Perceptions of Vocal Stimuli: The Effect of Lateralization

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Abstract

This study examined whether perception of voice attractiveness is influenced by lateralization effects when presenting stimuli in one ear versus the other ear and explored whether the content of vocal stimuli is important in the lateral processing of vocal information in terms of both voice perception and memory recall. Participants listened to voice samples of a number recitation and different phrases separately in their right and left ear and were later asked to recall the particular phrases they heard. Whereas there was no difference in voice attractiveness ratings when voices were heard in the right or left ear, listeners rated the number count recitations of opposite-sex speakers as sounding more attractive if they first heard that voice in their left ear. Further, men rated the voices of women reciting phrases relating to attraction as sounding more attractive than neutral phrases, whereas women rated the voices of men similarly regardless of phrase content. For phrases related to attraction, participants were better at recalling and were more confident in their decision of accurately recalling phrases when they heard the phrases than when they did not hear the phrases. For neutral phrases, participants were better at recalling the phrases and were more confident in their decision of accurately recalling phrases when they did not hear the phrases than the phrases they did hear. These findings further contribute to our understanding of how the human brain processes vocal information related to the perception of voice attractiveness and vocal content.

Perceptions of Vocal Stimuli: The Effect of Lateralization

Lateralization of the brain refers to the cerebral organization of cognitive processes being specialized to either the right or left hemisphere (Harms & Elias, 2014). One such cognitive task that shows lateralization is the processing of emotion, with the right hemisphere showing superiority at better identifying emotions (Heller, Nitschke, & Miller, 1998; Demaree, Everhary, Youngstorm, & Harrison, 2005). In particular, several studies have demonstrated that when processing *vocal* emotional stimuli, individuals are able to determine emotion with greater accuracy in their left ear than their right ear, this implicating right hemisphere dominance (Stirling, Cavill, & Wilkinson, 2000; Saxby & Bryden, 1984). When individuals listen to emotional tones and content in their left ear, it is both recognized and recalled better than when listening with their right ear (Sim & Martinez, 2005; Bryden, Free, Gagne, and Groff, 1991). The right hemisphere of the brain becomes activated when individuals feel certain emotions, including feelings of attraction (Fisher, Aron, & Brown, 2005; Xu, Aron, Brown, Cao, Feng, & Weng, 2011). Feelings of attraction activate brain regions associated with the dopamine reward system as do other positive emotions (Fisher, Aron, & Brown, 2005; Xu, Aron, Brown, Cao, Feng, & Weng, 2011; Bartels & Zeki, 2004). It is possible that when it comes to vocal attraction, there is a lateralization effect as there is for other vocal stimuli that trigger emotional responses.

The first aim of this investigation is to examine whether perception of voice attractiveness is influenced by lateralization effects when presenting stimuli in one ear versus the other ear. The second aim explores whether the content of vocal stimuli is important in the lateral processing of vocal information in terms of both voice perception and memory recall.

Right Hemisphere and Emotions

The right hemisphere plays a key role in processing emotions (Demaree, Everhary, Youngstrom, & Harrison, 2005). One theory known as the “Right-Hemisphere Model” states that the right hemisphere is specialized for the perception, expression, and experience of emotion. (Demaree, Everhary, Youngstrom, & Harrison, 2005). Gainotti (2012) found that emotional information gets sent to the amygdala by a right hemisphere subcortical route and therefore, the right hemisphere subcortical route is thought to be the main pathway that processes unconscious emotional information.

The right hemisphere’s critical role in processing emotions is demonstrated by several findings. Alpers (2008) examined the eye movements of healthy individuals to see if they direct their visual attention more towards pictures that elicited an emotional response rather than to neutral pictures. Participants attended to the pictures that elicited an emotional response more only when those pictures were presented on the left side of the screen. This finding suggests that attentional bias for emotional content is due more to the processing of the right hemisphere. Additionally, Ley and Byden (1979) had participants view five male cartoon drawings of characters exhibiting different emotional expressions and found that participants were better at recognizing emotions in their left visual field than their right visual field. These results further implicate right hemisphere superiority for processing facial recognition of emotions. Schwartz, Davidson and Maer (1975) examined individuals’ gaze preference when asked questions regarding affect (e.g., “For you, is anger or hate a stronger emotion?”, “When you visualize your father’s face, what emotion first strikes you?”). They found that when individuals answered these types of questions, they tended to gaze from right to left indicating more right hemispheric activation than left hemispheric activation. Collectively, these findings provide further evidence of how the right hemisphere is important in the processing of emotional information.

Other studies show that certain physiological responses occur when viewing emotional images that are lateralized to the right hemisphere. For instance, Spence, Shapiro, and Zaidel (1996) examined pulse volume and heart rate of individual's when viewing pictures that elicited an emotional response and neutral pictures. They found that when participants viewed the emotional images on their left side, the individuals' had an increased heart rate and the largest vasoconstriction responses because the physiological response system is the location of the right hemisphere superiority for emotion. Additionally, Dimberg and Petterson (2000) examined facial electromyographic (EMG) activity when individuals were exposed to pictures that elicited an emotional response. They found that when participants viewed photographs of people expressing either positive or negative facial expressions, the participants' left side of their faces showed a larger increase in the facial muscle activity. Therefore, the contralateral control of the right hemisphere over the motor movements of the left side of the face in this case implicates its superior role when responding to emotional stimuli.

Studies examining deficiencies in brain functioning provide further evidence for the right hemisphere bias of processing emotions. For instance, when Ahern, Schomer, Kleefield, Blume, Cosgrove, Weintraub, and Mesulam (1991) had anesthetized the right hemisphere of their participants, individuals rated the intensity of emotions expressed in facial photographs as less intense than their baseline ratings. However, when the left hemisphere was anesthetized, there was no change in ratings from baseline. The study showed how the right hemisphere is involved in the processing of emotions because when it was impaired, emotional intensity was not perceived as well. Similarly, in cases where patients had damage to a hemisphere, right hemisphere brain damaged patients were impaired in identifying the emotional expressions of facial images more than left hemisphere damaged patients and healthy control participants

(Kucharska-Pietura, Phillips, Gernand, & David, 2003). Therefore, when the right hemisphere is damaged, individuals have a difficult time processing emotions.

Studies examining brain damage of the right hemisphere have also provided information as to which specific parts of the right hemisphere are the most important for processing emotional information. Harciarek and Heilman (2009) examined the differences of stroke victims who had damage of either the posterior and anterior parts of the right hemisphere when they engaged in an emotional facial recognition task. Patients had viewed images of individuals expressing certain facial expressions and had to indicate which facial expression was being portrayed. Overall, patients with stroke damage to either the posterior or anterior section of the right hemisphere showed an impaired recognition of the emotional faces. However, patients who had more damage on the posterior section of the right hemisphere were better at recognizing the facial emotions than the patients who had a stroke on the anterior section. These results suggest that the anterior parts of the right hemisphere play more of a role in the recognition of emotional facial expressions than the posterior parts.

Left Ear Advantage

Because the right hemisphere appears to be dominant for the processing of emotion, it makes sense that the auditory information presented in the contralateral ear (i.e., left ear) would show an advantage for the processing of emotional vocal information. Several studies have shown that individuals can accurately determine emotions when listening to vocal information in the left ear better than when listening to vocal information in the right ear, creating " a left-ear advantage" (Bryden & MacRae, 1988; Bryden, Ley, & Sugarman, 1982; Erhan, Borod, Tenke, & Bruder, 1998). Furthermore, right-handed individuals show more of a left ear advantage when

processing auditory emotional information than do left-handed individuals (Alzahrani & Almuhammadi, 2013).

