



# TO WHAT EXTENT DOES BILINGUALISM AFFECT NATIVE LISTENING?

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# To what extent does bilingualism affect native listening?

Beliz Pekkan

## Abstract

This thesis investigates the influence of bilingualism on native listening abilities, with a particular focus on Turkish-English sequential bilinguals. Bilingualism, the ability to fluently speak two or more languages, reshapes human perception and cognition, altering innate language acquisition and use processes. One such process is native listening, the inherent ability to perceive and process auditory information in one's primary language. It aims to understand how second language acquisition affects native language perception and processing, an area previously underexplored in this demographic. The study compares the performance of bilingual individuals to that of monolingual peers in recalling specific linguistic sequences, particularly iambic syllable sequences. The findings indicate that age and audio cues significantly impact recall accuracy, whereas bilingualism and session types have minor, non-significant effects. These results suggest that while bilingualism may subtly influence native listening skills, other factors like age and the nature of audio stimuli play more substantial roles. This research enhances our understanding of the cognitive effects of bilingualism on native listening abilities and provides practical insights for educational practices and language learning programs.

## DATA SOURCE, ETHICS, CODE, AND TECHNOLOGY STATEMENT

Data Source: The data was collected by me last semester as a part of my internship. The usage of participant codes anonymizes the collected data. During this thesis, more data collection was done. All the figures are generated by me. The thesis code can be accessed through the GitHub repository following the link [[https://github.com/pandabeliz/CSAI\\_Thesis\\_BP](https://github.com/pandabeliz/CSAI_Thesis_BP)]. A generative language model GPT4 (<https://chatgpt.com>) was used to improve the writing of the original content. A grammar-checking tool Grammarly (<https://www.grammarly.com>) was used to check for plagiarism, paraphrasing, and grammar checking. No other typesetting tools or services were used.

## 1 Introduction

In today's globalized society, multilingual communication skills are increasingly valuable. Bilingualism, the ability to fluently speak two or more languages, has gained significant attention due to the growing number of people learning English, a phenomenon referred to as language spread (Cooper, 1990). Language spread is characterized by an increase in the number of users and functions of a language. English is the most successful example in history as it is currently the most preferred foreign language or language of broader communication worldwide. With the rise of people acquiring English as a second language, the interest in bilingualism has also increased, with more scientific attention being given to it. One specific area of interest has been how bilingualism affects our brains.

Bilingualism significantly influences cognitive and linguistic processing in various ways. The continuous use and management of two languages enhances executive functions such as working memory, cognitive flexibility, and selective attention (Bialystok et al., 2009). This enhancement is attributed to the need for bilingual individuals to constantly switch between languages and inhibit one language while using the other. Bilinguals also exhibit improved auditory processing abilities, developed through the need to discern similar sounds across different languages (Bialystok et al., 2009). This acute auditory skill facilitates better phonemic differentiation, which contributes to heightened metalinguistic awareness, aiding in understanding grammar and linguistic structures.

Brain imaging studies have shown that bilingual individuals often utilize neural resources more efficiently than monolingual individuals. This efficiency is due to the bilingual brain's adaptation to managing two language systems, which involves the same neural networks used for nonverbal executive control tasks (Bialystok et al., 2009). Additionally, the regular resolution of linguistic conflicts in bilinguals enhances their cognitive conflict resolution abilities, extending even to non-linguistic tasks (Bialystok et al., 2009). These advantages suggest bilingualism promotes cognitive flexibility and adaptability, reshaping perception and cognition. These reshapings of cognitive processes raise essential questions about the impact of bilingualism on innate language processes such as native listening.

### 1.1 Research Question and Hypotheses

This thesis explores a relatively underexplored area of research, examining the interplay between bilingualism and native listening skills. It focuses on how second language acquisition influences native language perception and processing, a topic that has not received the significant attention it deserves in the past. The term '*native listening*' refers to how an individual's native language significantly shapes their understanding and interpretation of linguistic cues (Cutler, 2012). This concept has been well-documented in the context of monolingual language acquisition. Cutler (2012) emphasizes that native listeners develop a highly adaptable and efficient system for processing speech in their native language. This flexibility is manifested in their capacity to adjust phonetic category boundaries to accommodate different speakers and listening environments. Consequently, the study underscores the robustness and flexibility of native listening, finely tuned to the structure and phonetic nuances of the listener's native language. However, there is a notable lack of research exploring the influence of bilingualism on native listening abilities.

This thesis aims to answer the central research question: "*To what extent does bilingualism affect native listening abilities?*" This question is subdivided into specific areas of inquiry to understand the cognitive alterations accompanying second language acquisition comprehensively:

- ❖ **Sub-Question 1:** How does bilingualism influence the accuracy of recalling specific linguistic sequences compared to monolingual counterparts?
- ❖ **Sub-Question 2:** How do different auditory conditions and age affect the native listening accuracy of bilingual and monolingual participants?

Based on these questions, the following hypotheses are proposed:

1. **Hypothesis 1: Enhanced Native Listening in Bilinguals**

Due to their experience with dual-language processing, bilinguals will exhibit superior native listening skills compared to monolinguals. This enhanced ability will be evident in tasks that involve the recall of iambic syllable sequences, where bilinguals are hypothesized to outperform their monolingual peers.

2. **Hypothesis 2: Differential Impact of Auditory Conditions and Age on Listening Accuracy**

Different auditory conditions (such as variations in pitch, duration, and flat conditions) and age will affect native listening accuracy differently for bilingual and monolingual participants. Specifically, bilinguals are expected to show a higher resilience to changes in auditory conditions across different age groups, reflecting their enhanced auditory processing flexibility. Conversely, monolinguals' native listening accuracy is anticipated to be more susceptible to changes in auditory conditions, especially as they age, due to having less adaptive auditory processing systems.

## 1.2 Motivation

This thesis aims to investigate the impact of bilingualism on native listening abilities, concentrating on Turkish-English sequential bilinguals. By comparing their performance to monolingual Turkish counterparts, it aims to explore how acquiring a second language reshapes the cognitive mechanisms associated with language perception. One particular area of interest is the accuracy with which both groups recall iambic syllable sequences and whether bilingualism influences this aspect of language processing and comprehension. The hypothesis is that bilinguals, due to their dual-language auditory processing system, may perform better at native listening tasks. The different linguistic systems of a person's two languages could influence their native listening abilities. This is especially relevant for Turkish-English bilinguals, as Turkish and English have fundamentally different linguistic structures.

Turkish is an agglutinative language with subject-object-verb word order and vowel harmony (Kutlu, 2015). In this language, suffixes are added to a base word to express grammatical relations, and each word generally maintains its original form. On the other hand, English is a non-agglutinative language with subject-verb-object word order, and word forms can change significantly based on the context (Kutlu, 2015). Therefore, learning English as a native Turkish speaker requires different processing, which might influence the innate listening abilities of these individuals. It's important to investigate how these perceptual biases could operate differently in bilingual individuals and how exposure to a second language might impact the development and operation of these biases. These differences, which extend to the two languages' phonological, syntactical, and semantic characteristics, could influence how bilingual individuals process auditory information in their native language.

To conclude, this research is significant because it has the potential to enhance our comprehension of bilingualism's cognitive impact, particularly on native listening skills in agglutinative and non-agglutinative languages. This study, which centers on Turkish-English sequential bilinguals, addresses an underexplored area of research and substantially contributes

to cognitive linguistics.

