logs of long-haul delivery truck drivers and of the 2737 crashes, near-crashes, and crash-relevant conflicts (collectively termed "critical incidents") that were recorded, 178 were attributed to "driver distraction." Thus, it is important to assess non-pharmacological adjunct techniques that might help assure a more attentive and safe driver.

In comparison to the non-odor control condition, ratings of alertness during the driving protocol were higher in both the peppermint and cinnamon conditions. Past research has indicated that odors have widespread effects on the human central nervous system (Kobal & Hummel, 1988; Lorig & Schwartz, 1988; Van Toller, 1988), even when the participant is unaware that an odor is being administered (Lorig, Huffman & DeMartino, 1991). While the mechanism of action is still unknown, it is hypothesized that the scents of peppermint and cinnamon are stimulating the areas of the brain responsible for alertness (e.g., reticular activating system). These results are also complimentary to those of Stampi, Aguirre, Macchi and Moore-Ede (1996) who had six male participants complete 40 minutes of simulated driving each hour, in addition to a variety of alertness questionnaires. It was found that after six to seven hours of testing, peppermint scent was associated with faster reaction times on a divided attention task.

Goel and Lao (2006) have administered peppermint scent to healthy sleep laboratory participants and found more non-REM and less REM sleep. Kimura, Mori, Suzuki, Endo & Kawano (2001) report peppermint significantly increased $\beta_1$ and $\beta_2$ EEG amplitudes after a monotonous stress test. Further, Norrish and Dwyer (2005) found that the presence of peppermint scent reduced level of daytime sleepiness. In relation to cinnamon, Zoladz & Raudenbush (2005) found cinnamon scent administered either retronasally or orthonasally improved participants' scores on tasks related to attentional processes, memory, and visual-
motor response speed. Additional studies should address specific EEG activity accompanying both peppermint and cinnamon odorant administration.

Peppermint scent was also successful in lowering ratings of anxiety and fatigue during the driving task, and both peppermint and cinnamon scents reduced temporal demand and frustration. Thus, the drivers were less anxious, fatigued and frustrated, and perceived the drive to be shorter. Concerns about “road rage” have grown over the past decade (for a review, see Galovski, Malta & Blanchard, 2005). Hemenway, Vriniotis and Miller (2006) found that 17% of motorists admitted to making obscene or rude gestures while driving, and 9% had aggressively followed too closely to the car in front of them. More startling, 46% reported victimization by such behaviors in the past year. The administration of particular scents while driving may lead to a decrease in such aggressive behaviors.

Finally, despite the numerous reports that support the notion of odor-enhanced performance, some research has revealed the converse. For instance, the presence of a pleasant lavender odor significantly undermines the performance of working memory, reaction time for memory and attention based tasks, and arithmetic reasoning (Ludvigson & Rottman, 1989; Moss, Cook, Wesnes & Dickett, 2003). Thus, it is not the mere presence of any pleasant odor that enhances performance, but rather something specific to the odorant itself. It is unlikely that peppermint and cinnamon are the only scents to produce such effects in drivers, however, equally pleasant and intense scents may actually be detrimental. Thus, future research should pay particular attention to the type of scent being administered.

Given the numerous deleterious effects of fatigue and inattention on driving performance, and the number of personal injuries and deaths brought about by such conditions, any non-pharmacological aid that could counter-act such conditions would be rapidly accepted. These results should be of particular interest to automobile manufacturers, departments of transportation, long-haul trucking firms, and insurance companies. Future research can also extend the present findings to other areas of transportation, such as nautical, rail, and air travel.

REFERENCES


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