When processing emotional vocal stimuli, several studies have demonstrated a left-ear advantage. For instance, Sim and Martinez (2005) examined if participants could recall emotional or non-emotional words spoken in a neutral intonation more accurately in one ear versus the other ear and found that participants recalled the emotional words (e.g., loving) heard in their left ear more than in their right ear. Additionally, Bryden, Free, Gagne, and Groff (1991) examined if individuals were able to determine if words were spoken in an angry, happy, or sad emotional tone or neutral tone. They found that individuals were able to correctly identify the emotional tones presented in the left ear more than when heard with the right ear. Furthermore, Bryden and MacRae (1988) found that when participants listened to two-syllable words that were expressed in different emotional tones, they were significantly better at identifying the specific emotion when heard in their left-ear than their right-ear. In particular, when words were spoken using a sad or angry emotional tone, there was an even stronger left-ear advantage for identifying the correct emotional expression than when words were spoken using a happy tone. Stirling, Cavill, and Wilkinson, (2000) had participants listen to a recording of two-syllable words (e.g., burden, furrow, mantle, ration, etc.) in happy, angry, sad, and neutral tones for five minutes. Participants were asked to indicate which ear they heard a specific phrase and asked to identify the emotional tone in which it was spoken. They found that the participants had more accurately paired the emotional tone and the recalled phrase when reporting they heard it with their left ear. Collectively, these findings demonstrate a there is a left-ear advantage when processing emotional stimuli.

In addition to examining the expression of emotion in singular words, studies have demonstrated a left ear superiority for determining the correct emotion when listening to sentences. Ley and Bryden (1982) had participants listen to sentences where the speaker's tone of voice expressed either happiness, sadness, anger or were spoken using a monotone voice. They found that participants recognized the emotions expressed in the sentences better when they listened to them in the left ear than their right ear. A left ear advantage for detecting emotion in vocal tone in sentences is even seen in children. Saxby and Bryden (1984) examined hemisphere differences in children for processing auditory content that was presented in different emotional tones. All age groups of children tested (age 5 to 14) had an overall left-ear advantage for identifying the correct number of emotional tones when listening to voice samples that expressed happy, sad, and angry tones. As our brains are developing early in childhood, there is still a left-ear advantage for determining which emotion is correctly being heard.

Even when the content of the speech is unrecognizable but spoken using a positive or negative emotional tone, individuals were able to identify the emotional tones better when using the left ear than the right ear (Hatta & Ayetani, 1985). Erhan, Borod, Tenke, and Bruder, (1998) found that when participants listened to non-sense syllables (e.g., ba, pa) that were spoken using emotional tones of happiness, interest, anger and sadness, they were more accurate at identifying those emotional tones when presented in their left ear than their right ear. Thus, emotional content is better recognized when heard in the left ear than the right ear.

Vocal Attraction

The sound of a person's voice plays an important role in perception and attraction (Saxton, Caryl, & Roberts, 2006). In particular, voice pitch seems to be associated with attractiveness, with men typically preferring higher pitch female voices (Re, O'Connor, Bennett,

& Feinberg, 2012; Jones, Feinberg, DeBruine, Little & Vukovic, 2008) and women preferring lower pitch male voices (Apicella, Feingberg, & Marlowe, 2007; Vukovic, Feinberg, Jones, DeBruine, Welling, Little & Smith, 2008). Re, O'Connor, Bennett, and Feinberg (2012) found that men thought higher pitch female voices sounded more feminine while women thought lower pitch male voices were more masculine. The authors concluded that high female voice pitch may sound attractive because it signals a sign of youth, whereas lower male voice pitch is a sign of higher testosterone production (Dabbs & Mallinger, 1999) and males with more testosterone have greater mating success (Peters, Simmons, & Rhodes, 2008). Therefore, men and women both associate attractiveness with certain voice pitches.

In addition to voice pitch, the content of the vocal information can influence feelings of attraction toward another (Jones, Feinberg, DeBruine, Little & Vukovic, 2008; Nagae & Moscovitch, 2002). When individuals speak to someone they find attractive, they tend to use certain phrases (i.e., "pick-up lines") (Senko & Fyffe, 2010) and flirtatious words (i.e., sexy, charming, cute) to convey that they find the other person attractive (Ranganath, Jurafsky, & McFarland, 2013). For instance, Jones, Feinberg, DeBruine, Little and Vukovic, (2008) found that their male participants generally found higher pitched women's voices sounded more attractive than lower pitched voices. However, when the content of the female voice samples were manipulated to express interest or not by using the phrase ("I really like you" or "I don't really like you"), men rated the female voices as sounding more attractive when they were using the phrase to express interest than when they were using the disinterested phrase. The results demonstrated that perception of voice attractiveness is not only determined by voice pitch, but men use vocal content, as well, to determine if a female's voice is attractive. In another similar study, women who were presented with male voices showed a preference for those who had

masculinized (lower pitched) voices (Vukovic, Feinberg, Jones, DeBruine, Welling, Little & Smith, 2008). However, unlike the male raters from the previous study, the vocal content of what was said by the men that either expressed interest or not (i.e., “I really like you” or “I don’t really like you”) seemed to have no impact on women’s attractiveness rating of the male vocal stimuli. These studies suggest that men use vocal content in determining if a woman has an attractive voice whereas, women do not use vocal content in determining whether a man has an attractive voice.

Examining the effectiveness of the use of “pick-up lines” to attract a mate further illustrates how vocal content is important in the evaluation of attractiveness. For instance, Senko and Fyffe (2010) examined women’s impressions of men using pick-up lines for short term and long term relationships. For long-term relationships, women preferred when men used a direct pick-up line (e.g.., “I saw you across the room and knew I had to meet you. What’s your name?”); instead, of a rude or ignorant pick-up lines (e.g., “Can I get a picture of you so I can show Santa what I want for Christmas?”). Thus, women preferred when men used vocal content that was direct, but not rude because they wanted to assess his potential interest as a long-term mate. On the other hand, women were less interested in men who use rude or ignorant pick-up lines because they thought these men were just seeking short-term relations.

Women are attracted to men who are willing to commit to a relationship and that will provide resources for her and her offspring (Buss, 1991). Hence, if a man attempts to use pick-up lines that express his wealth and generosity, he may be viewed as more attractive. For instance, Bale, Morrison and Caryl (2006) found that women were more willing to go on a date with men who started a conversation with comments regarding their helpfulness, generosity, athleticism, and wealth than with men who started the conversation with jokes, compliments, and sexual

references. Thus the content of what a man says to a woman during initial courting can provide important clues as to his intent to commit and can and advertisement of his resources that he could offer.

Men, on the other hand, prefer women who use pick-up lines to indicate that they are sexually interested in them. Wade, Butrie, and Hoffman (2009) examined men's preferences for different pick-up lines that women could use. Participants were given a list of behaviors and statements and had to rate how effective they thought each one was as an expression of interest in him. They found that the most effective way for a woman to attract a man when first approaching him was to directly ask a man on a date, hint at a date, give a man her phone number, or try to find out what things they share in common. Therefore, it appears that men prefer when women show direct signs of sexual interest and attraction to them because men are opportunistic maters and direct signs would get rid of the guesswork for the man (Buss & Barnes, 1986).