Moreover, this study's practical implications could have far-reaching consequences. The insights gained could inform educational practices, helping to develop more effective language learning programs and strategies that cater to bilingual individuals' unique needs and cognitive profiles. Additionally, the research could contribute to the ongoing efforts to support and promote linguistic diversity, which is crucial for preserving cultural heritage and fostering cross-cultural understanding.

### 1.3 Results

This research found that although group membership (bilingual or monolingual) and session types (duration or pitch) had some impact, it was minor and not statistically significant. In contrast, the age of the participants had a major, statistically significant effect. The audio cues also had a significant effect. Specifically, participants were more likely to correctly recall the iambic syllable sequences if they matched those from the familiarisation phase and less likely if they differed from the familiarisation phase.

## 2 Related Works

Bilingualism is a widely researched topic in linguistics, with substantial evidence demonstrating its impact on language processing and comprehension. The impact of bilingualism extends beyond linguistic competence, shaping auditory processing abilities by influencing how individuals interpret and respond to spoken language.

Whorf (1956) proposed that language shapes an individual's conceptual knowledge, highlighting the intricate relationship between language and cognition. Cutler (2012) explored native listening, highlighting the influence of native language on the perception and interpretation of linguistic cues. Ortega (2009) emphasized the role of native listening in language development and communication skills in bilingual individuals. She discusses how knowledge of the first language (L1) can positively impact the learning rate of the second language (L2). For example, learners from a tonal language (a language where different tonal inflections will convey different meanings of words) background are better in recognizing and distinguishing tones in an L2.

The Iambic-Trochaic Law and native listening are related to human perception and language and sound processing. Native Listening, the innate biases, and adaptations in response to one's language, forms the basis for understanding how bilingual individuals may process their native language differently after acquiring a second language. The Iambic-Trochaic Law, which guides how we perceive and group sound sequences, is a universal principle that helps compare the auditory perception between bilinguals and monolinguals, regardless of their specific languages. These concepts provide the theoretical framework for understanding the potential cognitive alterations accompanying second language acquisition.

The Iambic-Trochaic Law is a principle from sound perception that suggests humans have innate biases in how they perceive sound sequences (Bion et al., 2011). It originated in the field of music to explain the grouping of musical sequences (Cooper & Meyer, 1963). However, it was later expanded to account for regularities in speech production and biases in speech perception (Nespor & Vogel, 2012). According to the law, humans tend to segment sequences of sounds that differ only in duration, with the longest element in the final position (iambic pattern) and

sequences of sounds that differ only in intensity or pitch with the more intense or high-pitched element in the initial position (trochaic pattern). This law has been extended to explain grouping at the phrasal level in speech production (Bion et al., 2011).

According to Cutler (2012), native listening is the process by which native speakers of a language adapt to variations in speech, such as new talkers, dialects, and noisy conditions. It involves using specific adaptation mechanisms for speech recognition, highlighting the importance of flexibility. This process is highly beneficial for listening to noise, adapting across dialects, and identifying voices. However, the native bias in this process can pose challenges for non-native language processing.

Bion, Benavides-Varela, and Nespor (2011) investigated how acoustic markers of prominence, such as pitch and duration, influence the segmentation and memory of speech sequences by adults and 7-month-old infants. The study revealed that adults were better at remembering pairs of syllables that, during familiarization, had short syllables preceding long syllables (iambic pattern represented by duration in this experiment) or high-pitched syllables preceding low-pitched syllables (trochaic pattern represented by pitch in this experiment). Infants preferred to listen to pairs of syllables with a high pitch in the first syllable when familiarized with syllables alternating in pitch. However, no preference was found when the familiarization stream alternated in duration. These findings suggest that the perceptual biases for grouping based on pitch appear early in development, while biases for durational grouping might rely on more extensive linguistic experience. The research aligns with the principles of the Iambic-Trochaic Law, and it reveals that adults and infants display different perceptual biases, which could be due to varying developmental paths for grouping biases based on pitch and duration.

Another relevant study by Langus et al. (2016) suggests that our native language significantly influences our perception of linguistic stimuli. They have argued that different languages have different rhythmic structures, and this rhythmic structure impacts the way speakers of these languages perceive and group syllables. For example, Italian and Turkish/Persian speakers grouped syllables differently despite being familiarized with the identical syllable sequences. Iversen et al. (2008) also found similar results for English and Japanese speakers' perception of rhythmic grouping in auditory sequences. These findings demonstrate that auditory experience, particularly related to language, significantly influences the perception of rhythmic grouping in auditory sequences. Since bilingual individuals have exposure to and proficiency in two languages, they are likely to have a more diverse auditory experience than monolinguals. This could lead to different rhythmic grouping perceptions between bilinguals and monolinguals, suggesting that acquiring a second language may impact native listening abilities.

More research has delved into the specifics of how bilingualism affects auditory processing. Nijveld (2022) found that native listeners rely more on detailed word pronunciation representations, while non-native listeners are influenced by their first language familiarity. Bsharat-Maalouf and Karawani (2022) showed that bilinguals have increased difficulty with noisy speech perception despite cognitive advantages. Chauvin and Phillips (2021) discovered that bilinguals are more accurate in their first language but benefit more from visual cues and context in their second language. Kraus and White-Schwoch (2017) noted that bilinguals perform poorly in noisy environments despite improved neural processing. Olguin (2019) found that bilingualism affects neural mechanisms, especially in complex listening situations.

These literature has highlighted the significant impact of bilingualism on cognitive and auditory processing, revealing the interplay between an individual's linguistic environment and their perceptual capabilities. Studies like those conducted by Bion, Benavides-Varela, and Nespor (2011) and Langus et al. (2016) have demonstrated how different linguistic backgrounds can affect the fundamental processes of sound perception and grouping. Additionally, research by Chauvin and Phillips (2021) and Nijveld (2022) points to both the advantages and unique challenges bilinguals face, particularly in complex auditory environments.

Despite the rich body of research, there remains a notable gap in studies focusing on less common bilingual configurations, such as Turkish-English bilinguals. This demographic offers a unique opportunity to study the effects of bilingualism on native listening skills due to the distinct linguistic characteristics of Turkish and English. Previous research often focuses on more commonly studied bilingual groups, such as Spanish-English or French-English bilinguals. The study targets a demographic less commonly represented in the scientific literature by selecting Turkish-English sequential bilinguals, providing new insights into bilingualism's cognitive and linguistic outcomes in this unique population. The selection of Turkish and English as the languages for this study was based on prior research. Previous studies suggest that English native speakers group language following the Iambic-Trochaic Law, while Turkish native speakers group linguistic sounds with varying durations (long-short grouping) as trochee (Iversen et al., 2008; Langus et al., 2016).

Additionally, this research will take a unique approach by comparing the performance of bilingual individuals with monolingual peers in recalling specific linguistic sequences. This method has not been extensively explored in prior research. By employing this approach, this study aims to gain a comprehensive understanding of how bilingualism impacts native listening skills. The dataset for this study comprises a diverse group of monolingual Turkish speakers and Turkish-English sequential bilingual individuals, allowing for meaningful comparisons and valuable insights into the cognitive effects of bilingualism on native listening skills. Including monolingual Turkish speakers as a control group helps to isolate the effects of bilingualism from the baseline linguistic processing skills inherent to speakers of the Turkish language. This comparative approach enables a clearer understanding of bilingualism's specific cognitive benefits or challenges.

