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The Effects of Musical Instrument Gender on Spoken Word Recognition

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THE EFFECTS OF MUSICAL INSTRUMENT GENDER ON SPOKEN WORD RECOGNITION

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ABSTRACT

One area of auditory processing research involves investigations into how spoken words are processed. When hearing spoken words, in addition to the word itself, listeners process other information, such as the gender of the talker. Both spoken words and other sounds humans encounter in their environment are managed in the auditory system. A common example of an environmental sound is music. Additional research has demonstrated that participants associate musical instruments with genders. In the current research study, I examined the effects that musical instrument gender and talker gender have on spoken word recognition. Female participants heard a moment of silence or a male, female, or neutral instrument play a song clip followed by either a male or female talker saying a word or nonword. The participant responded by indicating whether the talker said a word or a nonword by pressing the appropriate button on the keyboard. Two repeated measures ANOVAs were used to analyze the data, one on accuracy and one on reaction time to correct responses. A main effect of condition was found in the reaction time analysis, with the silent condition producing the fastest responses. In addition, participants responses were faster following the female instruments than the male and neutral instruments. In the future, researchers could compare these results utilizing a male sample. The current research aids in the understanding of how humans process auditory stimuli and contributes to a body of research revealing connections between

environmental sound processing, including (perhaps especially) music, and spoken word recognition.

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CHAPTER I

INTRODUCTION

Representation and Processing

Cognitive psychologists are interested in understanding how information is represented and processed in many domains, including sensory information. For example, in vision, images are often segmented into simple geometric components to aid in visual perception (Biederman, 1987). There is also research for haptic (touch) perception (Winter et al., 2008), taste (Green et al., 2005), and olfactory (smell) perception (Bochicchio & Winsler, 2020). In the current research study, I focused on the auditory domain. Furthermore, the current research aids in the understanding of how humans process auditory stimuli and contributes to the body of research detailing the connections between environmental sound processing and spoken word recognition.

Representation and Processing of Auditory Input

One area of auditory processing research involves investigations into how spoken words are represented and processed. Abstract and episodic theories provide different accounts for how spoken words are represented (e.g., Connine & Pinnow, 2006). Abstract theories account for spoken word recognition in terms of inference processing during which surface details are lost. For example, during the process of recognizing the word “church”, listeners break the word down to “ch”, “ur”, “ch” in order to recognize the word and its meaning. When doing so, any extra details, such as the identity of the talker or the emotional tone of voice of the talker, are stripped away during a normalization process (Pisoni, 1997), and thus these details are not part of the lexical (word) representations. Episodic theories, on the other hand, propose that the mental lexicon retains “traces” of words that include detailed surface information from when the word was spoken. For example, during the process of recognizing the word “church”, listeners process and store details, such as the identity of the talker or the emotional tone of voice of the talker, in the mental lexicon. Both types of theories were developed in order to explain how listeners recognize spoken words.

When we process spoken words, we not only process the words being spoken, but we also process the acoustic patterns and social contexts in which the words appear (Sumner et al., 2014). Auditory memory for speech is highly detailed and selective (Church & Schacter, 1994). Listeners retain the information for intonation contour, emotion, and fundamental frequency. Talker gender is a common type of surface information.

One of the factors that influence how people perceive speech is the gender of the talker. Specific characteristics related to individual talkers, such as gender, are stored in long-term memory (Goh, 2005). Additionally, Palmeri et al. (1993) found that information that comes from a new talker of the same gender as the original talker is processed more efficiently than information from a new talker of the opposite gender as the original talker. Nygaard and Pisoni (1998) conducted three experiments to examine talker-specific learning in speech perception. At the end of the study, the researchers concluded that talker-specific information, such as the gender of the talker, affects how listeners perceive the linguistic properties of speech. When learning new information, participants used the talker-specific characteristics to aid in the recovery of the spoken content. This finding indicates that the gender of the speaker affects how we interpret and understand spoken words.

Additional research has used eye tracking as a technique for examining the effects of talker variation (Creel, Aslin, & Tanenhaus, 2008). Results suggest that words spoken by different talkers had greater proportions of fixation than words spoken by the same talker. The fixations referred to where the eyes focused during the task. Participants focused their eyes on the talker more during the tasks with a different talker, indicating an increased need for concentration during that condition. Continuing to research the effects of talker gender and other types of variation should lead to an increased understanding of the representations and processes underlying spoken word recognition.

Another type of auditory stimuli that people encounter are environmental sounds. Environmental sounds occur in our everyday environment and include alarms, birds chirping, and music. A longstanding debate in the literature is whether speech and environmental sounds are processed in the same way. One study examined the response of hearing speech and environmental sounds on the left posterior inferior frontal gyrus and the anterior supramarginal gyri (Deschamps et al., 2020). Both regions were affected by speech and environmental sounds, but in different ways. These results support the idea that speech and environmental sounds are processed differently.

Environmental sounds have been found to have an effect on the semantic representations of words (Sajin & Connine, 2013). By adding "babble" to the background of speech, researchers were able to enhance participants' ability to process certain words, leading to increased understanding of words. For example, when listening to the phrase "click on apple", the participants were also listening to the sound of 100 people speaking in a canteen. Listeners rely more on semantic information when they are trying to comprehend speech that is occurring during the background "babble", leading to an increase in processing and an increase in understanding. Research also suggests that environmental sounds can be primed similarly to how words can be primed (Chiu & Schacter, 1995). For example, sounds such as a clock ticking, and tooth brushing can be primed to be associated with specific words or phrases. These studies add to our understanding of how environmental sounds can impact our everyday activities and behaviors.

Music is a type of environmental sound that people encounter in everyday life. Music is unique in that musical training often allows people to enhance their ability to discriminate auditory stimuli. Recently, researchers investigated musicians' ability to recognize speech in a noisy environment compared to nonmusicians (Bidelman & Yoo, 2020). Musicians were more accurate and faster at recognizing speech while listening to a maximum of eight different talkers simultaneously and showed less performance decline than nonmusicians. Additionally, a two-year study compared children who were trained in music to children who were trained in sports, as well as to children with no additional training (Habibi et al., 2016). Children who were trained in music demonstrated an enhanced ability to detect changes in the auditory environment. These children also had an accelerated maturity in auditory processing relative to the children with no additional training and to the children trained in sports.

