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RESEARCH ARTICLE

A BEHAVIORAL APPROACH TO THE EFFECTS OF THE GENDER OF VOICE ON THE DICHOTIC LISTENING TEST PERFORMANCE

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ABSTRACT

Purpose: In the dichotic listening test, not only the asymmetry of the auditory system is evaluated but also the associated cognitive processes. The aim of this study was to examine the effect of male and female voices on dichotic listening.
Methods: Participants consisted of 10 men and 14 women, aged 18–45 (28.54±6.23) without neurological or auditory disorders. The dichotic listening test was applied to four different sessions. These sessions: female voices in both ears, male voices in both ears, male and female voices in both ears (mono session), male voices in the right ear, female voices in the left ear, and female voices in the right ear, and male voices in the left ear (stereo).
Results: It was determined that brain lateralization was significantly reduced in the female session compared with the stereo session; in other words, right ear dominance decreased (p=0.026, d=-0.293). It was determined that there was a significant difference between the number of errors in male and stereo sessions.
Conclusion: Participants preferred the syllables voiced with male voice more in mono and stereo sessions. It is observed that female participants mostly prefer syllables voiced with a male voice, and male participants prefer syllables voiced with a female voice.

Keywords: dichotic listening test, gender of voice effect, ear dominance

INTRODUCTION

The sound perception is a process that requires physical, auditory, and cortical co-adaptation. During this perceptional process, bottom-up information processing requires combining different modalities of information from the environment and reflects the physical-sensory processing part of sound perception. Also, Top-down information processing is involved to the process of originating information flow from upper perceptual systems. Because of human physiology, left-hemisphere dominance is characterized as a right ear advantage during the auditory perception. For this reason, sounds coming from the right ear are expected to be perceived as dominant. The asymmetry of auditory perception can be evaluated by the dichotic listening test which is a

non-invasive, low-cost, and simple test (1). In the dichotic listening (DL) test, not only the asymmetry of the auditory system, but also the associated cognitive processes are evaluated. The most common dichotic listening test is a test in which speech processing can be evaluated in terms of hemispheric asymmetry by simultaneously listening to different (heteronymous) or the same (homonymous) syllables consisting of a consonant and a vowel, respectively (2). Consonant–vowel (CV) syllables with stop consonants (/b/, /d/, /g/, /p/, /k/, /t/) and /a/ are the most common DL stimulus (3). One of the well-known results of the classical dichotic listening test is that right-handed participants prefer syllables presented to their right ears over those presented to their left ears when they are not asked to direct their attention to either ear (4-7). Kimura explained this situation with anatomical advantages such as the processing of speech signals in the left hemisphere, the functional differences of crossed and uncrossed nerve fibers in the afferent pathway extending from the cochlea to the cerebral cortex, and the occlusion of uncrossed fibers from the left ear because of their struggle with the signals coming from the right ear while reaching the left hemisphere (8). This is also called as the right ear advantage by Kimura (8). The main alternative to the structural model is the "attention model" proposed by Kinsbourne (9). In this model, when the participant is given a task or expects a task, the region responsible for that task is activated more in the left hemisphere compared to the right hemisphere. The accuracy of the answers given by the participants in the Dichotic Listening test is highly dependent on their attention (10,11).

One of the possible mediators of the DL test results could be the gender of the voice. Although there are studies examining the effects of the participant's gender on the dichotic listening test, the research on the effect of the gender of the sounds present in the dichotic listening test is very limited. In this study, it was aimed to evaluate the effects of male and female voices on auditory asymmetry during the DL test (cv-syllables) by removing the ear dominances. To achieve this, we re-designed the classical dichotic listening test sessions called as mono and stereo. In mono session we aimed to get the gender preference independent from the ear and syllables, while in stereo session we aimed to get the gender preference dependent to the ear and syllables.