### 3 Methods

#### 3.1 Population

The current dataset includes data from 80 participants, evenly split, with 40 identified as bilingual and 40 as monolingual. The average age of the participants is 36.41 years, with a standard deviation of about 14.54, illustrating a diverse age range within the sample group. This distribution provides a comprehensive view of the demographic and experimental conditions involved in the study, facilitating a robust analysis of native listening abilities across different linguistic backgrounds.

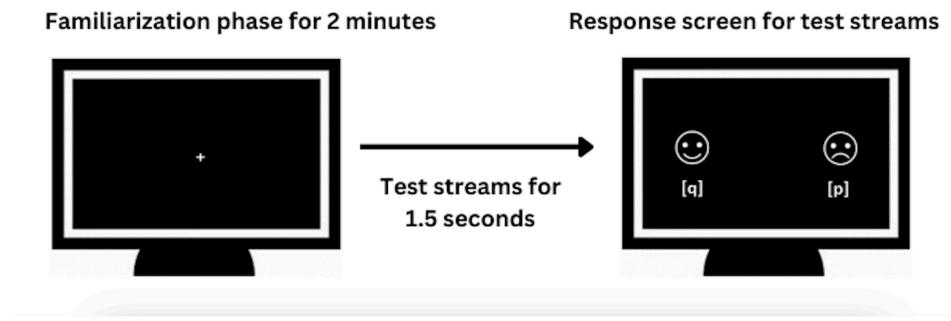
### 3.2 Material And Design

For this research, the data was collected last semester during my internship. Implementing an online experiment, which was facilitated by the Jatos experimental platform, made this possible. In addition, demographic information about the participants was gathered through the use of Qualtrics, a comprehensive online survey platform.

The online experiment was designed to allow the participants to be tested under diverse conditions. These conditions included the placement of their hands (either on the left or right sides), variations in the sessions (such as flat, duration, and pitch), and the language of the instructions given (either Turkish for monolingual participants or both Turkish and English for bilingual participants).

The stimuli used in this study were created using MBROLA and the IT4 voice synthesizer database for the familiarisation and test streams.

### 3.3 Procedure



**Figure 1:** Illustration of experimental procedure

This study built upon the experiment conducted by Bion et al. (2011) and Nur Cay (2022), making minor adjustments to the session setup. This experiment involved bilingual participants alternating between English and Turkish conditions over five sessions and monolingual participants experiencing three sessions with Turkish conditions.

Participants received links to Qualtrics surveys containing both the experiment links and demographic information questions. These surveys included the Jatos experiment links that participants needed to follow. The survey interspersed these links with distracting questions about demographic information to prevent participants from remembering the syllable stream between two consecutive sessions.

At the beginning of the first experiment, the participants were asked to create a unique identifier containing the first two letters of their mother's name, the first two letters of their father's name, and the first two digits of their birthday. This identifier was linked to their demographic information and experiment results. This code was used in all sessions for each participant as an identifier at the beginning of each experimental session.

The instructions were given in Turkish for monolingual participants, while bilingual participants alternated between Turkish and English instructions.

After the instructions, participants were shown a black screen with a white plus in the middle for the familiarization and test streams, as shown in Figure 1. Each session began with a two-minute loop of the familiarization stream of syllables (/pa su tu ke ma vi bu go ne du/), separated by 100 milliseconds, which was the same familiarization stream used by Bion et al. (2011) in their study.

The experiment was conducted under three distinct conditions. The first, the pitch condition, involved alternating syllable pitch. Here, syllables lasted 360 milliseconds and alternated between 180 and 400 Hz pitches. The second, the duration condition, had syllables that varied in length. They alternated between 360 and 580 milliseconds while the pitch remained at 180 Hz.

Finally, the flat condition served as a control, maintaining consistent pitch and duration for all syllables. In this case, each syllable lasted 360 milliseconds at a pitch of 180 Hz. Each condition included 20 trials with syllable pairings, half derived from the flat condition. Correct pairings in the flat trials were adjacent syllables, while incorrect pairings skipped syllables (Nur Cay, 2022).

In the testing phase, participants were directed to a screen with a happy and a sad face, arranged according to their hand placement condition. In the right-hand placement condition, the happy face, representing that they had heard the syllable pair, was on the right, and the sad face, indicating that they hadn't heard the pair, was on the left. This arrangement was reversed for the left-hand placement condition. The icons corresponded to the 'Q' and 'P' keys on the keyboard, respectively.

After all 20 pairs were heard, they were directed to a screen that said their experiment was over and asked to return to the Qualtrics survey to continue with the other sessions.

### 3.4 Statistical Methods And Analyses

To address the research questions and test the corresponding hypotheses, multiple Analyses of Variance (ANOVA) were employed to examine differences in listening accuracy among bilingual and monolingual participants under various auditory conditions (such as flat, duration, and pitch). This method is particularly suited to determine if the mean accuracy differs significantly between these groups, thereby providing a robust measure of how group membership (bilingual or monolingual) affects performance in native listening tasks.

**Hypothesis 1: Enhanced Native Listening in Bilinguals** — ANOVA will test whether bilinguals demonstrate superior listening accuracy compared to monolinguals, particularly when recalling iambic syllable sequences. This analysis will help ascertain whether bilingual experience enhances native listening skills, as bilinguals are hypothesized to outperform their monolingual peers in tasks that require processing complex linguistic patterns.

**Hypothesis 2: Differential Impact of Auditory Conditions and Age on Listening Accuracy** — The analysis will extend to examine how different auditory conditions and participant age interact with the listening accuracy of bilingual and monolingual participants. ANOVA will be utilized to dissect the interaction effects between auditory conditions (pitch, duration, and flat) and age, assessing whether bilinguals exhibit greater auditory processing flexibility and how

both groups' performance varies with age. This will help determine if bilinguals maintain consistent performance across varied auditory conditions and age groups, reflecting their potential cognitive advantages in adapting to different auditory environments.

The analyses primarily focus on the accuracy of participant responses to the linguistic tasks, which act as the dependent variable. The independent variables considered include the participants' age, their group membership (bilingual versus monolingual), the type of auditory session (pitch, duration, flat), and whether the stimulus heard was correct or incorrect (audio type). These factors are analyzed to understand their collective impact on native listening accuracy.

By conducting these specific analyses, this research aims to comprehensively understand the cognitive changes associated with bilingualism and how these changes manifest in enhanced native listening capabilities. The findings will contribute to the broader understanding of bilingual advantages in auditory processing and adaptation.

## 4 Results

### 4.1 Baseline Comparisons

A baseline ANOVA was conducted to compare the prediction accuracy between monolingual and bilingual participants in the flat session condition. The initial model included only the group variable (monolingual or bilingual), resulting in no significant difference in accuracy between the groups,  $F(1, 75) = 2.28$ ,  $p = 0.135$ . This indicates that group membership alone does not significantly impact accuracy in the flat session condition.