These effects can be seen across a lifetime. In another study, participants aged 17-79 with various levels of musical experience attempted to identify melodies that started fast and slowed down over time as well as melodies that started slowly and sped up over time (Andrews et al., 1998). Those with increased musical experience performed better on both the fast to slow and the slow to fast conditions. This result suggests that age and musical experience can affect one's ability to discriminate between auditory stimuli.

Other studies have demonstrated that musical instruments can be classified into genders, just like the voices of talkers (Stronsick et al., 2018). The timbre and pitch of the instrument contribute to a classification as masculine, feminine, or neutral. According to The American National Standards Institute, timbre is an attribute of auditory sensation that makes it possible to judge two similarly presented sounds with the same loudness and pitch to be dissimilar (1973). The finding that timbre influenced gender perception of musical instruments was consistent with previous research in that deeper, richer tones are considered to be more masculine and instruments with a flutier, more airy sound were perceived as more feminine. Pitch affecting gender perception of musical instruments was a new finding; instruments played in a lower pitch were found to be more masculine and instruments played in a higher pitch were found to be more feminine. The masculine instruments were French horn, string bass, and tuba. The feminine instruments were flute, handbell, and harp. Lastly, the neutral instruments (i.e., consistently rated as neither masculine or feminine) were harpsichord, piano, and bassoon.

The idea of musical instruments being associated with a gender is not new. Abeles and Porter (1978) found that parents would encourage their sons to play drums, trombone, and trumpet, and their daughters to play clarinet, flute, and violin.

Additionally, these researchers found that college students rated clarinet, flute, and violin as feminine, and drums, trombone, and trumpet as masculine. This line of research has continued over the years. Abeles (2009) surveyed people in 1978, 1993, and 2007 and found little difference in the sex-by-instrument distribution over time. Females typically played flutes, violins, and clarinets, while males typically played drums, trumpets, and trombones.

Ascribing gender to musical instruments can affect what instrument a person chooses to play. After examining secondary school-age children's perception of musical instruments of different cultures, it was found that students perceive larger instruments as more masculine and smaller instruments as more feminine (Kelly & VanWeelden, 2014). Larger instruments typically have a deeper timbre and a lower pitch, while smaller instruments typically have a lighter timbre and a higher pitch. Those with more musical experience are not immune to these effects. In fact, individuals who study music may be more prone to sex-stereotyping in the masculine direction than those that do not study music (Griswold & Chronback, 1981). Those that studied music found feminine instruments to include harp, flute, piccolo, glockenspiel, and to be a choral conductor. Masculine instruments included trumpet, string bass, tuba, saxophone, drums, and to be an instrumental conductor. These associations between musical instruments and genders further contribute to the motivation for the current study.

Relationships between Language and Auditory Processing

Previous research on various relationships between language and auditory processing has focused on many different domains. Research has been conducted on auditory processing in those with Dyslexia (Georgiou et al., 2010), those with Autism

Spectrum Disorder (Foss-Feig et al., 2017), and those who are legally blind (Röder et al., 2000). Research has also been conducted on how different environmental stimuli affect auditory processing, including aircraft noise (Hollander & Andrade, 2014). In the current research study, I focused on the relationship between music and spoken word recognition. Previous research includes work focused on the impact of being a musician on spoken word recognition. These effects could be used to show how music influences how listeners process spoken words in their day-to-day lives.

In one study, non-musician children were randomly assigned to be trained in either music or painting for two years (Chobert et al., 2014). The results suggest that musical training influences the perception of speech and the development of phonological representations in developing children more than paint training. Another study examined children after three years of studying a musical instrument and compared them to children that did not study a musical instrument (Forgeard et al., 2008). Parents reported how long their child had been studying music and the children participated in various tasks that test auditory and motor skills. The children with musical training performed better in auditory discrimination tasks and had enhanced fine motor skills. These experimental results further support previous correlations between instrumental music training and cognitive abilities, and between music training and fine motor skills.

Furthermore, other research suggests that musicians have more robust brainstem responses to both speech and music (Musacchia et al., 2007). Supplementary research has found that musicians' brains have a stronger encoding process for pitch information in speech (Wong et al., 2007). This relationship hints at the idea that the representations of music and speech are similar in the brain and that these representations could affect one another. These findings further suggest that music experience can affect auditory processing in general.

Hypotheses

In the current study, I examined the effects that musical instrument gender and talker gender have on spoken word recognition. The variable "Condition" refers to the pairing of the gender of the musical instrument and the gender of the speaker and is categorized as either match, mismatch, neutral, or silent. The match condition refers to the gender of the instrument paired with the same gender of speaker (masculine instrument with male voice or feminine instrument with female voice). The mismatch condition refers to the gender of the instrument paired with the different gender of speaker (masculine instrument with the female voice or feminine instrument with the male voice). The neutral condition refers to the gender-neutral instrument paired with either the male or female voice. Lastly, the silent condition refers to no music paired with either the male or female voice. The variable "Talker" refers to the gender of the talker (male or female).

I predicted no Condition by Talker interaction and no main effect of Talker; however, I predicted a main effect of Condition. Moreover, I predicted that planned analyses based on the predicted main effect of Condition would reveal more efficient responses (faster, more accurate, or both) in the match condition compared to the mismatch, neutral, and silent conditions (see Figures 1 & 2). I further predicted the neutral and silent conditions to be equally efficient, as well as more efficient responses in the neutral and silent conditions compared to the mismatch condition.

