Effects of Auditory Distraction on Performance of the Stroop Word Test: A Preliminary Study

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Abstract

Attention is finite, and auditory distractions can interfere with one’s ability to concentrate on high level thought processes. Previous researchers have found limitations on performance in the presence of distractors. Contemporary students find increasingly challenging conditions under which to do schoolwork and study. In the current study, investigators studied the effect of an auditory distraction on performance of the Stroop Color Word Test by a group of undergraduate university students. There were no statistically significant differences between the group performing the Stroop Color Word Test in silence versus the group that completed the test with an auditory distractor. It may be that students have learned to tune out distractors more effectively than in the past, and the investigators recommend replication of the study.
Auditory Distraction and Stroop

To be productive, one must be able to focus on a task with distractions present (Lavie, 2015). Task-irrelevant stimuli are common and can be present in many forms: an insect buzzing nearby, a stranger’s phone conversation, or an entertaining pop-up advertisement on the internet (Lavie, 2015). Notwithstanding attention deficit disorder, researchers suggest that the perceptual load of task-relevant stimuli is typically heavier than the perceptual load task-irrelevant distractors (Lavie, 2015). With many occupational and educational settings having open-space work areas, background noise has the potential to create interference, affect the perceptual load, and distract an individual from task-relevant goals (Lavie, 2015; Pool, Koolstra, & Van Der Voort, 2015).

Interference has been studied in regard to the Stroop effect (Stroop, 1935), which is the interference that occurs when responding to a color stimulus and a conflicting word stimulus presented simultaneously, such as the word “blue” written in red ink. Stroop quantified the interference by measuring increased reaction time to identify the color stimulus.

The Stroop Color Word Test (SCWT) has been the topic of thousands of studies (MacLeod, 1992) and has become a widely used tool to measure varied aspects of cognitive function in individuals (Golden, 1978). The ability to control interference is an indicator of executive function, and greater interference indicates lower attentional capacity (Ikeda, Okuzumi, Kokobun & Haishi, 2011) and sometimes, lower reading proficiency (Cox et al., 1997). The SCWT with auditory distraction has been used to test healthy individuals to determine interference control (Thackray, Jones & Touchstone, 1971). Bert and Schroger (2001) found that the presence of irrelevant sound during retrieval of visual memories reduced recollection of material. In particular, unfamiliar auditory input slowed down visual processing.
As much of the literature relative to auditory distractions was published some time ago, it is useful to investigate the effect of auditory distractions on contemporary individuals. With these known impact of background noise on performance, productivity, and memory, it may be beneficial to see how well current university students at a large Midwestern university can efficiently focus on a heavy perceptual load task, the SCWT, when there is audio dialogue present in the background. Therefore, the purpose of the study was to determine if the Stroop Color Word Test (SCWT) scores differed significantly between the auditory stimulus group and the non-auditory stimulus group in a selected group of college students.

Method

Participants

Following IRB approval from the institution, students \(n = 20\) who were enrolled in a motor learning class at a large Midwestern university were recruited for the study and ranged in age from 18-30 (20.65±2.641 years). The two groups (experimental with auditory distraction and control in quiet setting) consisted of 10 participants each. Participants stated they were in good health, had no hearing deficits, color blindness, nor a diagnosis of ADHD or dyslexia. All participants signed informed consent.

Instrumentation

Demographic Information. Demographic information collected included age, sex, classification, GPA, hearing loss, vision (colorblind, contacts, glasses), and diagnosis of ADHD. If participants identified as having hearing loss, color blindness, or ADHD they were excluded from the study.