Emotion and Attraction

Feelings of attraction can be viewed as a type of positive emotion because both feelings of attraction and other positive emotions activate similar neural pathways, especially the dopamine reward system. For instance, Matsunaga, et al., (2008) examined the neural pathways activated when individuals are viewing an audiovisual clip of an individual who they found attractive. The results showed that the dopamine reward system was activated and the positive emotions triggered from seeing a person who they found attractive had increased brain activity in brain areas associated with the dopamine reward system: the medial prefrontal cortex, thalamus, hypothalamus, subcallosal gyrus, posterior cingulate cortex, superior temporal gyrus and cerebellum. Fisher, Aron, and Brown (2005) examined the neural mechanisms associated with

romantic love by using fMRI to study the brains of individuals who were newly "in love." They found that when individuals are in love, the right ventral tegmental area and the right caudate nucleus associated with the dopaminergic reward pathway is activated. Even in longer-term relationships, the reward pathway appears to become active when viewing a romantic partner. Acevedo, Aron, Fisher, and Brown (2012) examined the neural correlates of long-term intense romantic love by the use of fMRI. Participants viewed images of their romantic partner, a highly familiar acquaintance, a close, long-term friend, and a person who is not familiar. They found that the dopamine-rich reward system increased in activation when individuals only viewed the image of their partner. Since similar neural pathways are activated when individuals are feeling attraction and positive emotions, feelings of attraction can be considered a type of positive emotion.

When emotional expressions are either seen or heard, they enhance the brain areas of the dopamine reward system. For instance, when individuals feel positive emotions, their dopamine reward system becomes activated (Menon & Levitin, 2005; Xu, Aron, Brown, Cao, Feng, & Weng, 2011). Therefore, since the dopamine reward system becomes activated when individuals feel positive emotions and when feeling attraction (Fisher, Aron, & Brown, 2005; Bartels & Zeki, 2004), attraction may be considered a type of positive emotion (Fisher, Aron, Mashek, Haifang, & Brown, 2002). Besterlmeyer, Latinus, Bruckert, Rouger, Crabbe, and Belin (2012) had participants listen to a series of vocal sounds of both sexes saying the word "ah" to examine if certain regions of the brain perceived certain voices as more attractive than others. They found that the inferior prefrontal regions, which are a part of the dopamine reward system, correlates with how individuals perceived vocal attractiveness despite no linguistic content.

Current Study

The aim of this study was to further examine how the human brain processes vocal information by testing how the perception of voice attractiveness may be related to brain lateralization. Additionally, this study aimed to determine whether the content of vocal stimuli was important in the lateral processing of vocal information in terms of both perception and memory recall. First, I hypothesized that individuals who are presented with voice samples of speakers reciting a number count would show a left-ear advantage such that they would rate a voice presented in only the left ear as sounding more attractive than when the same voice is presented only in the right ear. Previous research has shown that the right hemisphere is associated with the processing of emotions (Heller, Nitschke, & Miller, 1998; Gainotti, 2012; Erhan, Borod, Tenke, & Bruder, 1998) and individuals demonstrate a left ear advantage when processing words that are of emotional content (Stirling, Cavill, & Wilkinson, 2000; Saxby & Bryden, 1984; Schwarts, Davidson, & Maer, 1975). Because previous work has demonstrated that feeling attraction activate similar brain areas as do other positive emotions, (Matsunaga, et. al., 2008), I predicted that a similar left-ear advantage would apply when making ratings of attractiveness and listeners would rate voices as sounding more attractive when presented in their left ear than right ear.

Secondly, I hypothesized that individuals would rate the sound of a speaker's voice as sounding more attractive when the speaker recited phrases related to interest/attraction (e.g., "I like you.") than neutral phrases (e.g., "I like studying with you.") and would prefer those phrases more when presented in their left ear. Previous research has shown that vocal content can affect the perception of voice attractiveness (Jones, Feinberg, DeBruine, Little & Vukovic, 2008; Vukovic, Feinberg, Jones, DeBruine, Welling, Little & Smith, 2008). Lastly, I hypothesized that individuals would recall phrases they heard that reflected romantic interest significantly more

than neutral phrases when listening to voice samples, especially when those phrases were presented in their left ear than their right ear.

The findings derived from this study could further contribute to our understanding of how the human brain processes vocal information by exploring whether individuals rate voices, especially those with a romantic content, presented in only the left ear more as sounding more attractive than when presented in only the right ear.

Method

Speakers

The first set of 30 participants (15 women and 15 men) was obtained to provide voice samples used as stimuli in the study. These speakers were undergraduate students from the Psychology Department Participant Pool at Albright College who were solicited through word of mouth. The mean age of participants was 19.90 (*SD* = 1.18, range 18-22). The majority of the participants reported being White/Caucasian (87%) followed by Hispanic/Latino (7%), Black/African American (3%), and Asian/Pacific Islander (3%). The majority of these speakers indicated that English is their native language (100%). Most of the participants (90%) indicated that they did not fluently speak any other languages. In order to screen the speakers, we made sure that none of the participants had throat surgery or auditory surgery, suffered from a hearing impairment or speech impediment, or had a cold or any oral modifications that could affect their normal speech. The majority of the participants (93%) also indicated they did not smoke.

Raters

Another set of 96 participants were obtained to rate the vocal samples. Four of these participants were eliminated from analyses, where one individual reported a non-binary gender and 3 males and 1 female reported not being attracted to the opposite sex. The final number of

participants included 92 individuals (50 women and 42 men). Raters were also undergraduate students from the same college who were primarily solicited using the Sona Experiment Management System and through class announcements. The mean age of these raters was 19.55 (*SD* = 1.51, range 18-26). Within this sample, the majority of the participants reported being White/Caucasian (47.8%) followed by Black/African American (30.4%), Hispanic/Latino (15.2%), Asian/Pacific Islander (2.2%), and mixed (4.4%). 2.2% of participants indicated they had auditory surgery whereas none of the participants suffered from a hearing impairment which could have affected their ability to properly hear and evaluate the vocal stimuli presented. There were 39.1% of participants who indicated they were in an exclusive, committed, romantic relationship, whereas 60.9% were not. 42 men and 50 women indicated they were predominantly attracted to the opposite sex and because sexual orientation could influence ratings of attractiveness, all non-heterosexual raters were eliminated from analyses (*n* = 3). Additionally, most participants indicated they are right hand dominant (89.1%), with 10.9% being left-hand dominant, and their self-report of handedness was confirmed by their score on the Edinburg Handedness Inventory (Caplan & Mendoza, 2011).

Participation in the study was completely voluntary, and participants could receive course credit and/or extra credit in their psychology classes for their participation in this study at the discretion of their professors. All procedures were approved by the local Institutional Review Board.

Materials and Procedure

First, the participants providing voice samples had given informed consent and had completed a brief demographic survey with questions concerning their gender, age, ethnicity, whether English was their native language, if they speak any other languages fluently, if they had

any throat surgery or auditory surgery, if they suffered from a hearing impairment or speech impairment, if they had a cold that was affecting the way that they spoke, if they had any oral modifications (e.g., tongue ring), and if they smoked, as reported above. The voice samples were recorded in a quiet private setting. These speakers were asked to recite a number count from 1-5 using a normal speaking voice at a pace of approximately one numeral per second. Then, they were asked to recite five phrases indicating attraction (e.g., "I like you," "I am attracted to you," "You have nice eyes," "I like flirting with you," "I think you're hot.") and 5 neutral phrases (e.g., "I have the same idea as you," "I trust your judgment," "You are helpful," "I like studying with you," "I am in your class."). All of the voice recordings were recorded on an iPhone with the Voice Recorder – HD Audio Recording and Playback application.

These voice ratings were presented to participants as a laboratory task in order to examine the perception of vocal stimuli when heard only in the right ear or only in the left ear to examine lateralization effects. First, raters gave their informed consent. Then, raters were asked demographic questions concerning their gender, age, ethnicity, sexual orientation, dominant handedness, and if they were in an exclusive, committed and romantic relationship. Because this was a voice rating task, participants were also screened to see if they ever had any auditory surgery or a hearing impairment. Participants were asked to complete the Edinburgh Handedness Inventory (Caplan & Mendoza, 2011) to determine hand dominance.