Figure 1

Hypothesized Mean Reaction Times per Condition

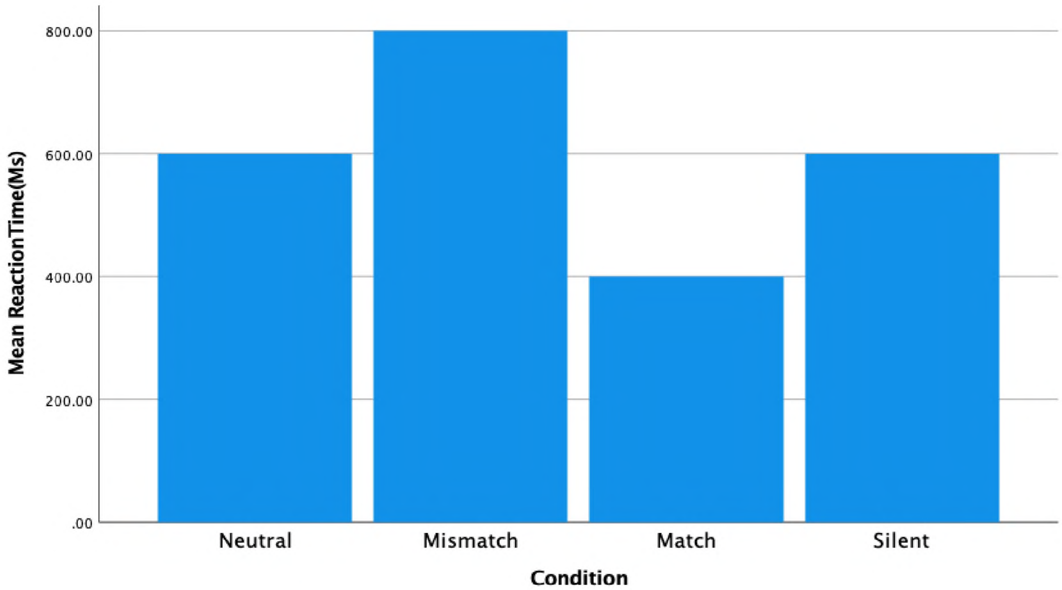
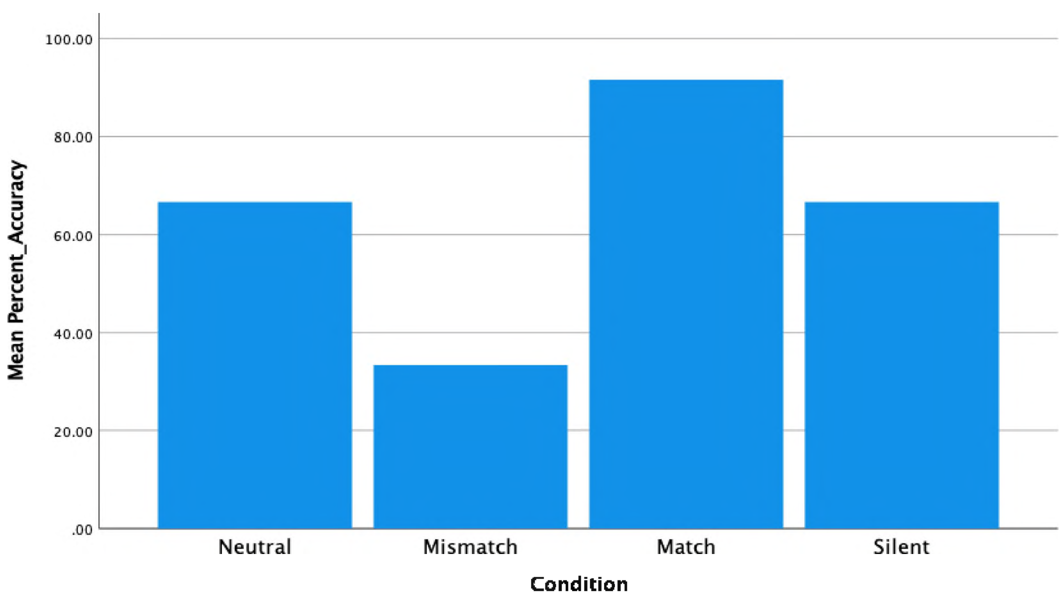


Figure 2

Hypothesized Mean Accuracy Percentages per Condition



CHAPTER II

EXPERIMENT: SHORT-TERM PRIMING AND LEXICAL DECISION

Participants

I planned to recruit 117 participants for the current experiment. This sample size was determined using G*Power (Faul et al., 2007) for a small effect size of 0.10 and a power of 0.80. To perform the analysis a priori, we chose "ANOVA: Repeated measures, within factors". Alpha was set to 0.05 and number of groups for was set to one with eight measurements. With these values, G* Power indicated a sample size of 90 would be sufficient. Due to the research being conducted online, an additional 25% participants were to be recruited for this study to account for error (113 participants). In order to have equal participants in each of the nine counterbalanced arrangements, a total of 117 participants were to be recruited for the proposed research (13 participants per counterbalanced arrangements).

Participants aged 18 and over from the Department of Psychology Research Participant Pool (Sona Systems) at Cleveland State University were recruited. Participants were accepted from any race/ethnicity and voluntarily participated in the study. Participants were compensated with research credits for their psychology courses.

Since gender had a strong impact on this study and there was potential for an unbalanced gender ratio among participants, only women participants were included in this research. Women participants were chosen over men due to a greater number of women in the Department of Psychology Participant Pool. Additionally, all participants were to be right-handed, have American English as their first language, and have no reported speech, hearing, or visual disorders[1].

Materials

Technology. Participants completed the study remotely on a laptop or desktop computer utilizing Labvanced (Finger et al., 2016). In order to answer the prompts, participants were instructed to press the "Q" (nonword) key with their left hand and "P" (word) key with their right hand on a standard QWERTY keyboard. If a disturbance occurred in the participant's environment, the participant was instructed to pause the experiment by exiting full screen mode. The musical stimuli were created using MuseScore 3 composition software, edited using PRAAT editing software (Boersma, 2001), and exported as .wav files for each of the instruments. The spoken word and nonword stimuli were recorded in Soundtrap music software and edited using PRAAT (Boersma, 2001) editing software.

Musical Stimuli. There were nine different instruments used in this study. The three masculine instruments were tuba, French horn, and string bass. The three feminine instruments were flute, handbell, and harp. The three neutral instruments were piano,

[1] The analysis presented in the current draft of this thesis document are from 97 participants. Consequently, all analyses and interpretations of the results are tentative. However, I will continue to collect data until the appropriate sample size (n = 117) of participants meeting the inclusion criteria is obtained. The final analyses and interpretations will be based on those data

harpsichord, and bassoon. In order to give the participants practice, three different instruments were used. These were cello, marimba, and organ.

Each instrument was presented in the form of three different “songs.” The “songs” were three different major chords based on Stronsick et al. (2018) and composed of four quarter note phrases (comprised of the root, third, fifth, and root of the chord, respectively). Each song was 2,000 milliseconds long. The chords were the G major chord (G, B, D, G), the C major chord (C, E, G, C), and the D major chord (D, F#, A, D). In order to further enhance the gender effects of the musical instruments, the masculine instruments’ songs were in a low octave, the feminine instruments’ songs were in a high octave, and the neutral instruments’ songs were in the middle octave. To avoid interpreting any emotionality in the stimuli, the phrases were free of any articulations or dynamics, such as accented notes, crescendos, or staccato notes.

