Phonological Perception Awareness: A Study with Bilinguals

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Abstract

This study aims to investigate the perception of Arabic-English bilinguals towards the phonological characteristics of English. It also explores whether they establish separate phonological categories for their second language, independent of their first language. Regarding the sample, the study divided the twelve participants into two groups: a control group of native American-English speakers (NS) and an experimental group of Saudi Arabian learners of English as a Second Language (NN), who exhibited varying proficiency levels. Four cognitive tasks were conducted to assess the participants' ability, on the one hand, to distinguish between correctly and incorrectly produced initial letter combinations of English words, and on the other hand, to identify speech with a foreign accent. By applying descriptive statistics and chi-square tests, the researcher analyzed data from bilingual assessment responses. The results showed that the bilinguals consistently identified unbroken letter combinations which formed a distinct phonological category for English. Older bilingual subjects demonstrated significantly better accuracy in distinguishing between native and semi-native speech due to increased exposure and the development of their perceptual processing skills. Phonetic analyses of the stimuli revealed differences in syllabic and suprasyllabic features, such as vowel duration, syllable quality, and overall word length. These differences likely helped identify dialects. These results support the theory that children who become bilingual early on are able to develop separate sound rules for each language. They also highlight the importance of sound cues when listening to a second language. The study concludes with recommendation for replications to include increasing the number of stimuli and participants to improve generalizability.

Keywords: Bilingual, phonological characteristics, perceptual tasks, suprasyllabic features

1. Introduction

Whether bilingual learners can achieve the same level of proficiency in a second language as native speakers has been a topic of ongoing debate in the field of second language acquisition. Many experiments have shown that children do better in their L2 either when perceiving or producing the language. They can usually attain a native-like proficiency in their second language quite easily (Flege et al., 1999; Montrul, 2009; De Houwer & Ortega, 2018). Some other authors, like Darcy and Krüger (2012) and Paradis and Genesee (1996), disagree with claiming that attaining a native-like proficiency is not guaranteed for bilingual children.

Furthermore, the wide variety of bilingual characteristics further complicates the discussion. Green and Aboutalby (2013) indicated that second language acquisition can be sequential (first language then second) or simultaneous (first and second languages at the same time). On the other hand, distinction between these two types remains a subject of debate among researchers. In the same context, De Houwer (1995), Genesee and Nicoladis (2007), Montrul (2009) Al-Ahdal (2020) argue that simultaneous bilingual children are those who start learning two or more languages from birth. However, since the delineation of categories is still unresolved, we decided to avoid theoretical debate and instead use practical criteria. Participants were grouped based on when they began exposure to English (their second language). The detailed reasons for this are explained in the methodology section.

There are two or more languages in bilingual environments: the dominant and the minor language(s). The dominant language is the one used most of the time, while the minor language is used less frequently. Bilingual children typically grow up in environments with a "dominant language" and a "lesser language," and the balance of these two languages significantly influences their language proficiency (Montrul, 2009). This study examined the cognitive abilities of Arabic-English bilingual children aged 3 to 7 years old who were exposed to English. Arabic and English differ significantly, particularly in the way consonants are joined.

Since the L1 and L2 of the subjects in this study feature certain phonological contrasts, it could be hypothesized that some variation would emerge during this experiment. Hence, the study aimed to investigate the proficiency of these Arabic-English bilingual children in identifying the correct pronunciation in their L2, examine their facility with broken and unbroken word-initial clusters, and determine the phonological clues they use to discriminate between accurate and inaccurate pronunciation (see methodology). It was hypothesized that the subjects would perform like native speakers in their L2 perception due to broad exposure to an English environment. Further, they would possibly not perceive these errors like native speakers due to the phonological interference by L2.

1.1 Research Gaps and Objectives

Pronunciation and phonetic acquisition of L2 have been extensively studied. However, there are still only a few studies that thoroughly examine how Arabic-English bilingual children distinguish differences in the sounds of their second language or how they distinguish foreign accents in the early stages of learning. Furthermore, previous research has produced mixed results. Some studies have shown that children exposed to bilingual environments from an early age exhibit native-like recognition of the second language (Flege et al., 1999; Fokes et al., 1985). On the other hand, other studies have shown that the influence of one's native language cannot be completely eliminated even after years of exposure to English (Pallier et al., 1997; Darcy & Krüger, 2012). These discrepancies may be due to differences in research methodology, such as the materials used, the way tasks were designed, and the backgrounds of the participants.