Raters were first presented with voice samples that included the five phrases related to attraction/romantic interest and the five neutral phrases. These 10 voices were presented in one ear at a time, and the order of whether presentation began in the right or left ear was counterbalanced for each participant. The voice recordings were only of opposite-sex recordings (n = 15) and were presented using the AC-840 Cyber Acoustics Mono USB Headset. Each rater

listened to a total of five different speakers, with each speaker reciting one romantic phrase, and one neutral phrase. There were 6 counterbalanced versions created to assure that all 30 speakers were represented across participants in the playback task. After each voice sample was manually played by the investigator, participants were asked to make ratings on *SurveyMonkey* presentation software using a 10-point scale (1 = very unattractive, 5 = average, 10 = very attractive) to assess voice attractiveness of the speakers.

Next, participants listened to all 15 opposite-sex voice samples that were a number recitation. Using the same AC-840 Cyber Acoustics Mono USB Headset, these voice samples were also first presented in one ear at a time, and the order of whether presentation began in the right or left ear was counterbalanced for each participant. The order in which the voice samples were presented was also counterbalanced, using three counterbalanced versions. After each voice stimuli was manually played by the investigator, participants were asked to make ratings on a 10-point scale (1 = very unattractive, 5 = average, 10 = very attractive) using *SurveyMonkey* software to rate voice attractiveness of the speakers.

Finally, participants were presented with a list of 50 written phrases on *SurveyMonkey* presentation software, 25 of which were phrases related to attraction/romantic interest and 25 neutral phrases. Embedded within this list were 10 phrases (5 interest, 5 neutral) that were the same phrases previously heard by the participants in the first task, while the other phrases were not previously presented. The list of phrases was counterbalanced for each participant. The participants were asked to recall whether they had heard each phrase or not when played in the previous task (i.e., yes or no). The number of correctly recalled phrases and false positives were calculated. Additionally, the participants were asked assess how confident they were about their

decision as to whether they heard each phrases or not using a 5-point scale (1 = not at all confident, 3 = somewhat confident, 5 = very confident).

At the conclusion of the study, participants were debriefed about the purpose of the study and were asked to provide information in order to gain participation credit for their classes.

Results

Voice Attractiveness Ratings of Number Counts

A 2(Gender) X 2(Right vs. Left Ear) X 2 (First ear heard) mixed model ANOVA was used to see whether mean attractiveness ratings for the number count was affected by the gender of the listener, which ear the participants heard the stimuli, and whether the voice was heard in the right versus left ear first. There was a main effect for gender of listener, $F(1, 88) = 5.06$, $p = .027$, $\eta^2 = .054$. Men rated the women's voices ($M = 5.35$, $SE = 0.17$) as sounding more attractive than did women rate men's voices ($M = 4.85$, $SE = 0.15$). Although there was no main effect for which ear the voice was heard, $F(1, 88) = 0.09$, $p = .762$. There was a main effect for which ear the participants first heard the number count in, $F(1, 88) = 5.32$, $p = .023$, $\eta^2 = .057$ (see Figure 1). Participants who first heard the number count in their left ear first ($M = 5.11$, $SE = 0.11$) rated the voices as sounding more attractive than the participants who heard the number count first in their right ear first ($M = 5.09$, $SE = 0.12$). There were no significant interactions between these variables (see Table 1). We also considered the handedness of the participants and eliminated all left-handed participants ($n = 11$) and dominant handedness had no impact on these findings.

Voice Attractiveness Ratings of Phrases

A 2(Gender) X 2(Right vs. Left Ear) X 2(First ear heard) X 2(Attractive vs. Neutral content) mixed model ANOVA was used to see if mean attractiveness ratings for the phrases were influenced by listener gender, the ear the participants heard the phrases, which ear they

heard the stimuli first, and whether the phrases were of attraction or neutral content. There was a main effect for gender of listener, $F(1, 87) = 5.02$, $p = .028$, $\eta^2 = .054$, where men ($M = 5.59$, $SE = 0.18$) rated the phrases said by women as sounding more attractive than women who rated the phrases said by men ($M = 5.03$, $SE = 0.17$). There was no main effect for whether the participant heard the voice sample in the right versus left ear, $F(1, 87) = 0.30$, $p = .584$. However, there was a main effect for ear listeners first heard the phrases, $F(1, 87) = 5.10$, $p = .026$, $\eta^2 = .055$; those who heard the phrases in their right ear first ($M = 5.60$, $SE = 0.18$) rated the phrases as sounding more attractive than the participants who heard the phrases in their left ear first ($M = 5.03$, $SE = 0.17$). There was a main effect for how attractive a voice sounded when reciting an attraction content phrase versus neutral phrases, $F(1, 87) = 8.60$, $p = .004$, $\eta^2 = .090$. Participants rated the voices of those who recited phrases related to attraction ($M = 5.43$, $SE = 0.14$) as sounding more attractive than when the speakers recited the neutral phrases ($M = 5.19$, $SE = 0.13$). Additionally, there was a significant interaction between gender and attractive versus neutral phrases, $F(1, 87) = 10.54$, $p = .002$, $\eta^2 = .108$ (see Figure 2). A post hoc analysis confirmed a significant effect between gender and attractive versus neutral phrases, $F(1, 90) = 12.59$, $p = .001$, $\eta^2 = .123$. Men rated voices of those reciting phrases related to attraction ($M = 5.85$, $SE = 1.19$) as sounding significantly more attractive than the neutral phrases ($M = 5.34$, $SE = 1.11$), $t(41) = 4.33$, $p < .001$. However, for women, there was no significant difference between voice attractiveness ratings between men who recited phrases related to attraction ($M = 4.98$, $SD = 1.47$) and neutral phrases ($M = 5.05$, $SD = 1.35$), $t(49) = 0.59$, $p = .561$.

We considered handedness of the participants and eliminated all left handed participants ($n = 11$). When left handed individuals were eliminated, there was no longer a main effect for which ear the participants heard the phrases in first, $F(1, 77) = 2.83$, $p = .097$, $\eta^2 = .035$.

Correct Recall of Phrases

We calculated the proportion of correctly recalled phrases that were heard and not heard. A repeated measures *t*-test showed that participants did not have significantly higher mean accuracy scores for the phrases they heard ($M = 0.78$, $SD = 0.17$) versus the phrases they did not hear ($M = 0.75$, $SD = 0.19$), $t(91) = 1.25$, $p = .213$.

A 2(Gender) X 2(First ear heard) X 2(Heard vs. Not heard) X 2(Attractive vs. Neutral content) mixed model ANOVA was used to examine whether correctly recalled proportion scores for phrases was affected by the listener's gender, the ear first heard, whether the participants heard the phrases or not, and the content of the phrases. There were no main effects for gender, $F(1, 88) = 0.13$, $p = .718$, for the ear the phrases were heard first, $F(1, 88) = 2.75$, $p = .101$, for whether the voice was heard versus not heard, $F(1, 88) = 1.34$, $p = .252$, and for attractive phrases versus neutral phrases, $F(1, 88) = 0.21$, $p = .648$ (see Table 3). However, there was a significant two-way interaction between listener gender and whether a phrase was heard or not, $F(1, 88) = 7.03$, $p = .010$, $\eta^2 = .074$ (see Figure 3). A post hoc two-way analyses confirmed this significant effect between gender and heard versus not heard phrases, $F(1, 90) = 6.58$, $p = .012$, $\eta^2 = .048$. Simple main effects showed that for male listeners, there was no significant difference between correctly recalling phrases that were presented ($M = 0.75$, $SD = 0.19$) from phrases they did not hear ($M = 0.79$, $SD = 0.15$), $t(41) = -1.08$, $p = .288$. However, women correctly recalled the phrases that were presented ($M = 0.81$, $SD = 0.16$) better than the phrases they did not hear ($M = 0.71$, $SD = 0.21$), $t(49) = 2.58$, $p = .013$.