Given the broad age range of participants, age was included as a covariate in the model to account for potential age-related differences in cognitive processing. When age was added to the model, the results remained non-significant for both the group variable and age. The group variable showed  $F(1, 74) = 2.52$ ,  $p = 0.117$ , and age showed  $F(1, 74) = 1.03$ ,  $p = 0.314$ . These results suggest that neither group membership nor age significantly affects accuracy in the flat session condition, confirming that the data from both groups are suitable for further analysis.

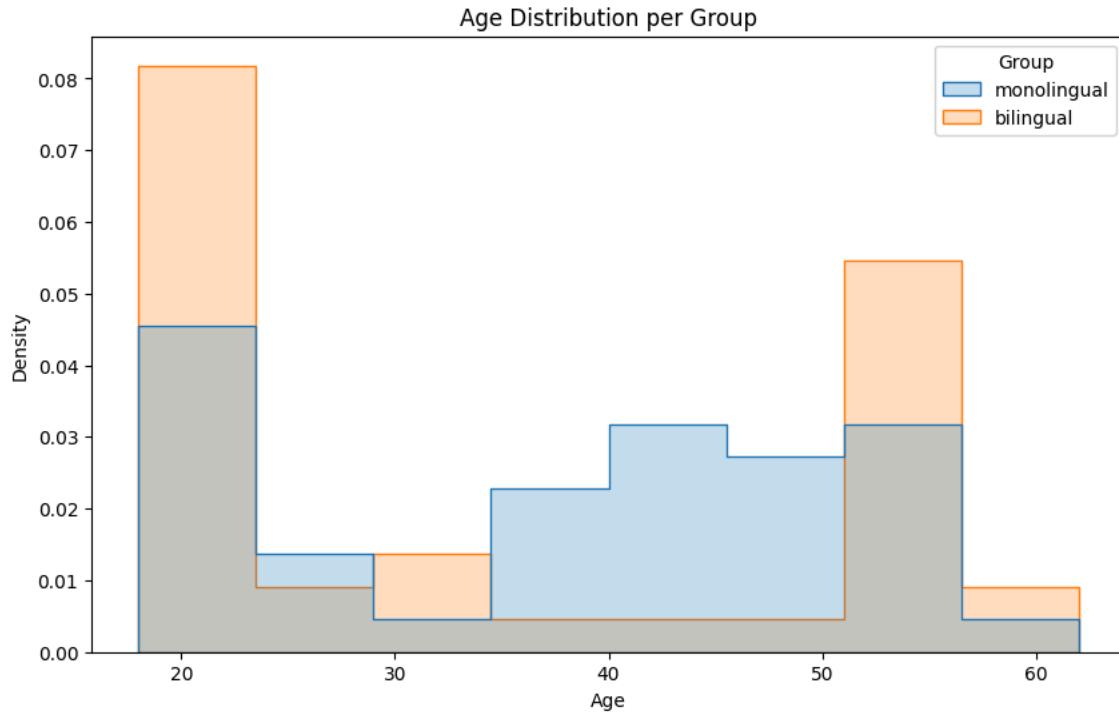
### 4.2 Influence of Bilingualism Accuracy

To evaluate the impact of bilingualism on prediction accuracy, an ANOVA was performed with group membership (monolingual or bilingual) and age as independent variables. The results of the ANOVA indicated that group membership did not significantly affect accuracy,  $F(1, 77) = 1.08$ ,  $p = 0.303$ , suggesting no statistically significant difference in accuracy between monolingual and bilingual participants.

However, age significantly impacted accuracy,  $F(1, 77) = 9.37$ ,  $p = 0.003$ , emphasizing the importance of considering age when analyzing cognitive performance. These findings indicate that while bilingualism itself may not significantly alter accuracy, age plays a crucial role in cognitive performance, highlighting the necessity of accounting for age-related effects in further analyses.

### 4.3 Age Group Analysis

The analysis focused on the influence of bilingualism on prediction accuracy, with participants divided into two age groups for further study: younger participants (18-35 years old) and older participants (36 years and older). There were 42 younger monolingual participants and 69 younger bilingual participants. In contrast, the older group consisted of 72 monolingual and 29 bilingual participants. In total, there were 111 younger participants and 101 older participants. The distribution of participants per group membership is shown in Figure 2.



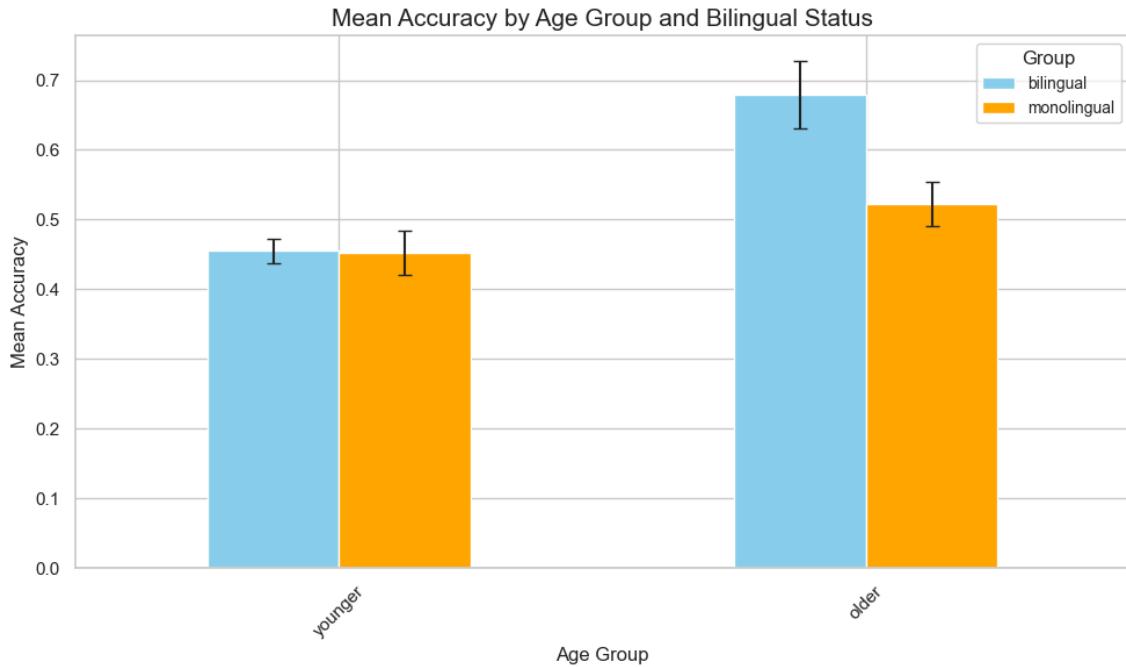
**Figure 2: Age Distribution Of Participants Per Group**

For the younger participants, an ANOVA was conducted to assess the effect of group membership (monolingual vs. bilingual) on accuracy. The results indicated no significant difference between the groups:  $F(1, 109) = 0.59, p = 0.444$ . This suggests that within the 18-35 age group, bilingualism does not significantly impact task performance in terms of accuracy. The mean accuracy per trial (duration and pitch) for young bilinguals was 0.468, while for young monolinguals, it was 0.498.

For the older participants, the ANOVA results showed a significant effect of group membership on accuracy:  $F(1, 99) = 8.85, p = 0.004$ . This significant finding indicates that bilingual status distinctly affects accuracy in older adults. Specifically, older bilinguals exhibited higher accuracy (mean = 0.659) than their monolingual peers (mean = 0.489).