Word/Nonword Stimuli. The word and nonword stimuli consisted of nine bisyllabic words and nine bisyllabic word-like nonwords used in a previous study (McLennan & Luce, 2005), although all of the words and nonwords were recorded by a new male and female talker for the current study utilizing Soundtrap recording software[2]. The words were not intentionally selected based on gender association. The words were “bygone”, “coping”, “luggage”, “jagged”, “nugget”, “ribbon”, “bucket”, “cabin”, and “circus.” The nonwords were “wp^ks”, “balpæb”, “klkbæp”, “mædk^s”, “bamʃz”, “ka˩fæp”, “kæbev”, “boIkcf”, and “d3æg^p.” The words and nonwords appeared two times in each condition (match, mismatch, neutral, silent) and were paired with each of the three songs across all nine instruments in the nine variations of the study. The mean

[2] The fundamental frequencies of the male and female voices were found to be significantly different ($p < 0.001$).

durations of the word and nonword stimuli spoken by the male (501 milliseconds) and female (554 milliseconds) talkers were matched and no significant difference was found between the talker durations, $F(1, 38) = 0.31$ $p = 0.16$. Looking separately at the word and nonword stimuli, the mean durations of the word stimuli spoken by the male (443 milliseconds) and female (513 milliseconds) talkers were matched and no significant difference was found between the talker durations, $F(1,18) = 0.07$ $p = 0.12$ and the mean durations of the nonword stimuli spoken by the male (559 milliseconds) and female (595 milliseconds) talkers were matched and no significant difference was found between the talker durations, $F(1,18) = 0.84$ $p = 0.50$

Design

This experiment consisted of a 4 (Condition: match, mismatch, neutral, silent) x 2 (Talker: male, female) completely within-participants design. The silent or no instrument condition served as a baseline. The dependent variables were accuracy and reaction time (to correct responses) to the word stimuli in the lexical decision task.

Procedure

Participants completed the study online utilizing Labvanced. Participants were provided with an informed consent form (See Appendix A) to review and electronically sign if they agreed to participate. Participants were also provided with a downloadable copy of the informed consent form as well as a downloadable debriefing form (See Appendix E) at the completion of the study. In order to encourage participants to complete the study in one sitting and in a quiet environment, participants were told that their session may or may not be recorded.

Once they provided consent, participants were presented with a demographic questionnaire to complete (See Appendix B), followed by the Edinburgh Handedness Inventory (Cohen, 2008) (See Appendix C). After the handedness inventory was completed, participants completed 16 practice trials of the experiment. The practice trials consisted of instruments and words that were not used in the main experimental trials, and no data were analyzed from the practice responses. Participants heard an instrument play a song (2,000 milliseconds), followed by a 100 millisecond pause, after which a word or nonword was spoken by either a male or female talker. Participants were instructed to respond as quickly and accurately as possible by indicating whether they heard a word or a nonword by pressing either the “P” or “Q” keys on the keyboard, respectively. Participants were asked to complete the study in a quiet environment. If a disruption occurred, participants were encouraged to pause the experiment by exiting full screen mode and continuing the experiment when the disruption ended.

After completing the practice block, participants began the main experiment. The main experiment followed the same procedure as the practice trials. Each participant completed a total of 144 trials comprised of 36 match conditions, 36 mismatch conditions, 36 neutral conditions, and 36 silent conditions. There were nine words and nine nonwords in this study that appeared eight times each (two times in the match condition, two times in the mismatch condition, two times in the neutral condition, and two times in the silent condition). In order to fully counterbalance the pairings of instruments, words, and songs, there were nine different counterbalanced versions of the experiment.

After completing the experiment, participants rated their perceived gender of the musical instruments[3] (See Appendix D). The musical instruments that were rated include tuba, French horn, string bass, flute, handbell, harp, piano, harpsichord, bassoon, cello, marimba, and organ. After ranking the instruments, each participant was provided with a downloadable debriefing statement (See Appendix E) and thanked for their time.

[3] A pilot study of 10 different participants was conducted on Labvanced before the current study in order to examine the perceived gender ratings of the musical instruments. Participants were from the Cleveland State University Department of Psychology Research Participation Pool (SONA systems) and received 0.5 research credit for their participation. Participants were at least 18 years old, female, right-handed, and had no current speech, visual, or hearing disorders. All participants were provided with an informed consent form before starting the study. As decided in advance, if 70% of participants agreed with the gender ratings of the musical instruments, the ratings in the main study would be multiple choice; however, if less than 70% of participants agreed, then participants in the main study would be provided with a 10-point Likert scale to rate the gender of the musical instruments. Less than 70% agreed with the gender ratings; therefore, the 10-point Likert scale was used in the main study.

CHAPTER III

RESULTS

In the current study, I examined the accuracy of participants' word responses and the participants' reaction time to correct word responses in a lexical decision task following hearing song clips by masculine, neutral, and feminine musical instruments. Prior to examining the results of primary interest, we performed a manipulation check to determine whether the instruments we had anticipated being rated as masculine were indeed rated as more masculine than the neutral and feminine instruments, and that the feminine instruments were indeed be rated as more feminine than the neutral instruments.

The gender of musical instruments was collapsed into the distinctions of masculine (tuba, French horn, string bass), feminine (flute, handbell, harp), and neutral (piano, harpsichord, bassoon). These values can be found in Table 1 below. The instruments were rated on a 10-point Likert scale with larger values indicating more feminine ratings and smaller values indicating more masculine ratings.

There was a significant main effect of Gender $F(2,777) = 188.64$, $p < 0.001$, $\eta_p^2 = 0.33$. Planned comparisons based on this significant main effect of Gender utilizing Bonferroni corrections for multiple comparisons revealed significantly different ratings in the neutral instruments compared to the masculine instruments ($p < 0.001$), the neutral condition compared to the feminine instruments ($p < 0.001$), and the masculine instruments compared to the feminine instruments ($p < 0.001$).

Table 1

Mean Gender Ratings of Musical Instruments by Group

Group	Mean	Standard Deviation
Masculine	3.86	1.97
Feminine	7.15	1.90
Neutral	5.30	1.80

Returning to the results of primary interest, we now analyze the accuracy and reactions to the word responses in the lexical decision tasks. However, we first note that the overall mean reaction time and accuracy to the nonword stimuli were 1,618.63 milliseconds and 85.42%, respectively.