Additionally, there was a significant interaction between listener gender and phrase content, $F(1, 88) = 24.36$, $p < .001$, $\eta^2 = .217$ (see Figure 4). A post hoc two-way analysis confirmed the a significant effect between listener gender and phrase content, $F(1, 90) = 5.21$, p

= .025, η^2 = .055. Simple main effects showed for men, there was no significant difference between how accurately they recalled whether they heard the phrases relating to attraction (M = 0.76, SD = 0.14) versus neutral phrases (M = 0.80, SD = 0.13), $t(41) = 1.95$, $p = .058$. However, women recalled the neutral phrases (M = 0.77, SD = 0.18) better than the phrases relating to attraction (M = 0.69, SD = 0.18), $t(49) = 4.95$, $p < .001$.

There was also a significant interaction between whether the phrases were presented or not and the phrase content, $F(1, 88) = 57.21$, $p < .001$, $\eta^2 = .394$ (see Figure 5). A post hoc analysis confirmed this interaction, $F(1, 91) = 67.77$, $p < .001$, $\eta^2 = .427$. For phrases related to attraction, participants were better at recalling the phrases they actually heard (M = 0.85, SD = 0.19) than the phrases they did not hear (M = 0.69, SD = 0.21), $t(91) = 4.94$, $p < .001$. On the other hand, for neutral phrases, participants recalled the phrases they did not hear (M = 0.82, SD = 0.19) better than the phrases they did hear (M = 0.74, SD = 0.23), $t(91) = 2.43$, $p = .017$.

There was a significant three way interaction between gender, first ear participants heard the phrases in and attractive versus neutral phrases, $F(1, 88) = 4.19$, $p = .044$, $\eta^2 = .045$. To deconstruct this three-way interaction, we split the file by sex of rater, and performed a two-way analysis. For men, there was no significant interaction between first ear they heard the phrases in and the content of the phrases, $F(1, 40) = 0.47$, $p = .498$, $\eta^2 = .012$. For women, women did not have a significant interaction between first ear they heard the phrases in and the content of the phrases, $F(1, 48) = 0.20$, $p = .655$, $\eta^2 = .004$. Males and females did not have a significant effect on whether they correctly identified the heard or not heard phrases and the attractive or neutral phrases. However, males correctly recalled the attractive and neutral phrases more when they heard the phrases in their left ear first than when they heard the phrases in their right ear first, $F(1, 40) = 0.47$, $p = .498$, $\eta^2 = .012$. Females also correctly recalled the attractive and neutral

phrases more when they heard the phrases in their left ear first than when they heard the phrases in their right ear first, $F(1, 48) = 0.20$, $p = .655$, $\eta^2 = .004$. A post hoc analysis examining simple main effects showed that males correctly recalled the phrases they heard in their left ear more than the phrases they heard in their right ear, $t(40) = 1.11$, $p = .275$. Additionally, females correctly recalled the phrases they heard in their left ear more than the phrases they heard in their right ear, $t(48) = 0.86$, $p = .397$.

We also considered the handedness of the participants and eliminated all left handed participants ($n = 11$). When left handed individuals were eliminated, there was an interaction found between which ear the participants heard the phrases in first and attractive versus neutral phrases, $F(1, 78) = 4.99$, $p = .028$, $\eta^2 = .060$. Additionally, there was a three-way interaction between gender, which ear the participants heard the phrases in first, and heard versus not heard phrases $F(1, 78) = 4.21$, $p = .044$, $\eta^2 = .051$.

Confidence Ratings of Recalled Phrases

We calculated the a mean for how confident participants indicated they were in their decision of whether or not they heard a particular phrase, and compared these ratings between phrases that were presented versus voices that were not. A repeated measures t-test showed that participants were significantly more confident in making their determination for whether they heard a voice or not for the phrases they heard ($M = 4.13$, $SD = 0.55$) than for the phrases they did not hear ($M = 3.89$, $SD = 0.61$), $t(91) = 4.76$, $p < .001$.

A 2(Gender) X 2(First Ear) X 2(Heard vs. Not Heard) X 2(Attractive vs. Neutral) mixed model ANOVA was used to see whether gender, which ear the participants heard the phrases first in, whether the participants heard the phrases or not and the right versus left ear on participants mean confidence ratings for recalling the phrases. There was a main effect for

listener gender, $F(1, 88) = 4.25$, $p = .042$, $\eta^2 = .046$. Men ($M = 4.14$, $SE = 0.08$) were more confident in their decisions of whether or not they heard a particular phrase than were women ($M = 3.91$, $SE = 0.07$). There was no main effect for which ear listeners first heard the phrases, $F(1, 88) = 0.24$, $p = .627$. There was a main effect for heard versus not heard phrases, $F(1, 88) = 22.78$, $p < .001$, $\eta^2 = .206$. Participants were more confident in their decisions of whether or not they heard a particular phrase for the presented phrases ($M = 4.14$, $SE = 0.06$) compared to the non-presented phrases ($M = 3.91$, $SE = 0.06$). There was no main effect for content of phrases, $F(1, 88) = 1.08$, $p = .302$. However, there was a significant two-way interaction between heard versus not heard phrases and content of the phrases, $F(1, 88) = 10.84$, $p < .001$, $\eta^2 = .110$ (see Figure 6). A post hoc two-way analysis confirmed the significant effect between heard versus not heard phrases and content of the phrases, $F(1, 91) = 10.40$, $p = .002$, $\eta^2 = .103$. Simple main effects showed that for phrases with content related to attraction, participants were more confident in their decision of whether or not they heard presented phrases ($M = 4.17$, $SD = 0.60$) than phrases not presented ($M = 3.81$, $SD = 0.60$), $t(91) = 6.56$, $p < .001$. For phrases with neutral related content, participants were more confident in their decision of phrases not presented ($M = 3.97$, $SD = 0.66$) than phrases they heard ($M = 3.81$, $SD = 0.60$), $t(91) = 4.50$, $p < .001$.

We considered handedness of the participants and eliminated all left handed participants ($n = 11$). When left handed individuals were eliminated, there was a three-way interaction between gender, which ear the participants heard the phrases in first, and heard versus not heard phrases, $F(1, 78) = 3.99$, $p = .049$, $\eta^2 = .049$.

Discussion

Lateralization Effects on Voice Attractiveness and Recall

We found that participants rated a speaker's voice at a similar level of attractiveness whether they heard the phrases in their right or left ear. However, participants who heard the number count in their left ear first rated the number count as sounding more attractive than the participants who heard the number count in their right ear first. This finding suggests some further evidence for a left ear advantage which is in line with previous studies (Bryden & MacRae, 1988; Bryden, Ley, & Sugarman, 1982; Erhan, Borod, Tenke, & Bruder, 1998) and thus, a right hemisphere advantage for processing emotions (Heller, Nitschke, & Miller, 1998; Gainotti, 2012; Erhan, Borod, Tenke, & Bruder, 1998). This left ear advantage in evaluating voice attractiveness may indicate the right hemisphere's role in processing feelings of attraction. (Demaree, Everhary, Youngstrom, & Harrison, 2005), just as a left-ear advantage has been shown in processing other positive emotions (Sim & Martinez, 2005; Bryden, Free, Gagne, & Groff, 1991; Bryden & MacRae, 1988; Stirling, Cavill, & Wilkinson, 2000).