1.2 Research Questions and Hypotheses

This study therefore addresses these issues using carefully designed cognitive tasks and speech analysis. Furthermore, this study made the following assumptions: Children who are fully immersed in an English-speaking environment will achieve native-level scores in second-language listening comprehension. However, the influence of the sounds of their native Arabic will not completely disappear, and they will perceive some errors differently than native-speaking children.

2. Literature Review

Few studies have investigated early bilinguals' L1 and L2 phonotactic categories in relation to their perceptual abilities in the second language.

2.1 Theoretical Framework: Phonetic Categorization in Bilingual Acquisition

This review is based on two important theoretical concepts. First, "phonetic categorization" refers to the mental image of acceptable sound sequences in a language. For example, English allows the /sp/ sound at the beginning of a word, but Arabic does not. Second, "perceptual ability" refers to the ability to distinguish between native-speaker-like and non-native pronunciation. The "intelligibility threshold" refers to the minimum difference necessary for a listener to detect a sound difference (Fleg and Efting, 1987). These concepts form the basis for explaining how bilingual children acquire pronunciation.

Using the AXB discrimination task, researchers found that bilingual children could distinguish and produce English vowels at native-speaker levels, but only initially. This result supports the phonetic learning model (Fleg, 1995), which suggests that early exposure to a new language facilitates the formation of sound images (phonetic categorization). In particular, this study also showed a strong correlation between pronunciation accuracy and listening ability, suggesting that cognitive ability likely underlies pronunciation.

However, because this study was cross-sectional, it is not possible to make definitive statements about developmental trends. Furthermore, the sample size was small, with 20 participants per group, so caution is advised when generalizing the results. Fleig and Mackay (2004) replicated similar results in Italian-English bilingual speakers in Canada. They also found that frequent use of one's native language affected second language comprehension, which is an important consideration when selecting participants. This result has been indirectly supported by subsequent research (Fleig & Efting, 1987; Al-Ahdal, 2020; Al-Otaibi, 2022; Al-Otaibi, 2021; Al-Otaibi, 2018; Al-Otaibi, 2013), which shows that early learning is indeed key.

Fleig and Efting (1987) studied how native Spanish speakers produce and understand English. Participants were divided into two age groups. The first group consisted of adult Spanish speakers, some of whom had been bilingual since childhood, and a second group of young adults who had become bilingual later in life. In the word production task, participants read aloud a list of words; in the word comprehension task, they pronounced "ta" or "da" based on their understanding of these sounds in the words they heard. The performance of both groups was then compared to that of native English speakers of the same age.

As this study focused on perception, the authors concentrated on perceptual tasks that confirmed adults' ability to form sound clusters in the second language (L2). Furthermore, these clusters were influenced by their native language (L1), with the comprehension threshold for bilingual Spanish-speaking children being significantly higher than that of bilingual adults. The comprehension threshold for bilingual Spanish-speaking children was 32.9 milliseconds, compared to 29.9 milliseconds for English-speaking children. For bilingual Spanish-speaking adults, the comprehension threshold was 28.3 milliseconds, compared to 42.6 milliseconds for English-speaking children. Seen together with Flege et al. (1999), the results highlight the higher level of L2 perceptual ability of young early bilinguals compared to that of older early bilinguals. This suggests that early bilinguals may establish two separate phonotactic categories that do not interfere with each other in their underlying phonological system. This might lead to native-like proficiency in their L2 production and in their attested L2 perception. A major strength of this study is that it used multiple pronunciation and comprehension tasks and matched the ages of the comparison groups. However, because the speech stimuli used were limited to isolated syllables (/ta/ and /da/), it's difficult to gauge how this works in everyday conversation. To be honest, this may be a bit far removed from natural speech situations.