MATERIALS AND METHODS

The participants consisted of 10 men and 14 women, aged 18–45 years (28.54±6,23), without neurological or auditory impairments. The participants were selected as a result of the hand dominance test, and all were right-handed. The participants who had an average hearing loss of 30 dB HL (dB hearing level) or more in one ear according to the audiometry test or who had an average difference of more than 15 dB HL between their left and right ears were excluded from the study. Participants whose number of

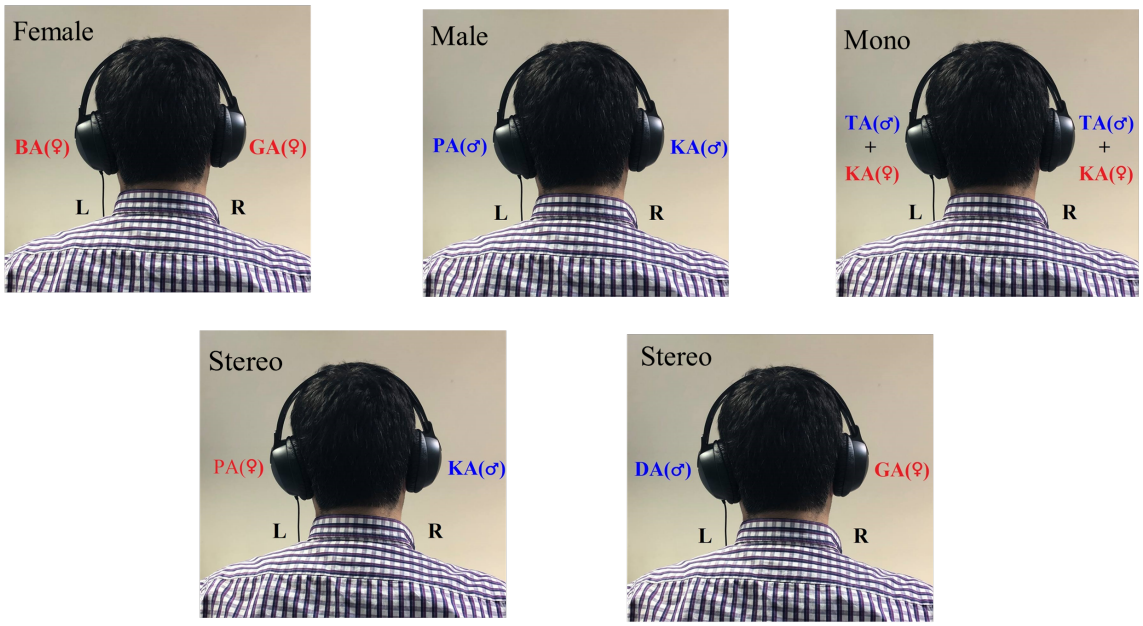

Figure 1. Presentation of female, male, mono and stereo sessions in one sample

erroneous responses exceeded 10 percent of the number of stimuli were excluded from the study.

Six consonant-vowel syllables (ba, da, ga, pa, ka, and ta) were delivered via headphones to the participants sitting in a sound-isolated room. Participants were asked to mark the first or best syllable they heard on the six-key response keyboard using their right hand (12). Before the application of dichotic listening test, a two-minute pre-test was conducted to help the participants to familiarize.

In the dichotic listening test, four sessions involving male and/or female voices were applied in balanced order to eliminate the order effect. These sessions are (i) female voices in both ears, (ii) male voices in both ears, (iii) male and female voices in both ears simultaneously (mono session) and (iv) male and female voices in both ears separately (stereo) (Figure 1).

Ethics committee approval was obtained from Dokuz Eylul University Non-Interventional Research Ethics Committee (Date: 13.05.2019, Decision no: 2019/4776). This prospective study was conducted between September 2019 to Nov 2022 at the Dokuz Eylül University, Izmir, Turkey.