Accuracy was assessed with the participant correctly or incorrectly identifying the stimulus as either a word or nonword with the keyboard. Reaction time of correct responses was determined in milliseconds from the onset of the presentation of the word or nonword stimulus to the onset of the participant's key press. These values are referred to as the efficiency of responses.

In order to analyze the data, two separate 4 (Condition: match, mismatch, neutral, silent) x 2 (Talker: male or female) repeated measures ANOVAs were conducted. The first ANOVA allowed us to examine participants' accuracy of responses. The second ANOVA allowed us to examine participants' accuracy of reaction time to correct responses.

No Condition by Talker interaction was predicted. Additionally, no main effect of Talker was predicted. A main effect of Condition was predicted. Furthermore, planned analyses based on the predicted main effect of Condition were expected to reveal faster responses, more accurate responses, or both in the match condition compared to the mismatch, neutral, and silent conditions, in the neutral and silent conditions compared to the mismatch condition, and that the neutral and silent conditions would be equally efficient.

The results presented in this analysis are tentative[4]. Throughout the reaction time analyses, values are reported from the onset of the word or nonword stimulus to the onset of the participant's button press response. The mean reaction time for the silent condition (1,297.66 milliseconds) was faster than the other three conditions. The neutral condition

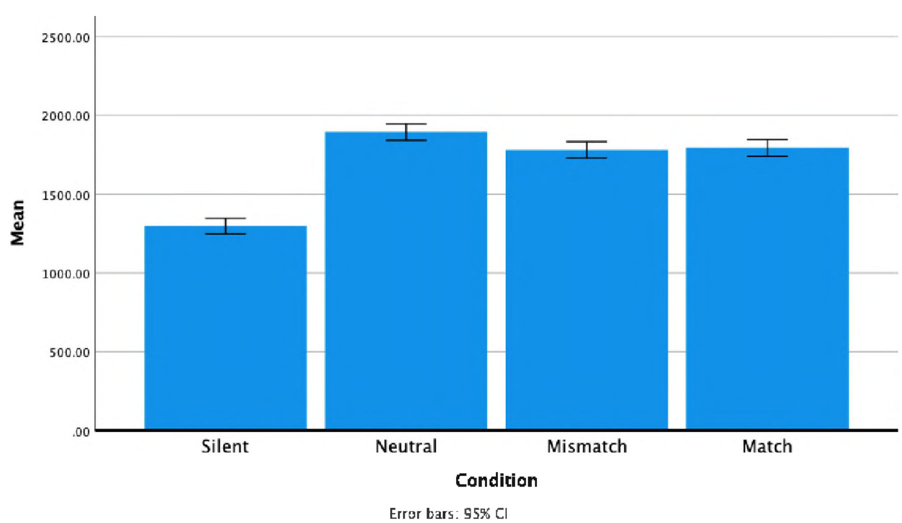
[4] The analyses presented are from 97 participants. Eight participants were removed from the analysis for giving the same response gender ratings to all musical instruments, leaving 89 participants. One participant was removed from analysis for recording a time delay three standard deviations beyond the mean, leaving 88 participants for all subsequent analyses. Additionally, 19.93% of reaction times were excluded due to recording values less than 200 milliseconds (before the onset of the word or nonword stimulus) or values that were deemed to be an extreme outlier (37 values with a range of 20 minutes to 221 minutes). For these tentative analyses, in order to maximize our sample size, I analyzed data from all participants, including those who did not meet the inclusion criteria of right-handed, English as their first language, and with no reported hearing, speech, or visual disorders. Thirty-five participants who did not meet these criteria, and thus would not have been included in the analyses, were included. There were no significant differences between the *would have been included* and *would have been excluded* groups. Consequently, throughout these tentative analyses, I collapsed across this variable. Nevertheless, data collection will continue until the appropriate sample size (n = 117) of participants meeting the original criteria is obtained.

(1,893.62 milliseconds) was the slowest condition. There was no difference between the match (1,794.35 milliseconds) and mismatch (1,780.65 milliseconds) conditions.

In the reaction time analysis, there was a significant main effect of Condition $F(3,4369) = 104.86$, $p < 0.001$, $\eta_p^2 = 0.07$. Planned comparisons based on this significant main effect of Condition utilizing Bonferroni corrections for multiple comparisons revealed significantly faster responses in the silent condition compared to the neutral ($p < 0.001$), mismatch ($p < 0.001$), and match ($p < 0.001$) conditions. Furthermore, planned comparisons based on the significant main effect of condition revealed significantly slower reaction times in the neutral condition compared to the mismatch ($p = 0.032$) condition. There was no significant difference between the neutral and the match conditions ($p = 0.112$) or between the mismatch and match conditions ($p > .999$) (See Figure 3.).

Figure 3

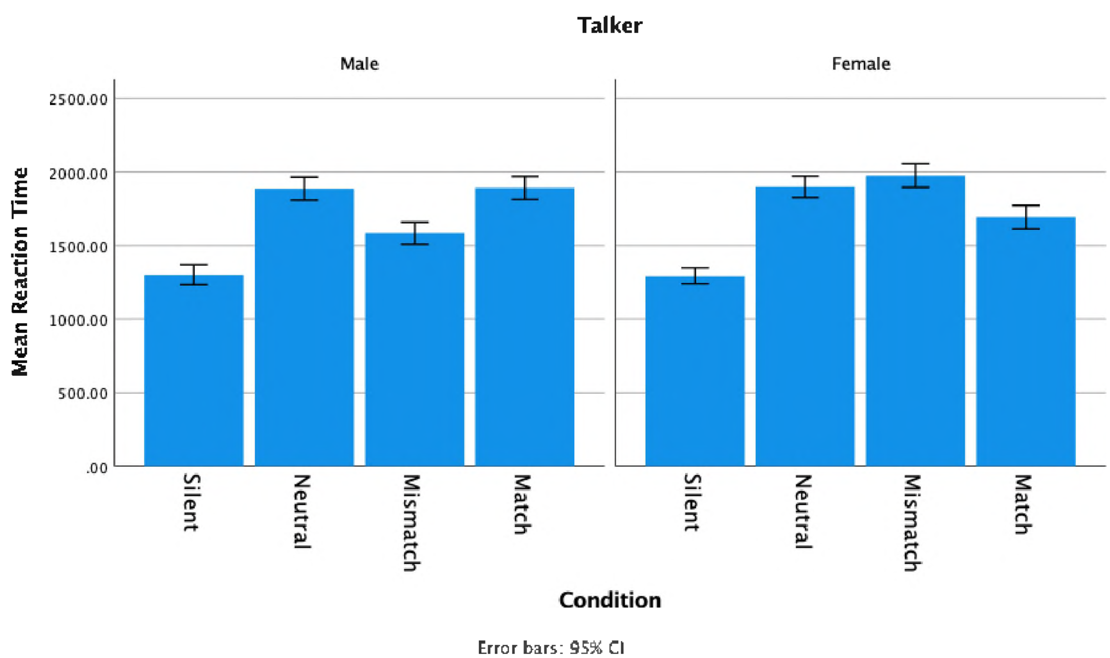
Mean Reaction Times (in milliseconds) by Condition



