GENDER DIFFERENCES IN AUDITORY PERCEPTION AND COMPUTATIONAL DIVIDED ATTENTION TASKS

Bankole K. Fasanya¹, Maranda E. McBride², Regina Pope-Ford¹, & Celestine Ntuen¹

¹ Department of Industrial and System Engineering
North Carolina A & T State University
Greensboro, NC 27455.

² Department of Management
School of Business & Economics
North Carolina A & T State University
Greensboro, NC 27455.

Phone number-443-939-0346
Corresponding author-bkfasan@ncat.edu

Abstract
Women have been stereotyped as better multitaskers when compared to their male counterparts. The purpose of this study was to investigate whether there are differences in gender performance when performing cognitive combined tasks. Twenty-four graduate students (twelve females and twelve males) volunteered to participate in the study. The task required participants to indicate when they perceived a change in the intensity of an auditory signal while simultaneously solving algebraic problems.

MANOVA results revealed no significant differences between genders when performing the combined tasks \( (p = 0.1831 \text{ and } \lambda = 0.7891) \) although the average number of false alarms made during the combined tasks by males was nearly 11% higher than the average number of false alarms made by females. However, ANOVA results for the combined tasks showed that males outperformed females on the computational task while listening for changes in the auditory signal \( F(1, 22) = 5.09, p < 0.03 \), but there were no significant differences in their ability to detect noise intensity variation or in the number of false alarms made while multitasking. For the single task analysis the ANOVAs indicated no significant differences in signal detection task performance, computational task performance, or the number of false alarms made by males and females.

Keywords:
Pink noise, Background Noise Tolerance Level (BNTL), Multitasking, Acoustic Chamber, Azimuths

INTRODUCTION

It is a common knowledge that women are often said to be better at performing combined tasks than their male counterparts. This stereotype has stemmed debates in various homes, schools, and office environments. With the emergence of technological advances that enable us to perform certain tasks more efficiently, expectations regarding the time required to complete certain types of tasks have changed and time pressures have increased. As a result, the extent of multitasking is greater today than in the 1970s. If women are indeed better at multitasking, it may benefit employers to take this into consideration when searching for candidates for positions that require a significant amount of multitasking. For such reasons, it is important to look into the issue of gender differences in multitasking through a scientific lens in order to provide evidence either supporting or opposing the stereotype.
A few researchers have already been investigating this topic. For instance, a study conducted by Havel (2004) looked at the multitasking abilities of 30 males and 30 females using verbal and spatial tests. The participants were required to listen to a story and count the number of occurrences of a particular keyword. Two stories recorded on audio cassette were used in the study. One of the stories contained 437 words and the keyword “rabbit” was mentioned 16 times. In the other story, the keyword “bluebird” was mentioned 17 times. In this study the verbal and spatial abilities of the participants were evaluated by having them complete word searches and mazes, respectively, while listening for the keyword. The study revealed no gender differences; however, male participants had a higher average score on the spatial task, while females had a higher average score on the verbal portion of the study. These differences were not statistically significant.

Multitasking is considered to be a higher order cognitive ability; therefore, the concept of human performance theory (HPT) can be used to explain the effects of multitasking on performance. As explained by Draycott and Kline (1996) and Ippel (1997), HPT implies that cognitive processes draw from a finite pool of cognitive resources and that the amount of resources required to perform a task (i.e., the cognitive task load) increases with the complexity of processing. Multitasking also involves distributing cognitive capacity among various activities which may increase the cognitive task load and have an adverse effect on human performance. Burgess and Shallice (1996) used the term “multitasking” to describe the ability that ensures successful performance in situations requiring the efficient parallel execution and coordination of several tasks. Multitasking research conducted by Criss (2006) showed no significant difference in regards to the relationship between gender and productivity when multitasking; however, a significant difference was found between the genders in the area of accuracy when multitasking. As documented in Criss (2006), “Dr. Glenn Wilson (2005) performed a study for Hewlett Packard to explore the productivity of multitasking. What he discovered was astonishing. The average worker’s functioning IQ, a temporary qualitative state, drops 10 points when multitasking. That is more than double the four point drop that occurs when someone smokes marijuana. Interestingly, the functioning IQ drop was more significant in men participating in the multitasking study.”