The Stroop Color-Word Test (SCWT). The test is a noninvasive paper test that consists of matching congruent and non-congruent words and colors. On the first card, the words

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RED, GREEN, and BLUE (yields Word score) appear in five columns of 20 in black ink in random order. On the second card, the letters “XXXX” appear in red, green, and blue ink in the same format (yields Color score). On the third card, the words RED, GREEN, and BLUE are printed in incongruent ink. For each card, participants have 45 s to identify and correctly read aloud as many colors as possible. The number of words read in 45 s is the raw score for each card. Interference is determined by calculating a Predicted Color-Word score (Predicted = W x C/W + C) and then subtracting CWraw from the Predicted Color-Word score (CWraw - Predicted = Interference) (Golden, 1978).

In regards to psychometric properties, the SCWT is one of several commonly used instruments to determine concussions in athletes (Chan, 2001). The SCWT score can accurately classify athletes into real and feigned concussion groups 83% of the time (Hill, Womble, & Rohling, 2015), therefore demonstrating construct validity. More severe and/or more concussions result in slower processing speed on the Stroop interference score (Killam, Cautin, & Santucci, 2005). Cox et al. (1997) cautioned, however, that the construct validity of the interference score is dependent on reading proficiency.

Although the SCWT (Golden, 1978) was developed to differentiate among brain-damaged and non-brain-damaged psychiatric patients and normal individuals, it has been demonstrated to be valid and reliable for various populations (Balota et al., 2010; Chan, 2001; Cohn et al., 1984; Lavoie & Charlebois, 1994). The SCWT has also been shown to be a reliable and valid test for measuring executive function in individuals with Alzheimer’s (Balota, Tse, Hutchison, Spieler, Duchek & Morris, 2010), cognitive decay due to aging (Cohn, Dustman, & Bradford, 1984), and attention deficit hyperactive disorder (Golden & Golden, 2002).
Ryu, et al. (2015) reported that the Stroop was able to distinguish between athletes with burnout and those without, with slower cognitive processing associated with burnout. However, Gustafsson, Lundkvist, Podlog, and Lundqvist (2016) have directly challenged the findings, so construct validity for the SCWT has not been agreed upon at this time. Test-retest reliability is a limitation of the SCWT, as a practice effect appears after the first administration (Register-Mihalik, et al. 2012).

**Decibel 10th version 4.1.2.** Volume of the auditory stimulus was measured and monitored with the phone application Decibel 10th version 4.1.2. Researchers chose a dialogue of an interview between comedians Jim Gaffigan and Jimmy Fallon as the auditory distraction. The auditory stimulus at 60 decibels was played on a laptop computer, and time was recorded with a stopwatch.

**Procedures**

On the day of administration, each participant completed informed consent, the SCWT, and demographic information in a quiet office setting, during one visit of approximately 20 min. As multiple administrations of the SCWT has been shown to affect reliability (Register-Mihalik, et al. 2012), each participant was randomly assigned to experimental group (auditory stimulus) or control group (no stimulus).

**Statistical Analysis**

Independent variables (conditions) were silence and auditory distractor. Dependent variables included Word score, Color score, Predicted score, Color-Word raw score, and Interference score. Due to small sample size, Kruskal-Wallis one-way analysis of variance was used to determine significance of findings. Significance level was set at .05.
Results

With the exclusion of one participant who did not disclose sex, 7 females and 12 males participated, averaging 20.65 years, ± 2.641. Participants reported an average GPA of 3.191 ± .402. None identified themselves as having hearing loss, color blindness, or ADHD. There were no significant differences between groups at baseline for any of the dependent variables. Kruskal-Wallis Test results were non-significant for all variables measured, indicating no statistically significant differences among any of the conditions for performance on the SCWT for this sample. Of the five dependent variables, the one coming closest to being statistically significant was the Interference score—$X^2 (1, N = 20) = 1.29, p = .26$.