The results highlight an interesting age-related difference in the impact of bilingualism on cognitive processing. While bilingualism does not significantly affect younger adults' task performance, it has a marked influence on older adults' accuracy. Specifically, older bilinguals perform better in accuracy tasks than older monolinguals, suggesting potential cognitive benefits associated with bilingualism that become more pronounced with age.

This finding underscores the need to consider age as a significant factor when examining the effects of bilingualism on cognitive abilities. The enhanced performance in older bilinguals might reflect greater cognitive flexibility and resilience developed through managing two languages, which could contribute to better maintenance of cognitive functions in aging.



**Figure 3: Mean Accuracy By Age And Group Membership**

Figure 3 depicts the mean accuracy for different age groups and bilingual status, illustrating the statistical outcomes. The graph indicates that older bilinguals consistently outperform their monolingual counterparts, but the performance difference is insignificant in younger participants.

#### 4.4 Impact of Auditory Conditions

Exploring the influence of auditory conditions, significant differences were found in the response to audio types.

The effect of being in a monolingual or bilingual group on accuracy was not statistically significant ( $F(1, 410) = 1.918, p = 0.167$ ), suggesting that group membership alone does not significantly influence accuracy across the tasks. However, the type of audio had a significant effect on accuracy ( $F(1, 410) = 143.319, p < 1.57 \times 10^{-28}$ ), indicating that the nature of the audio stimuli strongly impacts task performance. Additionally, age significantly affected accuracy ( $F(1, 410) = 6.126, p = 0.014$ ), highlighting the importance of considering age when examining cognitive performance in language tasks.

The low p-value highlights the significant impact of audio type on accuracy, underscoring its critical role in cognitive processing across different language groups. The results indicate that participants, whether monolingual or bilingual, perform significantly better with correct audio cues than incorrect ones.

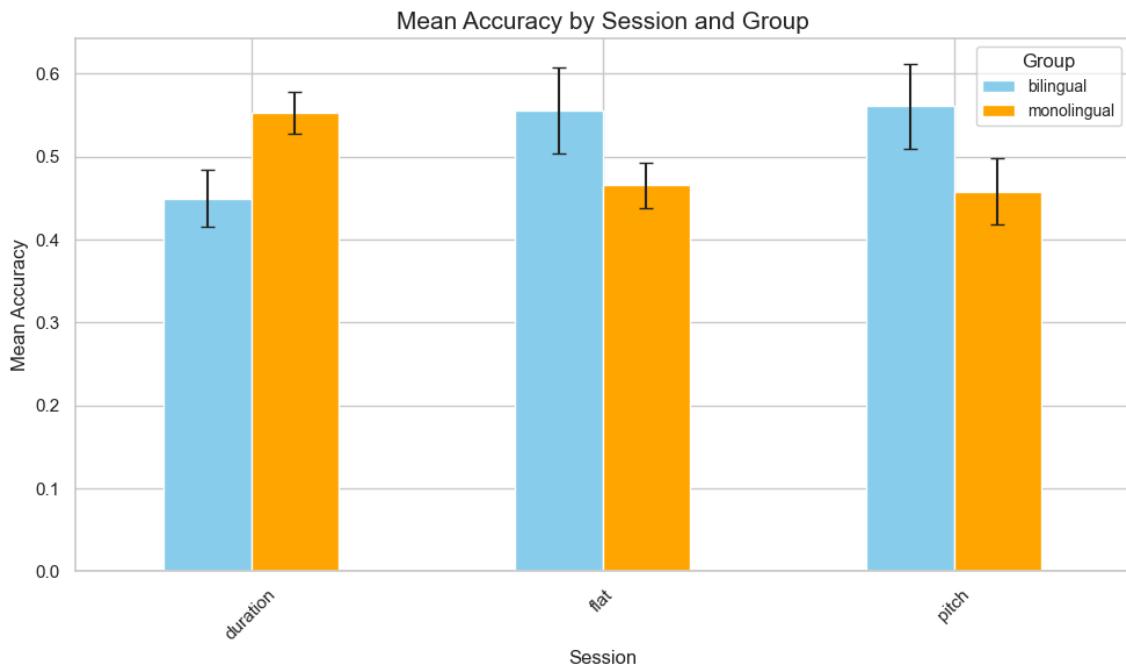
These findings highlight the necessity of considering both audio type and age when evaluating the accuracy of linguistic tasks. The pronounced effect of audio type on accuracy suggests that the specific characteristics of auditory stimuli are crucial determinants of performance. Meanwhile, the significant influence of age on accuracy points to age-related differences in cognitive flexibility and auditory processing.

#### 4.5 Session Type Interaction

Further analysis divided participants into monolingual and bilingual groups to compare their accuracies based on session types: pitch and duration. This analysis included the pitch and duration trial types.

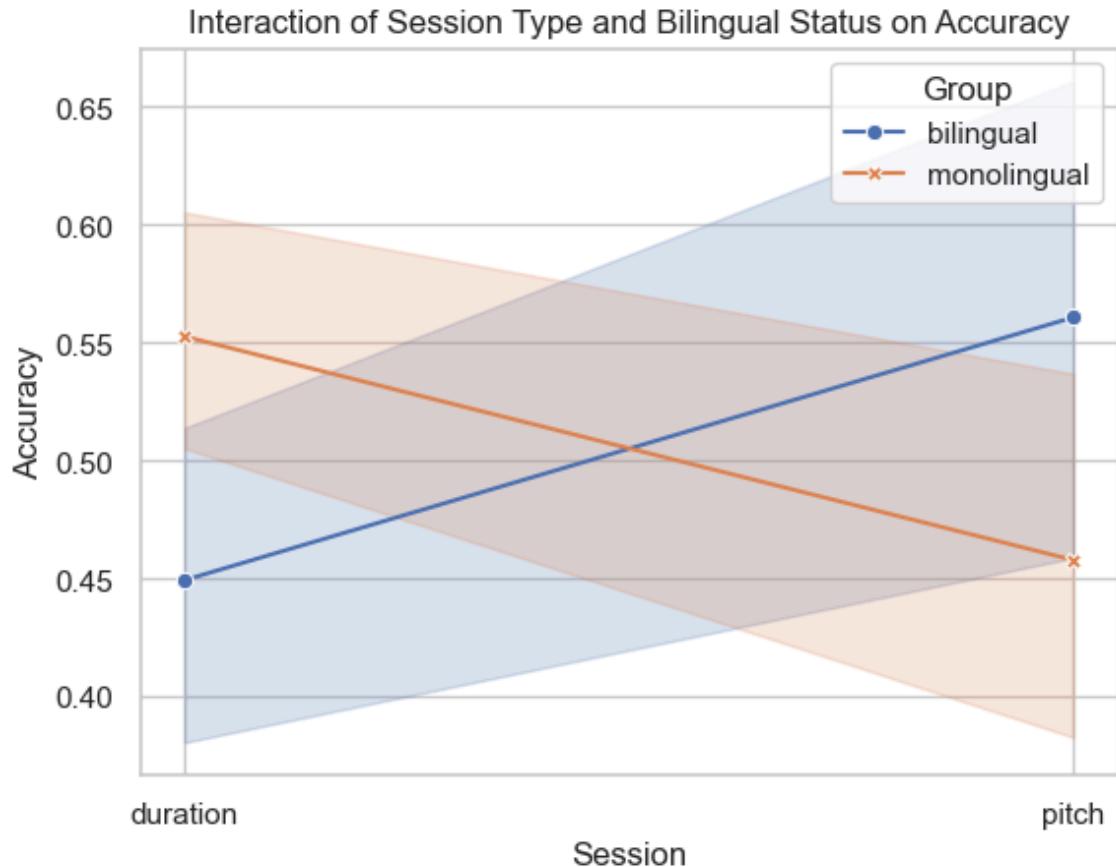
For monolinguals, session type had a marginally significant effect on accuracy,  $F(1, 73) = 4.031$ ,  $p = 0.048$ , suggesting that different sessions could affect performance outcomes. Age, however, did not show a significant effect,  $F(1, 73) = 0.092$ ,  $p = 0.763$ . The mean accuracies for monolinguals were 0.497 with a standard deviation of 0.129 in the pitch session and 0.467 with a standard deviation of 0.121 in the duration session.