Reaction time did not yield a significant main effect of Talker, $F(1,4369) = 3.54$, $p = 0.06$, $\eta_p^2 < 0.001$ (See Figure 4). However, reaction time did produce a significant Condition by Talker interaction $F(3,4369) = 22.65$, $p < 0.001$, $\eta_p^2 = 0.02$. Planned comparisons based on this interaction revealed significantly faster responses in the male mismatch condition compared to the male match condition ($p < 0.001$). Additionally, the female neutral condition had significantly slower responses than the female match condition ($p < 0.001$). The female mismatch condition was found to be significantly slower than the female match condition ($p < 0.001$) (See Figure 4.).

Figure 4

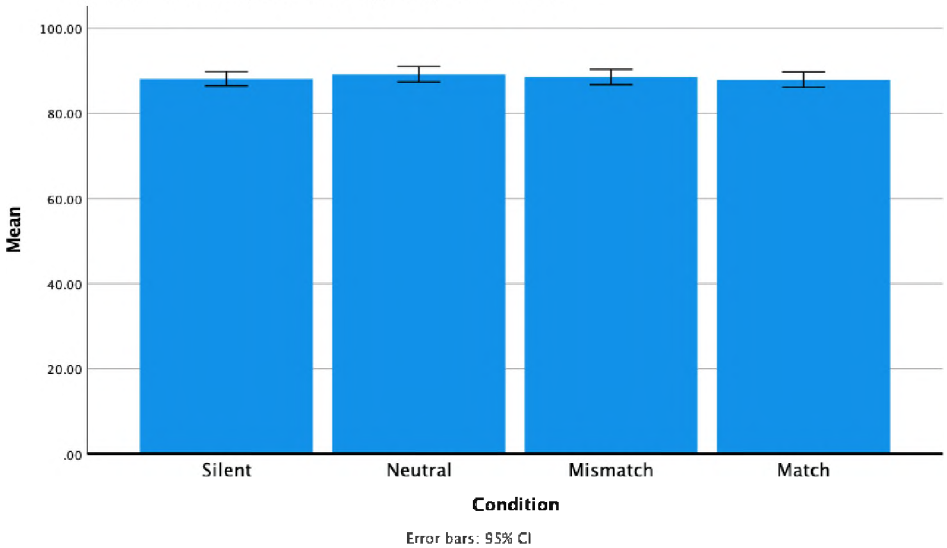
Mean Reaction Time (in milliseconds) by Condition and Talker



Accuracy of responses was also examined. The match condition was less accurate (87.91% correct) than the other three conditions. The neutral condition was found to be the most accurate (89.21% correct) condition. There was little difference between the mismatch (88.55% correct) and silent (88.15% correct) conditions.

Figure 5

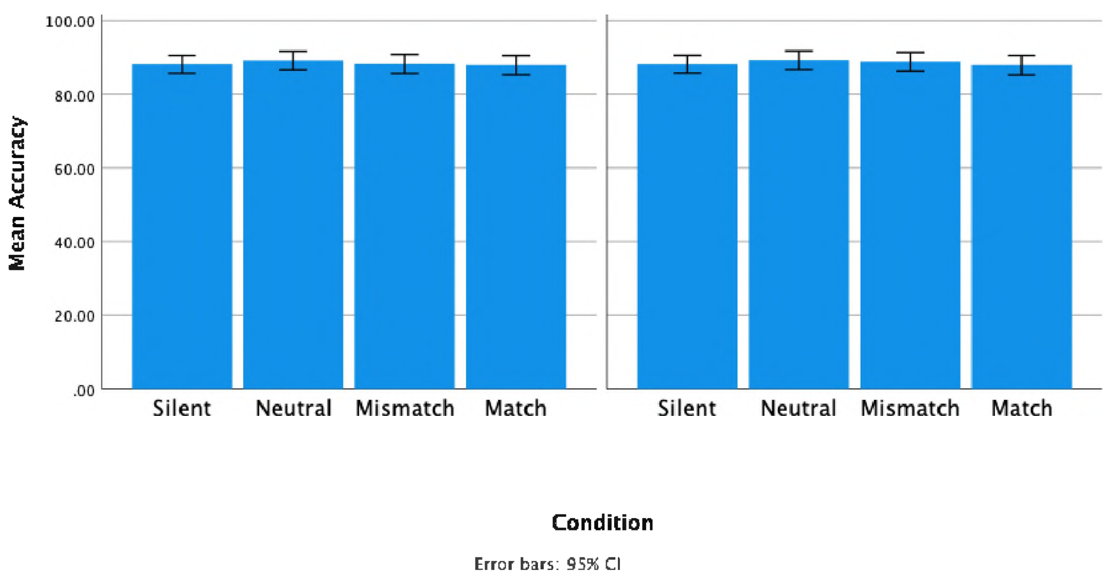
Mean Accuracy Percentages by Condition



When analyzing accuracy, no significant main effect of Condition was found $F(3,4942) = 0.71$, $p = 0.55$, $\eta_p^2 < 0.001$ (See Figure 5). Further analysis found no significant main effect of Talker $F(1,4942) = 0.02$, $p = 0.88$, $\eta_p^2 < 0.001$ (See Figure 6) and no significant Condition by Talker interaction $F(3,4942) = 0.02$, $p = 0.99$, $\eta_p^2 < 0.001$.

Figure 6

Mean Accuracy Percentage by Condition and Talker



CHAPTER IV

DISCUSSION

It is important to note that the results and discussion of the current research are tentative and that further analyses will be conducted when the original sample size ($n = 117$) of participants meeting all inclusion criteria are obtained.

While the results do not fully support the hypotheses, the data provide insight into the effects that environmental sounds (in this case, music) have on spoken word recognition. These findings have both theoretical and practical implications.