Research conducted by Leonard, Towler, Welcome, Halderman, Laura, Otto, Eckert, Mark & Chiarello (2008) on cerebral volume influences on gender differences in neuroanatomy showed that women have a 5% larger corpus callosum - the area of the brain that handles communication between the two hemispheres. Their study was not conducted to compare the multitasking capabilities of men and women but, according to the authors, popular press has used the results to support cultural assumptions about female superiority at multitasking. Media sources often claim that women are better at multitasking, yet a closer look at articles usually reveals that this is just an opinion rather than a fact. Studies conducted by Hochschild (1989) and Hessing (1994) suggest that females, particularly mothers, multitask in order to take care of all of their duties in a limited amount of time (e.g., doing laundry while watching television or taking care of children while also socializing with friends). However, little is known about the extent to which fathers multitask because previous work has focused primarily on domestic responsibilities and mothers’ strategies for minimizing time competition. Likewise, mothers may have more practice at multitasking than fathers because of the gendered nature of parenthood and the need to divide time between work and family (Mattingly and Sayer, 2006; Moen and Yu, 1999).

Contrary to these findings, other researchers (e.g., Leanard et el., 2008; Wilson, 2005; Hochschild, 1989; Hessing, 1994; Mattingly and Sayer 2006; Moen and Yu, 1999), Peter (2010) found that men actually perform better when performing multiple tasks simultaneously. The study was conducted under both forced and voluntary multitasking conditions. However, for our study, we hypothesize that females will perform better than males when performing multiple tasks that involve cognitive reasoning, such as auditory perception and computational analysis.
METHOD AND PROCEDURE

Participants
A total of twenty-four subjects participated in this study: 12 males and 12 females. All participants involved in the study were students currently enrolled in the North Carolina Agricultural and Technical State University’s Industrial and Systems Engineering graduate program. Their ages ranged from 22 to 40 years (female mean = 27.4 yrs, SD = 4.11 yrs; male mean = 30 yrs, SD = 4.5 yrs). All participants were recruited through personal acquaintance.

Apparatus and Testing Materials
The apparatus and testing materials used to conduct the study were a model RE-143MC sound attenuating booth (Figure 1), Larson Davis System 824 sound level meter, Dell desktop computer, Fonix audiometer, two loud speakers, pencils, plain paper, CD-ROM with pink noise recording, ear muffs, table, chair, and an algebraic test problem set.

![Figure 1: Acoustic Chamber](image)

The pink background noise signals were stored on a Gateway PC computer, normalized to average root mean square (RMS) levels ranging from -13.0 to 25.0 dB, and routed directly into the acoustic chamber where participants were seated. Loudspeakers were positioned at 0° and 180° azimuths relative to each listener. The speakers were adjusted to each listener’s ear height, approximately three feet away from the corresponding ear. The equipment setup is shown in Figure 2. Two sets of algebra problems were given, each containing five problems. All participants were given similar problems during each session.

![Figure 2: Equipment Set-up](image)

Procedure
During the study, participants were seated in the center of the sound attenuating booth. At the beginning of the study, the experimenter explained the purpose of the study and the tasks. Prior to beginning the main experiment, a hearing screening was conducted for each participant to ensure that they had normal hearing in both ears as defined by hearing thresholds of 20 dB HL or below for octave band frequencies between 250 and 8000 Hz. The hearing screening was followed by instructions for the participant to perform the computational task. Each participant took part in three five-minute, randomly assigned sessions. For the first seven participants, a control trial was conducted where a background noise was played to determine each participant’s background noise tolerance level (BNTL). In one trial, participants
were asked to solve five algebra problems without any background noise or any other task. A second trial involved the participant solving five algebra problems while at the same time indicating when they perceived an increase or decrease in the intensity of the background noise. The third trial involved only the identification of background noise intensity changes. For the trials involving background noise, the listeners pushed a response button once if they detected an increase in the level of background noise or twice if they detected a decrease in the level of the background noise. The decibel level for the background noise varied from 57.5 dB to 63.5 dB and the intensity differences used in the study were 1.0, 1.5, 2.0, and 3.0 dB. There were a total of twelve variations in the noise level which encompassed each of the four decibel intensity differences. As previously described, all trials were assigned randomly. Responses were recorded upon completion of each trial.