For bilinguals, both session type,  $F(1, 56) = 4.669$ ,  $p = 0.035$ , and age,  $F(1, 56) = 12.334$ ,  $p = 0.001$ , significantly influenced accuracy. This highlights that session type and age play a crucial role in determining the accuracy of bilingual participants. In the pitch session, the mean accuracy was 0.658, with a standard deviation of 0.137. For the duration session, the mean accuracy was 0.488, with a standard deviation of 0.113.



**Figure 4: Mean Accuracy By Session Type Per Group Membership**

Figure 4 illustrates that bilingual participants tend to maintain more consistent performance across varying session types compared to monolingual participants, who show more variability. For example, bilinguals show higher mean accuracy in the pitch session than monolinguals. This visual data suggests that bilinguals may possess adaptive advantages in fluctuating conditions, consistent with the hypothesis of enhanced native listening skills due to dual-language processing. In the duration session, monolingual participants displayed higher mean accuracy than bilingual participants, which was unexpected based on our initial hypothesis. The differences between the graphical representations and the statistical tests will be further discussed in the discussion section.



**Figure 5: Interaction Plot Of Session Type Accuracy And Group Membership**

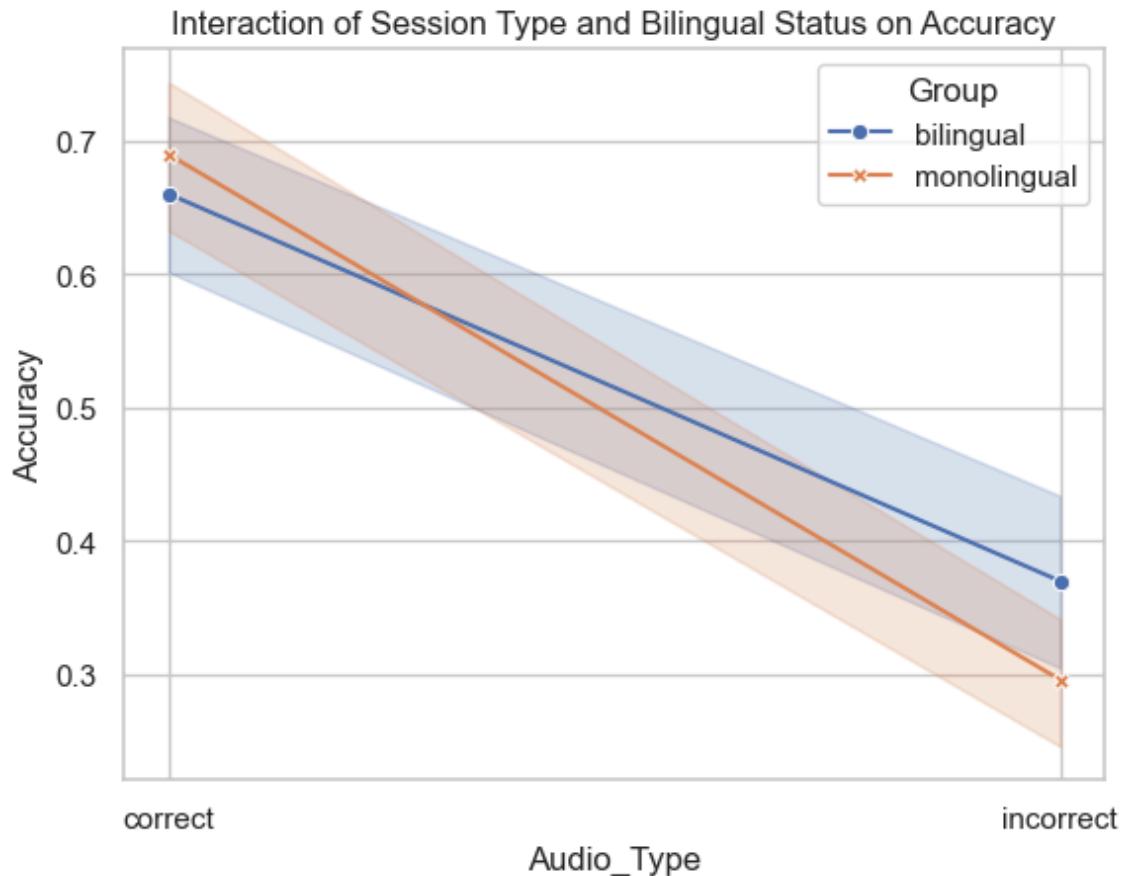
Figure 5 plots accuracy against session type for monolinguals and bilinguals, providing a comparative insight into how each group responds to different session conditions. What is evident from the visualization is not a straightforward impact but rather subtle differences in how each group adapts to the session types. For instance, the graph might show that bilinguals maintain relatively consistent accuracy across various sessions, suggesting a possible adaptive advantage or greater resilience to changing task conditions. Conversely, monolinguals might display more fluctuation in accuracy across different sessions, indicating potential challenges or sensitivities to session-specific variables.

These visual observations highlight the nuanced effects of bilingualism on native listening skills and underscore the importance of considering session type when evaluating cognitive performance. The implications of these differences will be further explored in the discussion section.

#### 4.6 Impact of Audio Type and Session Type on Accuracy

An ANOVA was conducted to evaluate the effects of session type (pitch and duration) and audio type (correct and incorrect) on the accuracy of monolingual participants. The results indicated that session type showed a potential trend but was not statistically significant,  $F(2, 224) = 2.428$ ,  $p = 0.091$ . However, the audio type significantly impacted accuracy,  $F(1, 224) = 104.258$ ,  $p < 2.42 \times 10^{-20}$ . Age did not show a significant effect.

Similarly, an ANOVA was conducted for bilingual participants. The results showed that session type was not statistically significant,  $F(2, 182) = 2.277, p = 0.105$ . Audio type significantly impacted accuracy,  $F(1, 182) = 44.121, p < 3.46 \times 10^{-10}$ , while age also significantly affected.



**Figure 6: Interaction of Audio Type with Group Membership on Accuracy**

Figure 6 showcases that while both groups experience a decrease in accuracy with incorrect audio cues, the impact is significantly steeper for monolinguals. This pattern visually supports the statistical data and provides a tangible insight into how audio inaccuracies can detrimentally affect task performance. By observing these trends, we understand the potential challenges participants face when dealing with incorrect audio types, reinforcing the necessity for careful audio cue selection in cognitive tasks.