Statistical Analyses

The data were analyzed using JASP *(Version 0.17.1*). The Shapiro-Wilk test was used for controlling the normality of the data in within-group comparisons, Pearson (parametric) or Spearman (non-parametric) tests were used to compare the correlation between voice types. Stereo session and mono session were compared with repetitive measures of variance analysis (rm-ANOVA). The Friedman test was used for statistical analysis of the difference between the three sessions, as it was shown that the data did not have a normal distribution when the number of incorrect answers in the female, male, and stereo sessions were evaluated using the normality test. The Conover test was applied for post-hoc analyses.

RESULTS

In the evaluations made in four separate sessions for each participant, no significant gender effect was found on the behavioral responses of the participants ($p>0.05$). For the comparisons of gender voice, an analysis of variance in repeated measures (rm-ANOVA) were employed. When the stereo session and mono sessions were compared, the session main effect [$F(1,20)=13.362$; $p=0.002$; $\eta^2= 0.001$] and the main effect of voice gender [$F(1.20)=35.132$, $p<0.001$, $\eta^2 =0.582$] were found to be significant. There was no significant difference between session and voice gender interactions ($p>0.05$) (Figure 2). Additionally, there was no significant difference between the age of male and female participants ($p>0.05$)

There is no significant difference between the number of syllables in which male and female participants prefer female and male voices in mono and stereo sessions. However, it can be seen from the way that female participants prefer more male voices and male participants mostly prefer female voices (Figure 3).

When the erroneous numbers in the mono and stereo sessions were evaluated using the paired sample t test, it was found that the errors made in the mono session were significantly higher than in the stereo session ($p<0.001$, $d= 0.805$).

According to the Friedmann test, it was determined that the number of erroneous responses changed significantly between sessions ($p=0.008$), and the Conover test was applied for post-hoc analyses. Accordingly, it was determined that there was only a significant difference between the number of errors in the male and stereo sessions ($t=3.055$; $p=0.012$).

DISCUSSIONS

When all participants in our study were evaluated as a group regardless of their gender, in mono and stereo sessions, they preferred the syllables voiced with a male voice more. When grouping according to participant genders for mono and stereo sessions, there is no significant difference between the number of syllables in which male and female participants prefer female or male voices. However, it is observed that female participants mostly prefer syllables with a male voice, and male participants prefer syllables with a female voice. By increasing the number of participants, it will be important to evaluate whether this trend continues and whether this difference is statistically significant. In the literature in which different results are obtained when the participants are compared with the voices of the opposite sex compared to the voices of the same sex. In a dichotic listening study using a female voice or a male voice in one ear and white noise in the opposite ear and participants' reaction times to these sounds according to the gender of the voice, female participants were shown to be faster at categorizing male voices more accurately than female voices. This situation supports the tendency toward opposite gender during voice categorization (13). Studies examining the possible

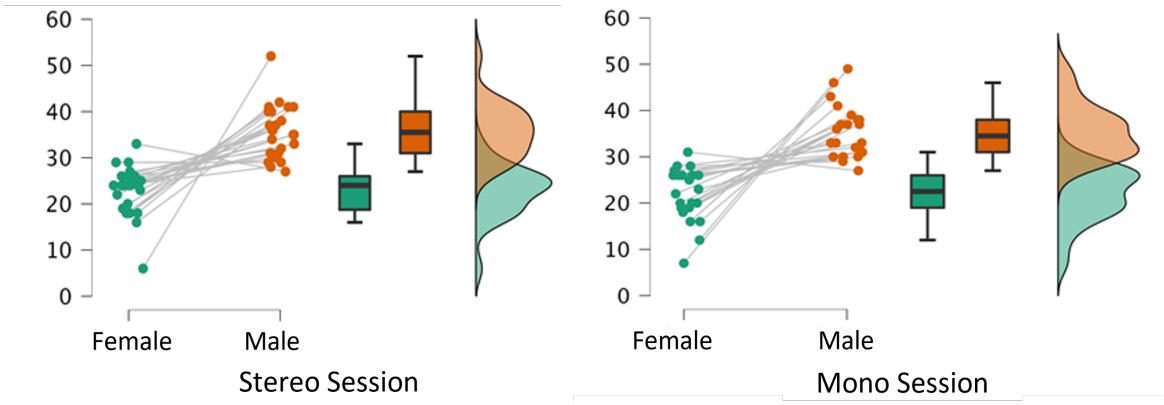

Figure 2. Number of female and male voice preferences of the participants in the stereo and mono sessions