Fokes et al. (1985) investigated the production of English stops by early bilingual Arabic children who had lived in an English-speaking country between the ages of 2 and 11. This study examined the cues these children used to recognize voicing contrasts in stops, focusing on voice onset time and vowel duration before the stop consonant in the final position. The results showed that, though these bilingual children had acquired facility in producing voicing contrasts, their VOT values were higher than those of adult native speakers of English. Overall, the subjects seemed able to use the VOT contrasts as cues and to make distinctions based on the length of the vowel preceding the final stop. The authors drew attention to the role played by language experience in the subjects' performance.

In contrast to previous studies on native-like L2 perception among early bilinguals, other studies have reached different conclusions. Hogan and Fleig (2006) compared bilingual Spanish speakers' ability to distinguish English vowels with that of native Spanish speakers. Participants were selected from three groups: 20 bilingual Spanish speakers, 20 monolingual English speakers, and 20 monolingual Spanish speakers (all adults). Participants' performance was assessed using the AXB Categorical Discrimination Test. The results showed that monolingual Spanish speakers performed worse than both bilingual Spanish speakers and monolingual English speakers. However, their ability to distinguish Spanish consonants was significantly lower than that of monolingual English speakers. The authors declared that these results demonstrated differences in cognitive processes between bilingual Spanish speakers and monolingual English speakers.

Research has shown that first-time Spanish speakers can acquire sound patterns different from those of their native language, but their second-language sound patterns are more likely to differ from those of native English speakers. Paller et al. (1997) reported similar findings. In this study, 40 university students were divided into two groups. The first group consisted of first-time bilingual speakers who had learned Catalan at an early age (6 years) and whose native language was Spanish, with Spanish-speaking parents. The second group also consisted of native Spanish speakers, mostly native Catalan speakers, while some spoke other languages. Since /e/ is the only front vowel in Spanish, this study sought to investigate how the participants perceived the Catalan front vowels /e/ and /ɛ/. The seven vowels (s1-s2) that form the triggers represent a continuation of /e/ to /ɛ/, which was later used in three tasks: a classification task, an AX discrimination task, and a judgment task. This finding demonstrates that early exposure alone does not guarantee native-like perception when the native language acoustic filter is active, challenging the strong version of the critical period hypothesis.

In all three tasks, the group born in Catalonia performed better than the group born in Spain in recognizing the vowels /e/ and /ɛ/. These results suggested that individuals born in Catalonia show two phonemic discriminations, whereas those born in Spain show only one, despite having learned Catalan early in life. The authors suggested that the Spanish phonological system makes it easier for the latter group to recognize /ɛ/ and hinders their ability to distinguish between /e/ and /ɛ/. Similar observations were made by Sebastián-Gales and Soto-Farráco (1999), who examined the perception of phonemic discrimination in Catalan by bilingual adults who had previously learned the language. A , structured procedure was used for this assessment. Participants were divided into two groups. The first group consisted of native Spanish speakers who had studied Catalan for three to four years, while the second group consisted of native Catalan speakers who had learned the language from day one. The results showed that bilingual Spanish speakers needed time to properly recognize Catalan sounds and vowels. Furthermore, the researchers confirmed that bilingual Spanish speakers were already influenced by their native language when they first learned Catalan, and that learning a new language alone was not enough to overcome this influence. This finding demonstrates that early exposure alone does not guarantee native-like perception when the native language acoustic filter is active, challenging the strong version of the critical period hypothesis.

Darcy and Kruger (2012) observed that native-language phonology has a strong influence on second-language acquisition. They studied how Turkish children recognize and pronounce vowels in German as a second language. Specifically, the children were asked to classify unknown vowels in a comprehension task and then name them in a pronunciation task. The study included 14 bilingual Turkish children, with an average age of 11.2. They had been studying German for about seven years. Comparing the performance of these children with native German speakers, they found that while the Turkish children struggled with the comprehension task, they did not exhibit similar difficulties with pronunciation. In fact, their pronunciation results were very similar to those of native German speakers. The authors emphasize that native-language pronunciation has no clear impact on German language acquisition, even when children are learning German for the first time. These findings are consistent with numerous previous studies investigating the influence of native language on second-language acquisition. The researchers emphasized that native pronunciation has no clear effect on German acquisition, even at the early stages of learning, a finding consistent with previous studies but raising questions about the mechanisms underlying the asymmetry between perception and production.