#### 4.7 Correct and Incorrect Audio Cues Analysis

To further understand these effects, ANOVAs were conducted separately for correct and incorrect audio cues for monolingual and bilingual participants.

For monolingual participants with correct audio cues, the session type had an  $F(2, 823) = 1.634, p = 0.196$ , indicating no significant effect, and age had an  $F(1, 823) = 0.031, p = 0.860$ , also showing no significant effect.

When it came to monolingual participants with incorrect audio cues, the session type showed an  $F(2, 821) = 1.959, p = 0.142$ , suggesting no significant impact, and age had an  $F(1, 821) = 0.049, p = 0.824$ , again indicating no significant effect.

For bilingual participants with correct audio cues, the session type had an  $F(2, 1090) = 0.085, p = 0.919$ , demonstrating no significant effect. The language showed an  $F(1, 1090) = 0.590, p = 0.443$ , indicating no significant effect. However, the age of the participants had an  $F(1, 1090) = 19.335, p < 0.000012$ , revealing a statistically significant effect.

With incorrect audio cues, bilingual participants' session type had an  $F(2, 1088) = 3.720, p = 0.025$ , indicating a significant effect. The language showed an  $F(1, 1088) = 1.403, p = 0.237$ , suggesting no significant effect. However, the age of the participants had an  $F(1, 1088) = 48.142, p < 6.79 \times 10^{-12}$ , revealing a significant effect.

These results indicate that for monolinguals, neither session type nor age significantly impacts accuracy, regardless of audio correctness. For bilinguals, age significantly affects accuracy in both scenarios, while session type influences accuracy only in incorrect scenarios.

## 5 Discussions And Conclusion

This thesis addressed the central research question: "To what extent does bilingualism affect native listening abilities?" This inquiry was subdivided into two specific areas: first, how bilingualism influences the accuracy of recalling specific linguistic sequences compared to monolingual counterparts, and second, how different auditory conditions and age affect the native listening accuracy of bilingual and monolingual participants.

Two hypotheses were proposed to explore these aspects. The first hypothesis anticipated that bilinguals, due to their experience with dual-language processing, would exhibit superior native listening skills compared to monolinguals. This enhanced ability was expected to be evident in tasks involving recalling iambic syllable sequences. The second hypothesis suggested that different auditory conditions and age would impact native listening accuracy differently for bilingual and monolingual participants. Specifically, bilinguals were expected to demonstrate higher resilience to changes in auditory conditions across different age groups, reflecting their enhanced auditory processing flexibility.

### 5.1 Group Membership On Accuracy

The initial analysis explored whether being monolingual or bilingual impacts prediction accuracy, with age included as a factor due to its variation across the participants. The results indicated that while bilingual status did not significantly influence accuracy, age had a profound effect. This finding suggests that age-related factors play a critical role in cognitive performance and need to be considered in any analysis of bilingualism's effects.

A study conducted by Asadollahpour et al. (2015) compared the working memories (WM) of monolingual and bilingual children. The study found that bilingual children outperformed monolingual counterparts in tasks measuring the phonological loop and central executive functions. As WM is a critical cognitive function underlying various language abilities, including listening skills, the superior WM performance observed in bilingual children could translate into better language processing skills. These skills include enhanced native listening abilities. Iambic-syllable sequences, which have a rhythmic and pattern-based nature, heavily rely on auditory working memory. This aspect of working memory is vital for processing and storing auditory information such as sounds and linguistic patterns. A potentially larger auditory working memory capacity in bilinguals could facilitate better encoding and retrieval of these syllable sequences.

The recall of iambic syllable sequences is related to working memory tasks because it requires the temporary storage and manipulation of information, which are key functions of working memory. In the case of iambic syllable sequences, individuals need to remember the order and rhythm of syllables. This involves not only storing this information but also updating it with each new syllable, requiring the use of working memory. Figure 4 shows that bilingual participants perform more consistently across session types than monolinguals. However, the statistical analysis results from this study do not match those from Asadollahpour et al. (2015), raising concerns about the generalizability of the participant pool in this study.

These findings support Hypothesis 2, indicating that age is a significant factor in native listening accuracy. While bilingualism did not significantly affect accuracy overall, bilinguals tended to perform more consistently across varying session types than monolinguals. This aligns with the expectation that bilinguals have enhanced cognitive flexibility, which could contribute to more stable performance under different conditions.

### 5.2 Age On Accuracy

The study's participants have a diverse age distribution, averaging around 36 years. This broad age range could introduce variables related to cognitive decline, potentially influencing the results. Figure 2 illustrates the age distribution in this experiment, showing a peak in bilinguals aged 20-25 and 50-55. In contrast, monolinguals are more evenly spread across ages 35-55, with a slight peak at 20-25. This discrepancy in age distribution may have impacted the overall accuracy of analyses.

As individuals age, various cognitive functions such as memory, attention, and processing speed may decline (National Academy of Sciences, 2015). These age-related changes could have influenced the experiment's results, especially in tasks requiring information recall. For instance, older participants might have had more difficulty accurately recalling iambic syllable sequences than their younger counterparts. This discrepancy indicates that age directly influences accuracy, with older adults showing different performance patterns based on group membership. Consequently, this could have impacted the overall findings, emphasizing the need to consider age as a potential confounding factor in the analysis and interpretation of results.

These findings highlight the importance of considering age as a moderating factor in studies assessing the cognitive effects of bilingualism. They suggest that the benefits or challenges associated with bilingualism may become more pronounced as individuals age, supporting Hypothesis 2.

### 5.3 Session Type On Accuracy

In analyzing the influence of session type on task accuracy, there were mixed results between monolinguals and bilinguals. Monolingual participants' session variability slightly affected performance, suggesting sensitivity to specific session conditions, such as pitch or duration changes. This underscores the potential role of session-specific variables in modulating task performance among monolinguals. The data indicates that monolinguals perform better in the duration session than bilinguals. In Figure 5, we can see that monolinguals perform better during the duration session than bilinguals.

Conversely, for bilinguals, both session type and age have a more pronounced effect on accuracy. This highlights the significant influence of these factors on bilingual participants, potentially due to their dual language system experience. The marked responsiveness of bilinguals to session type and age may reflect enhanced cognitive flexibility or a different adaptation to challenges in auditory processing. This aligns with prior research suggesting bilingualism can reshape cognitive mechanisms associated with language perception and processing. The data also reveals that bilinguals perform better in the pitch session compared to monolinguals. We can also see in Figure 4 and Figure 5 that bilinguals perform better in the pitch session than monolinguals.

The impact of auditory cues on accuracy, as observed across both linguistic groups, corroborates earlier studies by Bion et al. (2011) and Langus et al. (2016), highlighting acoustic markers' critical role in language processing. Bion et al. (2011) demonstrated how adults and infants use pitch and duration cues to segment and memorize speech sequences. This ability to preferentially process certain acoustic features aligns with the findings from this study, where session type—characterized by variations in these auditory markers—differentiated performance outcomes among participants.