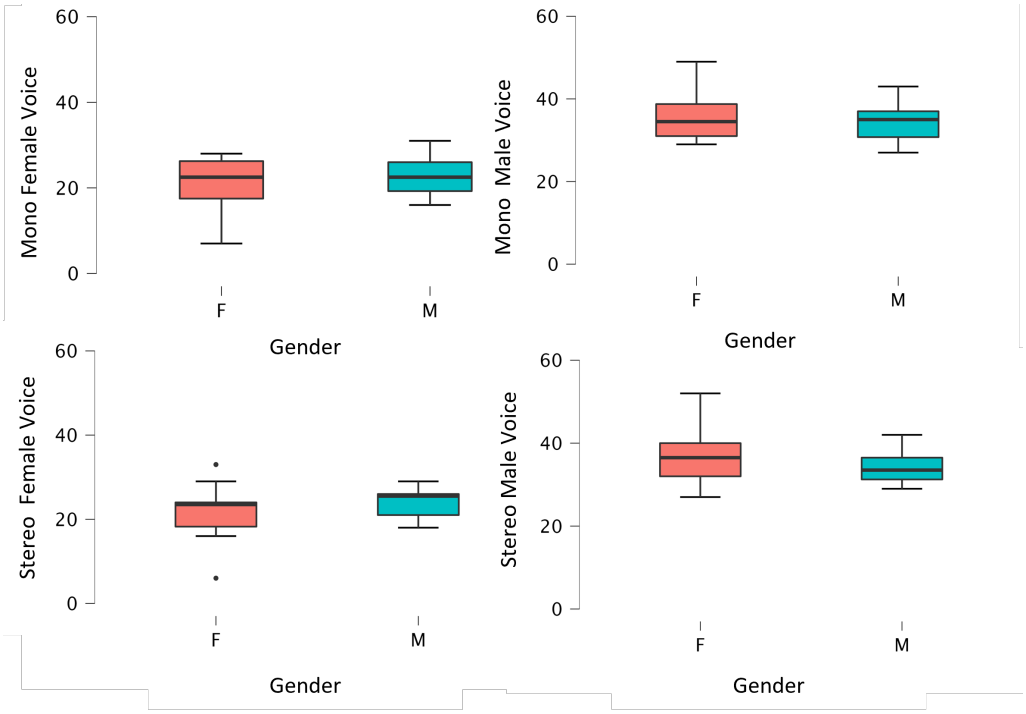

Figure 3. Average of female and male participants choosing syllables with male and female voice gender in Mono and Stereo sessions

differences in hearing and cortical structures between men and women generally did not find significant effects of the gender of the participants on the structural differences in the brain. It has been reported that auditory asymmetry is similar in both genders, and although structurally hemispheric differences are slightly more pronounced in males than females, they are not statistically significant (14). The role of the left and right hemispheres in processing the gender of sounds is controversial. Although some studies suggest that both hemispheres play an active role, others suggest the superiority of the right hemisphere (15). In a study conducted on healthy participants, it was shown that the categorization of the gender of the voice was faster when the stimuli were presented to the left ear. Additionally, healthy participants categorized female voices more accurately than male voices in the noise comprehension test. (13). In the fMRI study conducted regardless of the gender of the listeners, it was determined that female voices showed stronger activity in the temporal cortex than male voices (16). It is argued that this is due to the processing of timbre dimensions in the non-primary auditory cortex and creates a greater activation because female voices have a more complex timbre. Prete et al., while