While the phonetic features of the first language (L1) are important for understanding the second language (L2), they are not the only challenges bilingual speakers face. Bent et al. (2010) studied how bilingual Korean adults and native English speakers identify English vowels. They used recordings of vowels produced by 10 different speakers and asked listeners to choose the correct vowel in CVC words from 10 options displayed on a screen. The results were clear: native English speakers performed 22% better than bilingual Koreans. Phonetic analysis revealed that the Koreans exhibited specific error patterns due to differences in the phonetic systems of the two languages. Americans, on the other hand, were not affected by these differences because they fall within the phonetic range of Standard American English. However, the Koreans were unable to produce vowel combinations comparable to those of native speakers.

In summary, for early bilinguals, the time of L2 acquisition and the amount of exposure to the L2 is an important factor in their L2 perception. Previous studies on early bilinguals' L2 perception have reported inconsistent findings regarding their performance. Some studies have shown that early bilinguals can form two separate phonotactic categories for their L1 and L2 without interference between them. This allowed them to perceive L2 speech through an L2 phonotactic category just as native speakers did. On the other hand, other studies have shown that the formation of a phonotactic category that differs from that of the L1 does not necessarily mean that early bilinguals' perception would be native-like. This is likely to be due to the characteristics of their L1's phonotactic category.

This review of studies on L2 perception among early bilinguals suggests that several factors may explain the variable performance of early bilinguals. These factors could include the amount of exposure to the L2, the time of L2 acquisition, the loss of plasticity with age and, speech variability. Apparently, more focused research is needed to investigate L2 perception and the ability of early bilinguals to discriminate among the various sounds of their L1 and L2. Therefore, in the present study, we first collected data by carefully

manipulating phonological regularities (segmental vs. continuous) and the speaker's native language (native vs. non-native). We then acoustically analyzed the stimuli to identify the cues listeners actually rely on. Furthermore, we addressed gaps in previous research by examining age-related differences in bilingual participants and openly reporting methodological limitations. Specifically, we investigated whether early Arabic-English bilinguals could recognize violations of phonological rules in their second language as well as native speakers. We also aimed to clarify the acoustic cues they used when distinguishing foreign accents. Answering these questions will provide new theoretical insights into models of bilingual phonological representation and provide practical insights for second language educators.

3. Methodology

This study was conducted within the framework of quantitative research. It used both descriptive and inferential statistics to analyze the data and address the research questions. This section presents information concerning the aim of the study, the subjects, the research questions, the instrument, the procedure, and the methods used for data analysis. As mentioned earlier, the study aims to investigate bilingual raters' perceptions of a foreign accent.

3.1 Research Questions

The study seeks to answer the following questions.

1. Do Saudi L2 learners of English establish a new phonetic category for English as their level of proficiency increases?
2. Do Saudi L2 learners utilize the preceding vowel duration as a cue to final stop voicing in English?

3.2 Subjects

The subjects enrolled in this study were selectively assigned to two groups: There were three subjects in the Control Group, and all were American-English learners, one female and two males, the mean age was 22 years, and the age range was 19-25. The Experimental Group was larger, with nine subjects (four females and five males) aged 19-23 years, with a mean age of 21 years.

The experimental group (EG) subjects were selected from EFL learners studying at Indiana University, Bloomington, who had been in the US for at least 3 months. All subjects were recruited through word of mouth. The participants' self-reported TOEFL IBT scores were used to identify their proficiency levels as per Table 1 below:

Table 1. Participants' Self-Reported TOEFL IBT Scores

Level of proficiency	IBT-TOEFL
Advance	TOEFL 80-120 / Level 6 & 7
Intermediate	TOEFL 50-70 / Level 3, 4 & 5
Beginners	TOEFL 20-40 / Level 1 & 2

3.3 Instruments, Procedures, and Data Analysis

The present study used quantitative methods. Data were analyzed using descriptive and inferential statistics. Detailed methodology, including the study objectives, participants, equipment, procedures, and data analysis methods, is described below. First, the researchers recorded four English words ("word list and evidence") using a laptop and external microphone. The audio was then played to participants through an HP 6000 speaker. To control for these conditions, participants took the test individually at home at a set time. Everyone sat in front of their laptop and speakers, with the volume set to 100%. Researchers adjusted the volume if the participant(s) requested. There were four listening tasks in total. Participants were asked to verbally answer "yes" or "no" to indicate whether the recorded words sounded natural. Researchers recorded their responses.