The results from the instrument gender ratings support the hypothesized gender ratings. The mean gender ratings of the musical instruments were consistent with the findings by Stronsick et al. (2018) and provide further support for the notion that musical instruments can be classified into genders.

It was predicted that there would be a main effect of Condition for reaction time, accuracy, or both. This prediction was supported for reaction time; however, not in the way that was expected. It was predicted that the match condition would provide the fastest responses. The results show that the silent condition produced the fastest responses. There was no significant difference between the match and mismatch conditions. The neutral condition was significantly slower than the other three conditions.

In terms of accuracy, it was again predicted that the match condition would produce the most accurate responses. There was no significant difference between the match, mismatch, neutral, and silent conditions.

It was further predicted that there would be no significant main effect of Talker and no significant Condition by Talker interaction. While the accuracy results supported these predictions, reaction time produced a significant Condition by Talker interaction. Although slower responses were recorded in the female talker mismatch condition compared to the female talker match condition (as predicted), surprisingly faster responses were recorded in the male talker mismatch condition compared to the male talker match condition.

In the current research study, I aimed to examine if music has an effect on spoken word recognition. Comparing the silent condition to the neutral, mismatch, and match condition allows us to examine this effect. The quickest responses were recorded in the silent condition, demonstrating a potential distractor effect in the other conditions. Additionally, the significant main effects of Condition related to reaction time suggest a possible relationship between music and spoken word recognition.

Since there is a significant main effect of Condition on reaction time, we can begin to examine the nature of the effect. Unexpectedly, it appears that feminine instruments are seen as more efficient for aiding in spoken word recognition in both the match and mismatch conditions. It may be important to consider that all participants in this study were female. Future research could examine this effect in male participants. Would the effect of female instruments disappear, or would the masculine instruments have a greater impact on spoken word recognition? In other words, does the gender of the musical instrument need to match the gender of the listener - not the speaker, as originally predicted - in order to facilitate spoken word recognition?

Theoretically, this research helps shed light on the longstanding question of whether speech is special (i.e., processed by a separate module) or if perception of speech and non-speech auditory stimuli interact. The finding that the music stimuli (an environmental sound) had an effect on participants' lexical decision responses to spoken words suggests the latter. That is, the tentative results imply that music can indeed affect spoken word recognition, and thus that speech and environmental stimuli are processed in similar ways.

Extensions of the current study could further our understanding of the dissociable subsystems theory (Marsolek, 1999), according to which processing of information is performed in separate abstract and specific subsystems. González and McLennan (2009) found that when sounds were presented to the left ear (right hemisphere), participants were more efficient when specific characteristics of each stimulus matched than when there was a mismatch. This advantage for a match in specific characteristics was not observed when the sounds were presented to the right ear (left hemisphere). This pattern of results, consistent with dissociable-subsystems theory, suggests that the specific subsystem is more efficient in the right hemisphere.

In the future, the design of the current proposal could be presented similarly to the González and McLennan study. This extension could examine the effects of instrument gender in the right versus left hemispheres. It could be predicted that effects would be found in the right hemisphere, but not the left hemisphere. This pattern would further support the dissociable-subsystems theory.

In terms of practical implications, the current research could assist in quick-thinking, word-recognition situations. For example, an air traffic controller often has to make quick decisions where milliseconds could have a great impact on the outcome of a decision. If an air traffic controller is a woman, and is listening to background music between instructions, then background music by male instruments should be avoided. Another example could be in a doctor's office. If a doctor is explaining important health information to a woman, having music in the waiting room with female instruments could provide additional benefits that male instruments may not provide. If environmental sounds can impact that decision by milliseconds, this information could be used to benefit individuals in such high-pressure situations.

In the future, this research could be assessed in different cultures and languages. Some instruments have different gender associations in other languages, which could lead to different results than what is presented here. For example, in Spanish, tuba is feminine. Would the effects be the same for a female voice in Spanish as a male voice in English (Incera et al., 2019)? This continuation could aid in the understanding of the effects that music can have on word recognition. Furthermore, this research could be flipped in order to determine whether a talker's or a listener's gender influences music perception. For example, if a word is spoken in a male voice, will the instrument heard afterwards be perceived as more masculine? This extension could aid in the understanding of the relationship between music and spoken word recognition.

The focus of the current research is on processing by using short-term priming. Future research could extend the current design in a long-term priming study. This study utilized a short-term priming design in order to examine processing. Examining the effects of instrument gender on spoken word recognition in a long-term priming study would address the nature of the representations. This would also allow us to determine if the effect persists over some delay, and, if so, this would provide evidence that there is an influence on the representations in the mental lexicon. If not, this would suggest the effect is limited to processing, and has no impact on the long-term representations.

Researching the effects of musical instrument gender on spoken word recognition is important for developing a more complete understanding of the auditory system. This research aids in the understanding of auditory processing and helps determine if environmental sounds and speech are processed in an interactive fashion. The results have both theoretical and practical implications and motivate further research into the connection between processing music – and other types of environmental sounds – and the recognition of spoken words.

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APPENDIX A

(Participant Consent Form)

Cleveland State University
engaged learning

PARTICIPANT CONSENT FORM

BETHANY COX, GRADUATE STUDENT: B.G.COX48@CSUOHIO.EDU, (216) 687-3834
DR. McLENNAN, FACULTY ADVISOR: C.MCLENNAN@CSUOHIO.EDU, (216) 687-3750
LANGUAGE RESEARCH LABORATORY – UNION BUILDING 653
CLEVELAND STATE UNIVERSITY: DEPARTMENT OF PSYCHOLOGY

Bethany Cox is a graduate student working on an experiment under Dr. McLennan's supervision. Dr. McLennan is a Professor at Cleveland State University. The goal of this experiment is to learn more about how cognitive processes unfold over time.

You will hear an instrument play a few notes followed by a spoken word. You will respond to the words by pressing a key on your keyboard. You will be asked to fill out surveys by typing on your keyboard or selecting your responses with your computer mouse. You may or may not have your audio recorded during this study. In order to make sure your identity is confidential, we will assign you a number. All of your information will be coded with that number instead of your name.

The experiment will take up to 0.5 hour. You will receive **0.5 research credit** for your participation. Your participation is voluntary, and you may stop this experiment at any time without loss of credit. You will still receive credit if you decide to withdraw from the study.