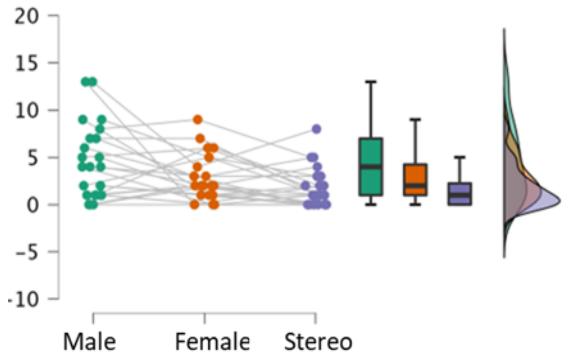

Figure 4: Distribution of number of incorrect answers in male, female and stereo sessions

dichotic syllables were used in their study, Weston et al. used words, and this affects the results. It is thought that as the complexity of the sound sent as a stimulus increase, the activation in the female voice increases. It can be thought that syllabic stimuli consisting of consonant and vowel syllables, and which can be evaluated as less complex, are evaluated over the fundamental frequencies of the sound in the primary auditory cortex. In the postmortem MRI study, there was no difference in temporal region structurality between males and females. (17). On the other hand, when the results of the tests in which hemispheric asymmetry was evaluated behaviorally, no difference was found between the genders. In a meta-analysis study compiled from studies aiming to reveal gender differences in language lateralization with the dichotic listening test, it has been observed that women have a more right ear dominance than men (17). In another study series, no significant effect was found on the gender of the participant in the dichotic listening tests performed with different types of syllables and word lists (18,19). There is a slight but consistent female advantage in early language development. This, however, appears to disappear during childhood. In adults, it is difficult to identify sex differences in verbal abilities and brain structure and function related to language processing (20,21).

When the erroneous responses in all sessions are examined, it is seen that the most errors were made in the session in which syllables pronounced with a male voice were given. Another session with a very close number of errors made in the men's session was the mono session. The session with the least error was the stereo session. So, few errors were made in the stereo session. This can be explained by the fact that the participants focused on the female or male voice, suppressing the voice of the other gender coming from the opposite ear and reducing the confounding effect. Since the fundamental frequencies of the syllables are the most different from each other in the male and female sessions, the probability of them masking each other may decrease. Thus, with the arrival of syllables of different genders from both ears in the stereo session, the dominance of syllables over each other may be lost. For this reason, more errors may have been observed in the male and female sessions than in the stereo session. When the number of errors made in mono and stereo sessions is examined, it is seen that significantly more mistakes are made in the mono session than in the stereo session. This situation may have arisen from the difficulty of the process that occurs when syllables of different genders are sent to both ears at the same time in a mono session. In this session, the syllables coming from the right or left ear for the male voice and the syllables coming from the right or left ear for the female voice are the same. In this respect, it is unclear from which ear the participant heard the answer, and the gender of the syllable chosen by the participant can be evaluated. Since the participants in the mono session heard two different syllables from two different genders in both ears simultaneously, the syllables affected each other's intelligibility, and a syllable that was not actually sent might have emerged as an erroneous response. At this point, it may be important in terms of phonetics to examine erroneous responses and determine which two syllables are most often incorrectly selected.

CONCLUSION

In this study, for the first time in the literature, a dichotic listening test paradigm and a modified dichotic listening paradigm (mono and stereo sessions) were created in the Turkish mother tongue with male and female voices. With the modified dichotic listening test, the right ear dominance, which is the most known result of the dichotic listening test, was eliminated as much as possible, and the hemispheric dominance of the sound, which was caused only by the stimulus difference, was examined. There was no statistically significant effect on the behavioral responses of the participants, male or female. It was observed that the participants preferred the male voice more, regardless of their gender.

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