It is worth mentioning that the rating scale used for the younger subjects was slightly different. Due to their age-related lexical limitations, they were asked in the first and second tasks whether the words they uttered were correct or not. In the third and fourth tasks, they were asked whether the words had been uttered by a Saudi or an American. The task was divided into four parts. In the first two parts, the subjects provided the data that would answer the first research question, and their responses served as the basis for the third and fourth tasks to provide the data that would answer the second research question.

In the first task, the subjects heard four English words pronounced twice, once as an initial clustered word and again as a broken initial clustered word (both words being uttered by a native speaker (NS)). The words were played across four tracks, each containing different words. The uttered words were played randomly within each track. For example, the first word in the first track featured an initial cluster and the second word contained a broken initial cluster, while the first word of the second track had a broken initial cluster and the second word contained an initial cluster, e.g., W1 CC/CIC, W2 CIC/CC, W3 CC/CIC, etc. The second task replicated the first task two days later, using the same English words, but this time uttered by a near-native speaker (NN) in the following order: W1 CC/CIC, W2 CIC/CC, W3 CC/CIC, etc.

The subjects performed the third task three days later. In this task, the subjects heard the same four English words with only broken initial clusters, presented once by the NS and once by the NN. The uttered words were played randomly within each track. For example, the first word of the first track was uttered by the NS and the second word by the NN, while the first word of the second track was uttered by the NN and the second word by the NS, e.g., W= CIC W1 NS/NN, W2 NN/NS, W3 NS/NN, etc.

The fourth task replicated the third task two days later, using the same English words, but this time all the words contained an initial cluster: W = CC W1 NS/NN, W2 NN/NS, W3 NS/NN, etc.

The collected data were later analyzed using the Statistical Package for the Social Sciences (SPSS 16.0) through the use of a chi-square test of independence and descriptive statistics. The chi-square test was used to measure the subjects' perceptions of the same two words, as rated by both groups: an older early bilingual group and a younger early bilingual group. The rating was calculated for each heard word as a separate mean score. If the heard word was rated as having been pronounced much like a native, its numerical value was 1, while a value of 0 was given to words that had been rated as not having been pronounced much like a native.

4. Results and Discussion

The present study aimed to examine bilingual listeners' perceptions of a foreign accent. Towards this end, two questions were formulated to serve as the research questions. These questions were designed to elicit the perception of a foreign accent among bilinguals.

The first research question was aimed at finding out whether bilinguals establish separate phonotactic constraints for English words. For this purpose, two tasks were conducted with the same subjects. The first task examined their perception of broken/non-broken initial clustered words uttered by a native speaker, and the second task examined their perception of broken/non-broken initial clustered words uttered by a near-native speaker.

The results of both tasks revealed the subjects' high ability to detect differences between broken and unbroken clustered words. In Task 1, when the subject heard the broken and non-broken initial clustered words uttered by the NS, 100% of the subjects rated the non-broken clustered words as sounding most like having been pronounced by a native speaker. The same held true in Task 4: when the NN uttered the same words, the subjects chose the non-broken cluster.

These findings provide some support for the Speech Learning Model (Flege, 1995), which postulates that L2 speakers can improve their production and, similarly, their perception of the L2 by establishing an L2 phonetic category separate from their L1 phonetic category. The findings represent evidence in support of the Full Access hypothesis (Cook, 1988), which simply proposes that the acquisition of an L2's properties will be independent from the speaker's L1 and will not be affected by the properties of the L1. In light of these two hypotheses, the bilingual subjects' underlying phonological system would be divided into two categories without any interference between them. The language learner's L1 and L2 phonotactic categories would then differ from a monolingual's sole L1 phonotactic category.