Table 1

Results of Kruskal-Wallis for Word, Color, Predicted, Color-Word raw, and Interference

<table>
<thead>
<tr>
<th></th>
<th>Experimental ($n = 10$)</th>
<th>Control ($n = 10$)</th>
<th>$X^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word</td>
<td>11.85</td>
<td>9.15</td>
<td>1.05</td>
<td>0.31</td>
</tr>
<tr>
<td>Color</td>
<td>11.15</td>
<td>9.85</td>
<td>0.24</td>
<td>0.62</td>
</tr>
<tr>
<td>Predicted</td>
<td>11.90</td>
<td>9.10</td>
<td>1.12</td>
<td>0.29</td>
</tr>
<tr>
<td>CWraw</td>
<td>11.95</td>
<td>9.05</td>
<td>1.21</td>
<td>0.27</td>
</tr>
<tr>
<td>Interference</td>
<td>12.00</td>
<td>9.00</td>
<td>1.29</td>
<td>0.26</td>
</tr>
</tbody>
</table>

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The researchers’ hypotheses were not supported; an auditory distraction did not have a significant negative impact on attention or accuracy for matching congruent and non-congruent color-words.

**Discussion**

Due to the previously reported negative impact of background noise and distraction on performance, productivity, and memory (Haapakangs et al., 2014; Pool, Koolstra, & Van Der Voort, 2015), it was beneficial to determine how significantly an auditory distraction impacted executive function of contemporary college-aged students.

The findings of the current research study differ from those in previous studies. Bert and Schroger (2001) concluded that unfamiliar auditory input slowed visual processing. The delay in processing the color stimuli may have been caused by the word and color stimuli competing for memory as they were presented simultaneously. Alternately, others have theorized that parallel presentation might cause delay in the input and encoding speed of the color because the written word is a distraction to the task of color identification and the participant is unable to ignore interference of the word form (Hintzman, et al., 1972; Cohen, McClelland & Dunbar, 1990).

Recently, Haapakangs et al. (2014) found that auditory distractions among open-plan offices negatively impacted short-term memory, productivity, and speech intelligibility. It should be noted, however, that Connelly and Hasher (1991) determined that a when a meaningful distraction was present, age played a significant role in reading efficiency, with the distraction having a greater negative impact on older adults than young adults.

Smucny, Rojas, Eichman, and Tregellas (2013) studied the neurobiological effects of noise on a sustained attention-to-response task with “urban noise” such as talk radio, music and
conversation as the auditory distractions. The effect of auditory distraction on cognitive load varied, with higher processing load (sound) negatively influencing attention more than silence.

In this investigation, there were no significant differences in executive function between groups. Although the groups’ performances did not meet the criteria for differing significantly, the group exposed to the dialogue while performing did better under every condition. The researchers can only offer pre-existing differences as a possible explanation, which might be resolved with a larger sample.

This research study is significant and beneficial because the results differ from those in the existing literature, indicating contemporary, college-aged students may not be affected by auditory distractions. Young people today routinely (and illegally, in some cases) multi-task with motor skills, cognitive tasks, and daily living routines. Many college students study with the television on, headsets streaming music, or surrounded by roommates making noise. More than one college-aged driver has texted, listened to the radio, and driven a motor vehicle simultaneously. It may be that university students are becoming more adept at tuning out potential distractors than their predecessors. If so, more investigation is certainly warranted.

Limitations

The current study involved a small sample. Although non-significant differences appeared in the current study, a larger sample is recommended to determine if results can be replicated. If findings using a larger sample resemble those of the current study, implications could be significant.

The authors assumed reading proficiency, which was probably the case, but did not check. Cox et al. (1997) found those with poorer reading skills showed lower correlation scores
with other measures of response inhibition than good readers. Therefore, not knowing the reading proficiency level of each participant was a possible limitation to this study.

If this study is repeated, the authors suggest that current study modes of participants (silence, audio present, audio/video present) be determined. It would be interesting to determine the extent to which GPA is correlated with study mode, which could lend further evidence to support or refute the current preliminary findings.

There may be alternate scoring methods that could possibly yield somewhat different results. This year, Italian researchers proposed a method of scoring in which both speed and accuracy are taken into account in arriving at a score (Scarpina & Tagini, 2017), a method that is not currently in use.
References


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