Your participation in this experiment involves minimal risks. You will be asked to provide some personal information. The researchers will do their best to keep your responses confidential. In particular, your responses will be kept in a locked lab, on password-protected computers, or both. You will have the opportunity to sign a copy of this informed consent form as well as be given an opportunity to download a copy of this informed consent form to keep for your own records.

Thank you!

"I understand what will happen during the experiment. I understand I may ask questions at the end of the experiment. I understand that the only direct benefit is that I will receive 0.5 credit of research participation.

I understand that if I have any questions about my rights as a research subject, I can contact the Cleveland State University Institutional Review Board at (216) 687-3630.

I am 18 years or older and have read and understood this consent form. I give my consent to voluntarily participate in this experiment."

______________________________ ______________________

Signature of Participant *Date*

____

Name of Participant (PLEASE PRINT) *E-mail Address* *Telephone Number*

______________________________ ______________________

Signature of Researcher *Date*

APPENDIX B

(Demographics [modified and completed in Labvanced])

PARTICIPANT INFORMATION FORM

BETHANY COX, GRADUATE STUDENT: B.G.COX48@CSUOHIO.EDU, (216) 687-3834
DR. MCLENNAN, FACULTY ADVISOR: C.MCLENNAN@CSUOHIO.EDU, (216) 687-3750
LANGUAGE RESEARCH LABORATORY – UNION BUILDING 653
CLEVELAND STATE UNIVERSITY: DEPARTMENT OF PSYCHOLOGY

FOR LRL USE:
Room #__________
Participant #__________
______ (credits) OR $______
Experiment __________
Date __________
Experimenter __________

Please fill in the following information:

1. Date of Birth:__________ **2.** Place of birth (City):__________

3. Gender:__________ **4.** Race:__________

5. Place of Longest Residence (City): __________

6. How many years of education have you completed: __________

7. Highest Degree earned: __________

8. Current Job: __________

9. Are you (circle one): right-handed left-handed ambidextrous

10. Would you like to be added to (or remain on) our "Paid Participants Database" so that we can notify you in the future of paid experiments for which you are eligible to participate? __________

11. Please list all the languages you know in order of dominance:

1	2	3	4	5

12. Please list all the languages you know in order of acquisition (your native language first):

1	2	3	4	5

13. At what age did you start to learn English? ***(Use 0 [zero] if English is your native language)*** ______________________________

14. Have you ever had a hearing or speech disorder?

(circle one)   YES   NO

If yes, please explain: ______________________________

15. Have you ever had a visual or reading disorder (other than glasses/contacts)?

(circle one)   YES   NO

If yes, please explain: ______________________________

16. Have you ever been diagnosed with Attention Deficit Disorder (ADD) or Attention Deficit Hyperactivity Disorder (ADHD)?

(circle one)   YES   NO

If yes, please explain: ______________________________

APPENDIX C

(Edinburgh Handedness Inventory Questionnaire [modified and completed in Labvanced])

Edinburgh Handedness Inventory (modified and completed on computer)

You can further help us by providing answers to the following questions. There are no right or wrong answers. Please indicate your preferences in the use of hands in the following activities by answering L for Left hand OR R for Right hand, OR X for No preference. After answering L, R, or X, please answer whether or not you ever use the other hand for each activity by typing Y for Yes OR N for No. Please answer all of the questions. If you have any questions, please ask the experimenter. Please type in your assigned ID number.

Which hand do you write with?
L)Left R) Right X) No Preference

Writing
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you draw with?
L) Left R) Right X) No Preference

Drawing
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you throw with?
L)Left R) Right X) No Preference

Throwing
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you use when using scissors?
L)Left R) Right X) No Preference

Scissors
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you put your toothbrush in?
L)Left R) Right X) No Preference

Toothbrush
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you use when using a knife without a fork?
L)Left R) Right X) No Preference

Knife
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you use when using a spoon?
L)Left R) Right X) No Preference

Spoon
Do you ever use the other hand?
Y for Yes OR N for No

Which hand is your upper hand when using a broom?
L)Left R) Right X) No Preference

Broom
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you use when striking a match?
L)Left R) Right X) No Preference

Striking a match
Do you ever use the other hand?
Y for Yes OR N for No

Which hand do you use when opening a lid to a box?
L)Left R) Right X) No Preference

Opening a lid to a box
Do you ever use the other hand?
Y for Yes OR N for No

Thank you! Please inform the researcher that you have completed this questionnaire.

APPENDIX D

(Instrument Gender Rating Questionnaire [modified and completed in Labvanced])

Musical Instrument Gender Questionnaire

Please indicate if the following instruments are masculine, feminine, or neutral. There are no right or wrong answers.

1. Is the cello masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

2. Is the flute masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

3. Is the handbell masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

4. Is the string bass masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

5. Is the marimba masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

6. Is the piano masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

7. Is the bassoon masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

8. Is the organ masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

9. Is the French horn masculine, feminine, or neutral?
   1 2 3 4 5 6 7 8 9 10
   Masculine Neutral Feminine

10. Is the harpsichord masculine, feminine, or neutral?
    1 2 3 4 5 6 7 8 9 10
    Masculine Neutral Feminine

11. Is the tuba masculine, feminine, or neutral?

1 2 3 4 5 6 7 8 9 10

Masculine Neutral Feminine

12. Is the harp masculine, feminine, or neutral?

1 2 3 4 5 6 7 8 9 10

Masculine Neutral Feminine

Thank you! Please press "Next" below to continue.

APPENDIX E

(Participant Debriefing Form)

Cleveland State University
engaged learning

Debriefing Form
Bethany Cox, graduate Student: b.g.cox48@csuohio.edu, (216) 687-3834
Dr. McLennan, Faculty Advisor: c.mclennan@csuohio.edu, (216) 687-3750
Language Research Laboratory – Union Building 653
Cleveland State University: Department of Psychology

Thank you for your participation in this experiment today! In the Language Research Laboratory, we are interested in discovering how people understand spoken and written language. In this experiment, we were interested in learning how the gender of musical instruments might affect your performance and reaction time on cognitive tasks.

Thanks again for your participation in this experiment. If you have friends participating in experiments in this laboratory, please keep the purpose of this experiment confidential in case we ask them to participate in the future.

Any data you have provided will be kept confidential. Any information you provided relating to perceptual impairments will not be tied directly to your name. No audio was recorded during this study.

If you have any further questions about this experiment, please feel free to ask. You may also contact the Language Research Laboratory at (216) 687-3834 if you have questions later that you wish to have answered.

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