Despite the fact that the subjects' L1 was Arabic, which, unlike English, allows initial broken clusters, they did not choose the uttered broken-clustered words as sounding close to a native speaker's pronunciation. Instead, 100% of them chose the non-broken cluster as being closer to the pronunciation of a native speaker in both tasks. This could possibly indicate the existence and the independence in their minds of English L2 phonological constraints; otherwise, they might have chosen either the broken clustered words or a combination of the broken and non-broken clustered words. These findings are in line with previous research by Fleig et al. (1999) and Fleig and Efting (1987). Previous research has shown that bilinguals who acquire two languages from an early age are able to create distinct phonological classes in their second language, and their ability to hear and speak English sounds is nearly comparable to that of native speakers (Fox et al., 1985).

Based on these findings, one can posit that the bilingual subjects had established two phonotactic categories in their underlying phonological systems. These two phonotactic categories are L1 Arabic and L2 English, and as the subjects perceived the words, these categories functioned separately without overlapping. This means that each of the heard words was processed through one of these categories only, and because in this instance they were English words, they were perceived only through the L2 English phonotactic category without being influenced by the L1 Arabic phonotactic category.

These results contradict those reported by Højen and Flege (2006), who found that bilinguals differ from native speakers in L2 perception. They also contradict the results reported by Pallier et al. (1997), Sebastian-Galles and Soto-Faraco (1999), and Darcy and Krüger (2012) regarding the influence of the L1's phonotactic category upon the L2's phonotactic category in the perception of the L2. Neither does it accord with the conclusions reported by Bent et al. (2010) regarding the influence of speech variability on bilinguals' L2 perception.

The second research question was to investigate the cues that bilinguals may use in detecting a foreign accent. For this purpose, a third and fourth task were conducted with the same subjects. The third task examined their perception of broken initial clustered words uttered by an NS and an NN, and the fourth task examined their perception of non-broken initial clustered words uttered by the NS and the NN. In both tasks, based on the initial results, the subjects were categorized as younger or older bilinguals. Later, the results were analyzed through descriptive statistics and a chi-square test.

In the third task, the chi-square test revealed significant age differences in perceiving and rating the uttered words by both native and near-native speakers. As can be seen in Table 2, the results of the third task revealed that the age of the subjects played a significant role in their perception of a foreign accent, $X (N = 6) = 6000$ $p = .014$.

Table 2. The significance of the subjects' age in task 3

Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.001[a]	1	.013		
Continuity Correction[b]	2.757	1	.103		
Likelihood Ratio	7.451	1	.003		
Fisher's Exact Test				.100	.050
N of Valid Cases	6				

a. 4 cells (100.0%) have an expected count of less than 5. The minimum expected count is 1.50.

b. Computed only for a 2x2 table

The subjects' ratings of the broken, clustered words by native and near-native speakers varied by age category are depicted in Figure 1. The cluster bar chart demonstrates that the younger subjects perceived and rated both types of uttered words as sounding **not** close to a native speaker's pronunciation, while the older subjects perceived and rated the words uttered by the NS as sounding closer to a native speaker's pronunciation than the words uttered by the NN.

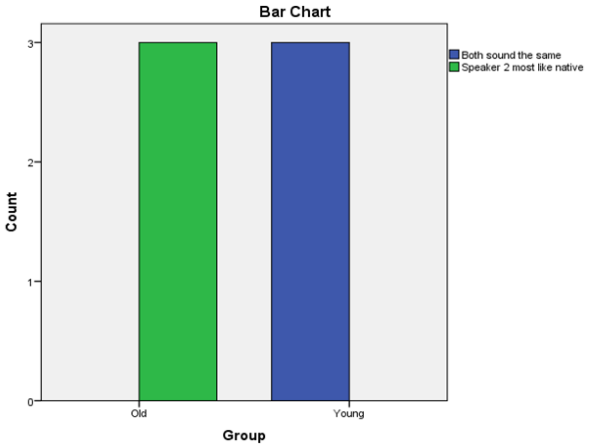


Figure 1. Cluster bar chart for subjects' ratings in Task 3

In the fourth task, in which subjects heard the non-broken cluster produced by native and near-native speakers, age was not a significant factor in perceiving or rating the speech. As shown in Table 3 for the fourth task, the chi-square test results showed that age was not a significant factor in the perception of a foreign accent, X (N = 6) = 1200 p = .273.