When participants heard the phrases in their right ear first, they rated the phrases as sounding more attractive than the participants who heard the phrases in their left ear first. However, this effect was not retained once we accounted for handedness and eliminated all left handed participants. Unline the number recitation stimuli, phrases that contained content was not evaluated differently based upon the ear in which the stimuli was heard and this finding contradicts other research that has shown that the left ear has an advantage for processing emotional stimuli (Bryden & MacRae, 1988; Bryden, Ley, & Sugarman, 1982; Erhan, Borod, Tenke, & Bruder, 1998).

However, when it came to recalling phrase content, both sexes correctly recalled whether or not they first heard a particular phrase if they first heard in their left ear better than when they heard the phrases in their right ear. Thus, it appears that the content of the phrase did not matter

in determining brain lateralization. Previous research that has also has shown that individuals tend recall emotional phrases heard in their left ear more than in their right ear (Sim & Martinez, 2005), but we were unable to replicate that finding that content of phrase had an impact.

Sex Differences in Voice Attractiveness Ratings

Overall men rated women's voices as sounding more attractive than had women rated men's voices. Because men place a premium on attractiveness when evaluating the mate value of women (Buss & Barnes, 1986), men may more easily evaluate a woman's voice to sound attractive. Additionally, as suspected, voices reciting phrases that had content related to attraction were rated as sounding more attractive than voices reciting neutral content phrases. Previous research demonstrated that vocal content can affect the perception of voice attractiveness (Jones, Feinberg, DeBruine, Little & Vukovic, 2008; Vukovic, Feinberg, Jones, DeBruine, Welling, Little & Smith, 2008).

Furthermore, men rated the voices of women reciting phrases that were related to attraction as sounding more attractive than when the same women recited neutral phrases. In contrast, women did not show a difference when rating the voice attractiveness of men's voices when they recited phrases related to attraction versus neutral phrases. Since men are opportunistic maters, men prefer when women show direct signs of sexual interest and attraction to them (Buss & Barnes, 1986) so it makes sense that men preferred women's voices when they recited phrases related to attraction. These findings also support previous studies. Jones Feinberg, DeBruine, Little and Vukovic (2008) found that men rated the female voices as sounding more attractive when female voice samples were manipulated to express interest than when the female voice samples sounded disinterested. Additionally, Vukovic, Feinberg, Jones DeBruine, Welling, Little and Smith (2008) found that women also did not show a difference in

rating voice attractiveness when listening to men who recited either t interested or disinterested vocal content. Thus, vocal content does not appear to influence women's perception of the attractiveness of a man's voice whereas it does for men's perception or women's voices.

Accuracy in Recalling Phrases

Men showed no difference in their accurate recollection of whether a phrase was heard or not between the presented and unpresented voice samples. However, women correctly recalled the phrases they were presented than the phrases they were not presented. Perhaps women were better at identifying the phrases said by male speakers because women tend to show skepticism in assessing male intent in relationships (Brown & Olkhov, 2015). Women tend to scrutinize commitment in men when it comes to a romantic relationship. If a women does not feel a man will commit to her, then she will not engage in a relationship with him (Brown & Olkhov, 2015). Therefore, perhaps women are more likely to be skeptical and over analyze a conversation she is having with a man to be sure that he wants to be committed to her. Additionally, for phrases related to attraction, participants were better able to recall whether or not they heard a phrase for the phrases that were presented than the phrases that were not presented. On the other hand, for the neutral phrases, participants better recalled they phrases they did not hear better than the phrases that were presented, Our findings supported the hypothesis that individuals would recall phrases they heard that reflected romantic interest more than neutral phrases. As such, previous studies have shown that emotional, phrases tend to be remembered more than neutral words (Kensignger & Corkin, 2003).

Men were more confident in their decisions of whether or not they heard a particular phrase than were women. Previous studies have shown that men tend to show more confidence than women (Roberts, 1991). Participants had a higher mean confidence rating for the phrases

they heard than the phrases they did not hear. Additionally, for the attractive phrases, participants had higher confidence ratings for the heard phrases than the not heard phrases. However, for the neutral phrases, participants did not show a difference in their confidence ratings for the presented phrases and the not heard phrases.

Limitations and Confounds

There were several limitations and confounds that could have affected these results. Participants could have recognized the individual who provided their voice sample which may have biased their rating. Additionally, there appeared to be some variation in how quickly the voice samples were spoken which may have also influenced ratings. Additionally, when participants were asked to recall whether they heard the phrases or not, they were presented with 10 phrases that they actually heard versus 40 phrases that they did not hear, thus biasing the accuracy of recall for the unheard voices. Because voices were all presented within segments that were separated by relatively brief periods of time, participants may have realized they were listening to the same speaker they heard previously and this may have influenced their second rating of that voice. Future studies could consider allowing for more time between the presentations of voices in the right versus left ears.

Conclusion

Although participants did not rate the same voice as sounding more attractive when heard in one ear versus the other, they did tend to rate voices heard in their left ear first as sounding more attractive for the number count stimuli. This finding suggests some evidence of a left ear advantage for rating voice attractiveness. When listening to vocal stimuli that consisted of phrases with content related to attraction or neutral, participants did not show a lateralization

effect when accounting for listener handedness. However, we found sex differences related to ratings of attractiveness based on phrase content; men rated the voices of women reciting phrases relating to attraction as sounding more attractive than neutral phrases, whereas women rated the voices of men similarly regardless of content. Further, the results showed that overall, men rated the voices of women as sounding more attractive than had women rated the voices of men. We found sex differences related to whether participants recalled the heard or not heard phrases; women correctly recalled the phrases that were presented better than the phrases they did not hear, whereas, men did not show a difference between correctly recalled heard versus not heard phrases. Additionally, we found content of phrase differences related to whether phrases were presented or not. For phrases related to attraction, participants recalled the phrases that were presented better than the phrases they did not hear. Whereas, for neutral phrases, participants recalled the phrases that were not presented better than the phrases they did hear. Our results showed that participants were more confident in making their determination for whether they heard a voice or not for the phrases they heard than the phrases they did not hear. For phrases related to attraction, participants were more confident in their decision of whether or not they heard presented phrases than phrases not presented. For neutral phrases, participants were more confident in their decision of phrases not presented than phrases they heard.

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Table 1.
2(Gender) X 2(Right vs. Left Ear) X 2(First Ear Heard) mixed model ANOVA was used to examine the effects of mean attractiveness ratings for the number count.

Factors	***df***	***F***	***p***	η^2
Gender	(1, 88)	5.06	.027*	.054
Right vs. Left Ear	(1, 88)	0.09	.762	< .001
First Ear Heard	(1, 88)	5.32	.023*	.057
Gender X Right vs. Left Ear	(1, 88)	1.23	.271	.014
Gender X First Ear Heard	(1, 88)	2.35	.129	.026
Right vs. Left Ear X First Ear Heard	(1, 88)	0.10	.752	.001
Gender X Right vs. Left Ear X First Ear Heard	(1, 88)	< 0.01	.972	< .001

Note. *p <.05; **p < .01; ***p< .001

Table 2.

2(Gender) X 2(First ear Heard) X 2(Right vs. Left Ear) X 2(Attractive vs. Neutral content) mixed model ANOVA was used to examine the effects of mean attractiveness ratings of the phrases.