Further, Langus et al.'s (2016) research on rhythmic structures' influence on syllable perception underscores the broader implications of these findings. Bilinguals' differential response to session types could be influenced by their exposure to varied rhythmic patterns in their two languages, suggesting that bilingualism enhances adaptability to auditory cue variations. This adaptation could manifest the cognitive flexibility that bilinguals develop through managing multiple linguistic systems, a trait that could confer advantages in tasks requiring complex auditory scene analysis.

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The impact of auditory cues on accuracy, as observed across both linguistic groups, corroborates earlier studies by Bion et al. (2011) and Langus et al. (2016), highlighting acoustic markers' critical role in language processing. These findings suggest that bilinguals' differential response to session types could be influenced by their exposure to varied rhythmic patterns in their two languages, supporting Hypothesis 1.

#### 5.4 Audio Type On Accuracy

Further analysis focused on the type of audio, distinguishing between correct and incorrect cues. It confirmed that the nature of the audio significantly affects accuracy. This suggests that the characteristics of auditory stimuli are crucial in cognitive processing across linguistic groups.

Subgroup analysis further differentiated the effects of session type and age on accuracy within audio scenarios. Monolinguals showed no significant impact from these variables in correct and incorrect audio conditions. However, bilinguals demonstrated significant age-related effects in both scenarios, with session type also affecting accuracy significantly in incorrect conditions.

These findings contribute to understanding the profound effects of acoustic markers and rhythmic structures on auditory perception and memory. These results can be compared to the research by Bion et al. (2011) and Langus et al. (2016), which emphasized the influence of auditory markers and rhythmic structures shaped by native language on cognitive processing. In these findings, the nature of the audio—correct versus incorrect cues—significantly affected task accuracy, underscoring the role of auditory stimuli properties in language processing tasks. This correspondence suggests that auditory characteristics continue to influence cognitive tasks across age groups and linguistic backgrounds, consistent with the role of acoustic markers in speech perception outlined by Bion et al. (2011). In our study, the significant effect of session type on bilingual individuals, particularly in scenarios involving incorrect audio cues, may reflect advanced adaptability and cognitive flexibility among bilinguals. This could be due to their experience with multiple rhythmic patterns from different languages, suggesting that bilingualism may enhance the ability to process and adapt to varied auditory environments. This finding aligns with Langus et al.'s (2016) observation that rhythmic perceptions are deeply influenced by the linguistic context shaped by an individual's native language.

Figure 6 clearly illustrates that both groups experience decreased accuracy with incorrect audio cues, with a steeper decline for monolinguals. This visual representation aligns with the statistical findings and highlights the greater susceptibility of monolinguals to audio inaccuracies.

These findings support Hypothesis 1 and Hypothesis 2, indicating that bilinguals have enhanced auditory processing flexibility and can better adapt to varied auditory environments. This adaptability might be due to their experience with multiple rhythmic patterns from different languages, suggesting that bilingualism enhances the ability to process and adapt to varied auditory stimuli.

### 5.5 The Significance Of English in Turkey

English has been integrated into the education systems of many countries, such as Turkey. English is a significant language in Turkish society, with a role in national education and the job market since the initial contact dating back to the Ottoman Empire around the 1530s (Dogancay-Aktuna, 1998). Turkey currently has an EF English Proficiency Index (EF EPI) general score of 493 (low proficiency), and the capital, Ankara, has a score of 503 (moderate), with an increase being reported since 2019 (EF Education First, 2023).

Learning English in Turkey holds significant importance due to its role as a gatekeeper for advancement in prestigious jobs. Proficiency in English is associated with better positions and higher pay. It is often a prerequisite in job advertisements, especially those dealing with import and export, data analysis, product management, sales, and secretarial tasks. Therefore, English proficiency can significantly benefit an individual's career opportunities and social status in Turkey. The spread of English in Turkey has been rapid and has made English a vital factor in Turkish educational institutions and the job market. This spread has incentivized people to learn English for its instrumental rewards. However, due to discrepancies in how English is taught, those at the upper ends of the socioeconomic ladder usually have access to it, perpetuating the division between the upper and lower socioeconomic strata. (Dogancay-Aktuna, 1998).

In Turkey, access to information heavily relies on English proficiency for more current up-to-date knowledge. The internet, a primary source of information for many, predominantly uses English. Many academic journals, databases, and global news outlets also primarily use English. Thus, English proficiency greatly expands one's access to information, enabling them to access international news, scientific research, and other resources not available in Turkish. As a result, English proficiency becomes more than just a communication tool. It serves as a means to access current information in Turkey and aids in integrating citizens into the global information ecosystem.

Another factor that might have contributed to the vast expansion of English in Turkey is media consumption, particularly through digital platforms. Streaming services such as Netflix have around 2.5 million active subscribers based in Turkey (*Top Streaming Services by Subscribers in Turkey*, n.d.). The dominance of English in global media cannot be overstated. It is the preferred language of most international content, from movies TV series, documentaries and news broadcasts. Therefore, learning English transcends its practical and business value and delves into Turkey's entertainment realm. It becomes more than a language but a medium through which Turkish citizens can access a broader scope of leisure activities and cultural experiences. This, in turn, might serve as a potent incentive, motivating more Turkish individuals to learn English or become more accustomed to it.

This research, therefore, highlights how valuable it is to understand how bilingualism affects native listening. As our cultures become increasingly multilingual, the effects this has on our auditory processing will become more significant.

### 5.6 Limitations

While this study has a larger sample size than similar studies, the variety in age groups indicates that more participants could strengthen the results, especially when studying age-related effects. Additionally, this research focused exclusively on Turkish-English sequential bilinguals. Therefore, the results may not apply to simultaneous bilinguals or individuals speaking different language pairs. Moreover, using iambic syllable sequence recall to test native listening skills may have limitations. This specific task might not fully capture the broader aspects of native listening abilities and how they interact with bilingualism. Future research should consider incorporating a wider variety of tasks to provide a more comprehensive assessment of native listening skills in bilinguals.

### 5.7 Future Directions

Future research could explore different bilingual groups to see if these findings hold universally. Investigating the cognitive mechanisms behind bilingual advantages, perhaps through neuroscientific methods, would deepen our understanding of how bilingualism influences language processing. Additionally, studying the impact of the age of second language acquisition could yield insights that are beneficial for optimizing language education strategies.

Moreover, it would be interesting to investigate the psychological and sociocultural factors that could influence bilingual individuals' performance in native listening tasks. Understanding how bilinguals' self-perceived language proficiency, attitudes towards their languages, and cultural identities interplay with their cognitive performance could shed light on the intricate interplay between bilingualism and cognition.

### 5.8 Conclusions

This research has highlighted the complexities between bilingualism and native listening skills. Despite the minor and statistically insignificant impact of group membership (bilingual or monolingual) and session types (duration or pitch), significant influences were observed from factors such as the age of the participants and audio cues. This suggests that while bilingualism may not drastically alter native listening skills in the ways it was anticipated, it cannot be completely discounted as a factor in shaping these skills.

Interestingly, the participants' age significantly affected their ability to recall iambic syllable sequences. This implies that as individuals mature and have more exposure to their languages, their native listening abilities may evolve, which is a compelling direction for future research.

In conclusion, while bilingualism might subtly influence native listening abilities, it's evident that other factors, such as age and specific linguistic cues, may have a more pronounced effect. This study underscores the need for further research into the multifaceted impacts of bilingualism on cognitive and linguistic processes.

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