Table 3. Significance of the subject's age in Task 4

Results of Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.200[a]	1	.273		
Continuity Correction[b]	.000	1	1.000		
Likelihood Ratio	1.588	1	.208		
Fisher's Exact Test				1.000	.500
N of Valid Cases	6				

a. 4 cells (100.0%) have an expected count of less than 5. The minimum expected count is .50.

b. Computed only for a 2x2 table

The following cluster bar chart in Figure 2 shows that five out of six subjects, three older and two younger ones, rated the native speaker's production as being closer to a native speaker's pronunciation than the production of the near-native speaker. Only one of the younger subjects rated the near-native speaker's production as closer to a native speaker's pronunciation.

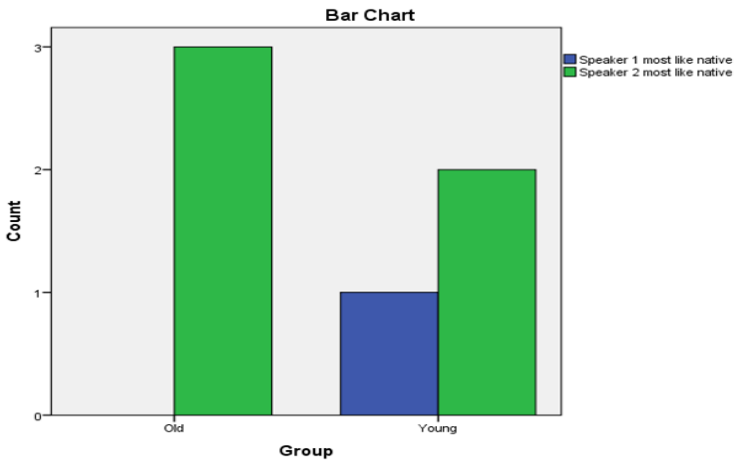


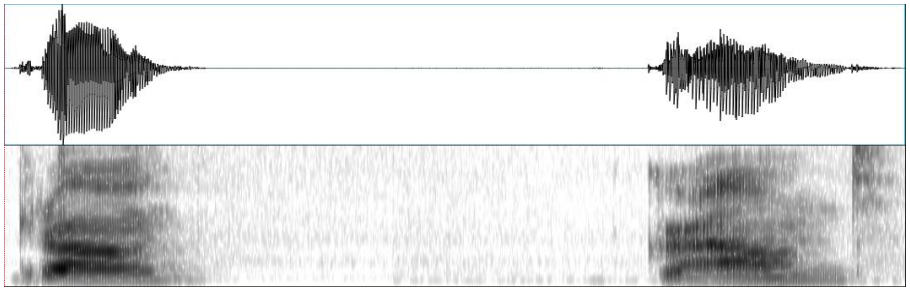
Figure 2. Cluster bar chart for subjects' rating in Task 4

The results of Tasks 3 and 4 establish the greater ability of the older subjects in determining which of the uttered words sounded "most native-like". The words that were uttered by the NS were always rated by the older bilinguals as sounding closer to a native speaker's pronunciation. This highly developed ability of discernment can be explained by the older bilinguals' greater exposure to their L1 and L2, which may have been sufficient to allow them to distinguish between the two types of words uttered by the two types of speakers.

Since our subjects had formed their L2 phonotactic category which would allow them to perform like native speakers in L2 perception, as attested by the results of Task 1 and Task 2, one may link this to what has been proposed by Cutler (2012); Best and Tyler (2007); Fleg (1984); Gottfried (2007); Gottfried and Beddor (1988), that adult native listeners are better in detecting whether a sample of heard speech has been uttered by a native or a non-native speaker.

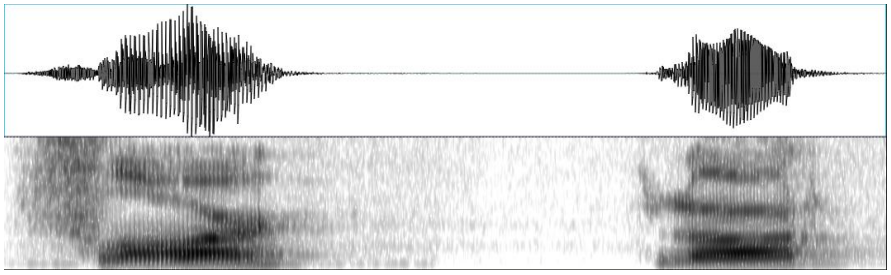
Yet, it seems that there were certain acoustic cues that the older subjects in Task 3 and, later, both the older and the younger bilinguals in Task 4 made use of in rating the words uttered by a native speaker as sounding closest to a native speaker's pronunciation. With these acoustic cues, the researcher returned to the research stimuli and conducted an acoustic analysis of the recordings of both the NN and the NS.