Factors	*df*	*F*	*p*	η^2
Gender	(1, 87)	5.02	.028*	.054
Right vs. Left Ear	(1, 87)	0.30	.584	.003
First Ear Heard	(1, 87)	5.10	.026*	.055
Attractive vs. Neutral	(1, 87)	8.60	.004**	.090
Gender X Right vs. Left Ear	(1, 87)	0.27	.606	.003
Gender X First Ear Heard	(1, 87)	0.45	.504	.005
Gender X Attractive vs. Neutral content	(1, 87)	10.54	.002**	.108
Right vs. Left Ear X First Ear Heard	(1, 87)	1.39	.242	.016
Right vs. Left Ear X Attractive vs. Neutral content	(1, 87)	0.34	.559	.004
First Ear Heard X Attractive vs. Neutral content	(1, 87)	0.02	.898	< .001
Gender X Right vs. Left Ear X First Ear Heard	(1, 87)	0.72	.400	.008
Gender X Right vs. Left Ear X Attractive vs. Neutral content	(1, 87)	0.04	.836	< .001
Gender X First Ear Heard X Attractive vs. Neutral content	(1, 87)	0.55	.459	.006
Right vs. Left Ear X First Ear Heard X Attractive vs. Neutral content	(1, 87)	0.36	.547	.004
Gender X Right vs. Left Ear X First Ear Heard X Attractive vs. Neutral content	(1, 87)	0.71	.400	.008

Note. *p <.05; **p < .01; ***p< .001

Table 3.

2(Gender) X 2(First Ear Heard) X 2(Heard vs. Not Heard) X 2(Attractive vs. Neutral content) mixed model ANOVA was used to examine the effects of mean proportion of accuracy scores.

Factors	*df*	*F*	*p*	η^2
Gender	(1, 88)	0.13	.718	.001
First Ear Heard	(1, 88)	2.75	.101	.030
Heard vs. Not Heard	(1, 88)	1.34	.252	.015
Attractive vs. Neutral content	(1, 88)	0.21	.648	.002
Gender X First Ear Heard	(1, 88)	0.66	.417	.007
Gender X Heard vs. Not Heard	(1, 88)	7.03	.010*	.074
Gender X Attractive vs. Neutral content	(1, 88)	24.36	< .001***	.217
First Ear Heard X Heard vs. Not Heard	(1, 88)	< 0.01	.990	< .001
First Ear Heard X Attractive vs. Neutral content	(1, 88)	1.68	.198	.019
Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	57.21	< .001***	.394
Gender X First Ear Heard X Heard vs. Not Heard	(1, 88)	1.40	.241	.016
Gender X First Ear Heard X Attractive vs. Neutral content	(1, 88)	4.19	.044*	.045
Gender X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	1.49	.226	.017
First Ear Heard X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	2.79	.098	.031
Gender X First Ear Heard X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	1.71	.194	.019

Note. *p <.05; **p < .01; ***p< .001

Table 4.
2(Gender) X 2(First ear Heard) X 2(Heard vs. Not Heard) X 2(Attractive vs. Neutral content) mixed model ANOVA was used to examine the effects of mean confidence scores.

Factors	***df***	***F***	***p***	η^2
Gender	(1, 88)	4.25	.042*	.046
First Ear Heard	(1, 88)	0.24	.627	.003
Heard vs. Not Heard	(1, 88)	22.78	<.001***	.206
Attractive vs. Neutral content	(1, 88)	1.08	.302	.012
Gender X First Ear Heard	(1, 88)	1.14	0.289	.013
Gender X Heard vs. Not Heard	(1, 88)	1.99	.162	.022
Gender X Attractive vs. Neutral content	(1, 88)	1.22	.272	.014
First Ear Heard X Heard vs. Not Heard	(1, 88)	0.31	.580	.022
First Ear Heard X Attractive vs. Neutral content	(1, 88)	< 0.01	.987	< .001
Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	10.84	.001**	0.11
Gender X First Ear Heard X Heard vs. Not Heard	(1, 88)	3.14	.080	.034
Gender X First Ear Heard X Attractive vs. Neutral content	(1, 88)	0.01	.907	< .001
Gender X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	1.36	.247	.015
First Ear Heard X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	0.52	.475	.006
Gender X First Ear Heard X Heard vs. Not Heard X Attractive vs. Neutral content	(1, 88)	2.78	.099	.031

Note. *p <.05; **p < .01; ***p< .001

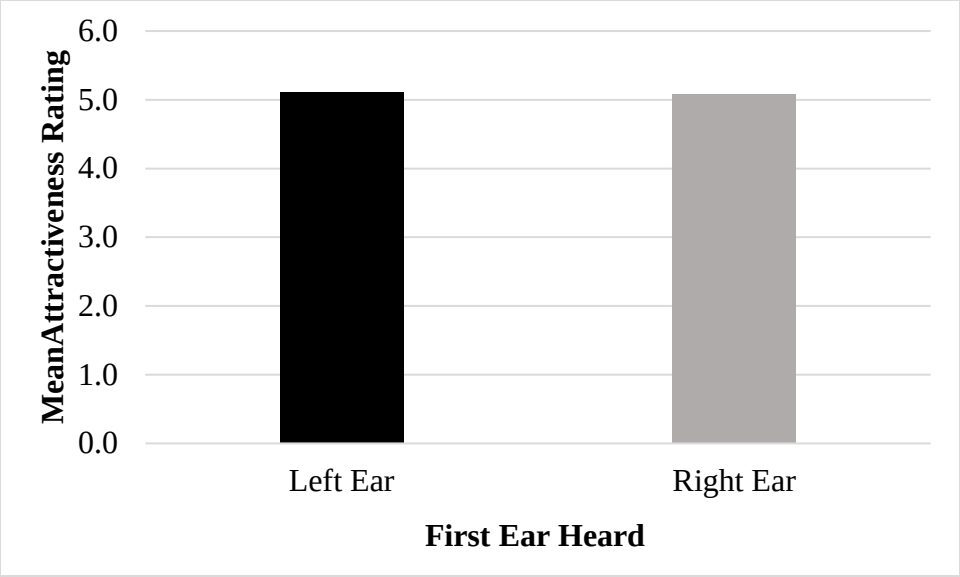

Figure 1. The main effect of whether the participants heard the number count in their right or left ear first for mean attractiveness ratings for number count.

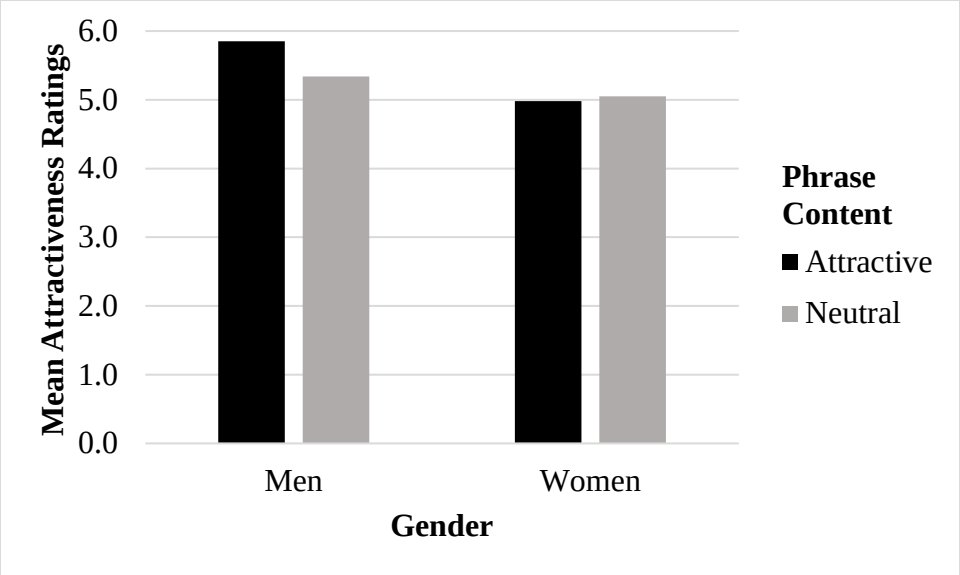

Figure 2. The interaction between gender of participant and content of phrases for phrases for mean attractiveness ratings for phrases.