**DATA ANALYSIS AND RESULTS**

SAS Inc 9.2 (2007) was used to analyze the data collected during this study. There was one independent variable - gender two levels (male and female) and three dependent variables - algebra score (Computation task), signal detection (Auditory Perception task) and false alarms (Auditory Perception task). The algebra score was the number of problems subjects got correct in the 5-minute session. The signal detection score consisted of the number of times subjects accurately detected an increase or decrease in signal intensity, while the false alarms score reflected the number of times a subject said there was a signal intensity change when no change occurred. At the beginning of the analysis, the data was checked for normality. The average scores for the computation task, auditory perception task, and the number of false alarms made when performing the combined tasks by gender for all subjects are displayed in Table 1. The results show that the algebra test score for males is approximately 22% higher than that for females, while the number of auditory signals detected was less than 2% higher for males. On the other hand, the number of false alarms made by females during the auditory perception task was approximately 11% lower than that for males.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Computation (Max=10)</th>
<th>Auditory Perception (Max=12)</th>
<th>False Alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>3.83(2.40)</td>
<td>7.58(2.11)</td>
<td>2.83(3.71)</td>
</tr>
<tr>
<td>Male</td>
<td>5.92(2.11)</td>
<td>7.83(1.34)</td>
<td>3.50(3.29)</td>
</tr>
</tbody>
</table>

Table 2 shows the results for the single task activities. This table shows that males outperformed females in the computation task by approximately 11%, while females detected approximately 5% more of the
signal changes. In addition, females committed approximately 7% more false alarms than their male counterparts. Figure 3 shows the graphical representation of the average scores by gender for both single and combined tasks.

<table>
<thead>
<tr>
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<th>Computation (Max=10)</th>
<th>Auditory Perception (Max=12)</th>
<th>False Alarms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>5.29(1.30)</td>
<td>10.33(3.50)</td>
<td>1.92(1.95)</td>
</tr>
<tr>
<td>Male</td>
<td>6.54(1.68)</td>
<td>9.42(1.92)</td>
<td>1.67(1.48)</td>
</tr>
</tbody>
</table>

A one-way multivariate analysis of variance MANOVA statistical tool was used to determine if any significant differences exist between the scores by gender in the combined tasks condition based on an alpha level of 0.05. The independent variable was gender (male and female) and the dependent variables were computational scores, auditory signal detection scores, and number of false alarms. The MANOVA for the combined tasks condition indicated no significant differences between genders ($p > 0.05, \lambda = 0.7891$). However, ANOVA results for each of the dependent variables showed that male’s computational scores were significantly higher $F(1, 22) = 5.09, p < 0.03$; but there were no significant differences in the signal detection task scores or the number false alarms made between genders. For the single task none of the scores between genders were significantly different from one another based upon the ANOVA results.
DISCUSSION

The findings of this study did not support our initial hypothesis that females would outperform males when multitasking. In fact, the results reveal that males are better in solving algebra problems during both single and combined tasks conditions. These results oppose the findings of Leanard et al. (2008), Wilson (2005), Hochschild (1989), Hessing (1994), Mattingly and Sayer (2006), and Moen and Yu (1999). They also do not support the findings of Peter (2010) who found that males are better at multitasking in general. However, the results of this study supported the De Lisi and McGillicuddy-De Lisi (2000) study on gender differences in mathematical abilities and achievement. Their study found that males tend to perform better in mathematical problem solving than females in high school and college. The study also identified Scholastic Aptitude Test-Mathematics (SAT-M) as the area in which the male advantage seemed large enough to be of concern. Likewise, the study conducted by Hyde, Fennema, Ryan, Frost and Hopp (1990), a meta-analysis of gender differences for attitudes and influence relevant to mathematics, showed that female participants had greater anxiety and less self-confidence regarding mathematics. This may be one explanation for the male participants in our study scoring higher on the algebra problems than female participants.

LIMITATIONS AND RECOMMENDATIONS

There are a few limitations that should be mentioned in regards to this experiment. First, the findings are based on a short task time of only five minutes and a small number of participants. This could have contributed to the lack of significance for some of the statistical tests. Due to this small sample size, the findings should not be generalized across the entire population to determine gender differences in multitasking activities. Second, the experiment involved only industrial engineering students, thus the results could possibly be discipline specific. For future studies, the number of participants should be increased and participants from different disciplines should be involved in this study. Time to perform the task should be increased, so that the subjects’ endurance to perform task can also be measured. The time of day when the experiment is conducted should be randomly assigned to ensure that the timing of the experiment does not confound the data.

CONCLUSION

The results described in this paper are preliminary findings of a larger ongoing research project. Based on the analysis of the empirical data, the following can be said: gender differences on the auditory perception task were not statistically significant when performing multiple tasks; however, males on the whole
performed better on the computational task than females. However, in overall combined tasks analysis showed not significant between genders. We believe the findings can be the springboard for conducting further research on studying gender differences and in determining if, under certain conditions, either gender is better at multitasking. These findings could impact job design, employee training programs, individual expectations, and employer expectations.

REFERENCES