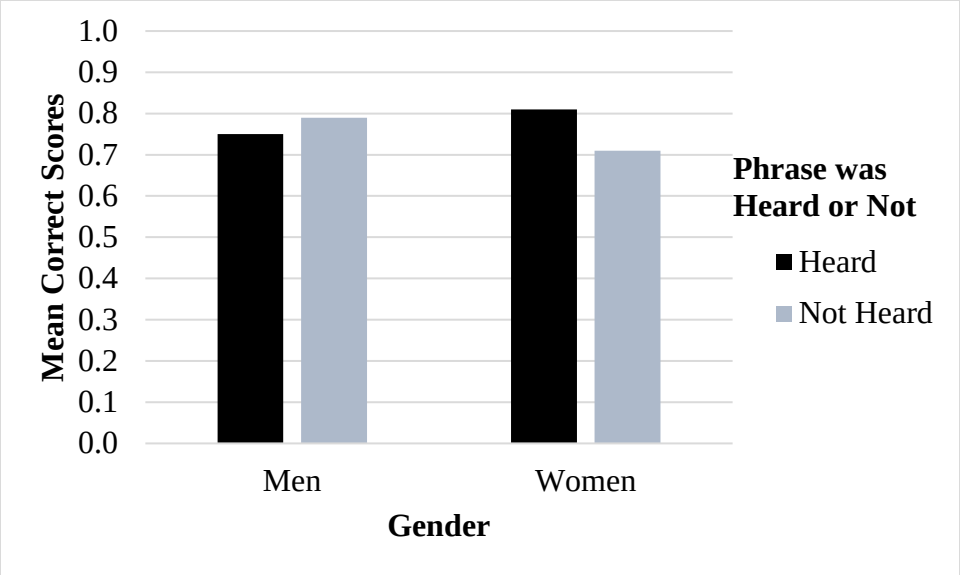

Figure 3. The interaction between gender of participant and whether the participants heard the phrase or not on mean correctly recalled proportion scores.

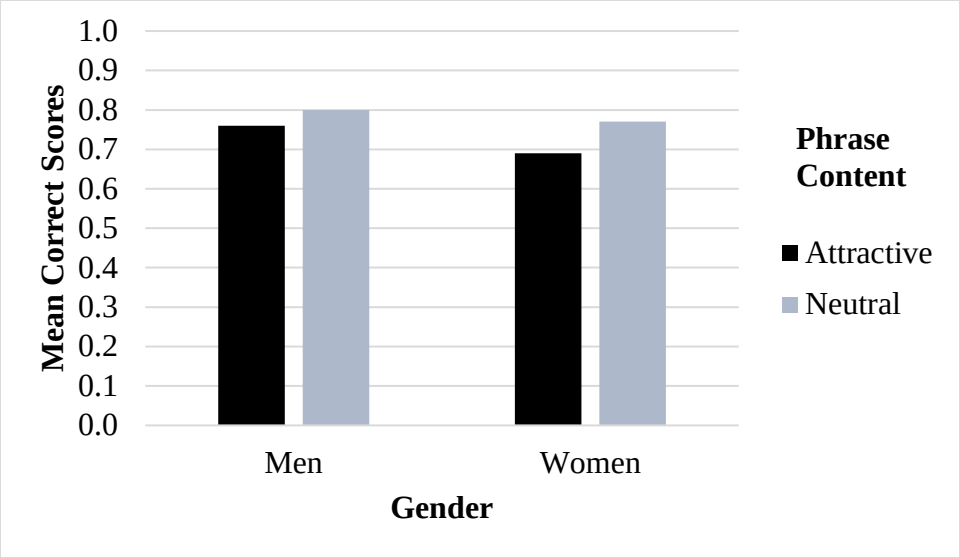

Figure 4. The interaction between gender of participant and attractive versus neutral phrases on mean correctly recalled proportion scores.

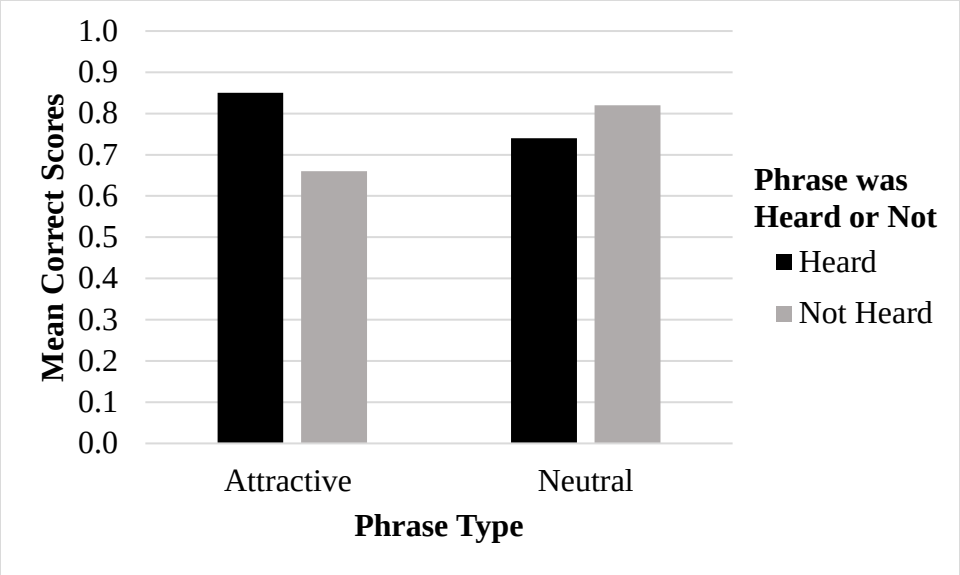

Figure 5. The interaction between attractive versus neutral phrases and whether the participants heard the phrases or not on mean correctly recalled proportion scores.

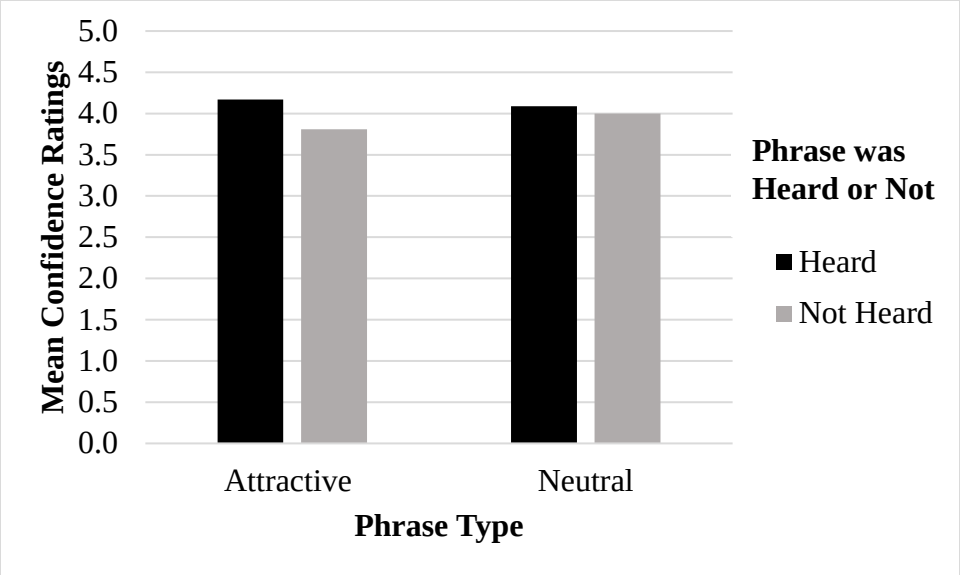

Figure 6. The interaction between content of phrases and whether the participants heard the phrases or not on mean confidence ratings of the recalled phrases.