Interestingly, as had been expected, the researcher found that there were indeed acoustic differences between the NN's and the NS's speech (see Figures 3 & 4).



NN= [gɾɑwn] NS= [gɹɑwnt]

Figure 3. Spectrogram for ground by the NS and NN speakers



NS = [fɬoɹ] NN = [flor]

Figure 4. Spectrogram for floor by the NS and NN speakers

These two figures clearly demonstrate the differences between the NS's and the NN's speech. In Figure 3, the differences between the two uttered words lie mainly in vowel duration. The length of the diphthong /ɑw/ in the word "ground" was 271 ms in the NS's utterance and 185 ms in the NN's utterance. Also, the differences shown in Figure 4 were based on segment type. The word "floor" was uttered by the NS with a dark /ɬ/, while the NN pronounced it with a light /l/. See Tables 4 and 5 for further general acoustic analysis notes on the differences between the NS's and the NN's speech.

However, one of the main differences between the NS's and the NN's pronunciation was in word duration (see Table 4). The words that were uttered by the NS were always longer in duration than those uttered by the NN. There were also other minor differences in terms of segments, vowel duration, and VOT (see Table 5).

Table 4. Differences in word duration between the NS and the NN

Word	NS Task 3	NN Task 3	NS Task 4	NN Task 4
Floor	569 ms	529 ms	561 ms	415 ms
Snack	689 ms	598 ms	761 ms	501 ms
Ground	701 ms	459 ms	643 ms	514 ms
Train	625 ms	417 ms	577 ms	495 ms

Table 5. Some other segment and vowel duration differences between the NS and the NN; IPA transcript

Word	NS Task 3	NN Task 3	NS Task 4	NN Task 4
Floor	fɤɬɤɹ	fɤlor		
Snack	senæk æ = 144 ms	senæk æ = 67 ms	snæk æ = 216 ms	snæk æ = 153 ms
Ground	gɐɹɑwnd	gerɑwnd	gɹɑwnt	gɾɑwn
Train	teɹɑɪn VOT = 69 ms	terɑɪn VOT = 53 ms	tʃɹɑɪn	trɑɪn

These findings raise the possibility that segmental and non-segmental properties may serve as cues that subjects use to detect a foreign accent (see Tables 4 & 5). The possible use of these acoustic differences as cues also provides clear-cut evidence in support of what has been mentioned above regarding the establishment of an L2 phonotactic category separate from the L1 in the subjects' phonological systems. During the perception process, the subjects may have recognized the acoustic differences between the words uttered by the NS and the NN. This recognition may have developed as they acquired their L2, and so they knew the acoustical properties of the words as they are authentically uttered in the L2, along with their differences from words in their L1. According to McAllister et al. (2002), the lexical properties of L2 are instrumental in establishing a phonetic L2 category that is separate from the L1 in L2 acquisition.

This observation is similar to a study by McCullough (2013), which investigated the role of acoustic cues in detecting a foreign accent. The raters were adult native English speakers who listened to English words spoken by L1 American English, L1 Spanish, L1 Hindi, L1 Korean, and L1 Mandarin speakers. The results showed that VOT and vowel duration, along with vowel quality, contributed significantly to the subjects' detection of a foreign accent.

The findings in this study are a unique contribution to the understanding of bilinguals' perception of the phonological patterns of English as L2 and in this case, whether Arabic as MT learners construct distinct phonological categories for it. For example, the phonological similarities between bilingual learners and native English speakers appear to be closely related to the characteristics of the English letter set. This means that bilinguals created a new sound system for English separate from their native language. The Speech Learning Model (SLM) and Perceptual Assimilation Model (PAM) also uphold this, which means that bilinguals attain perceptual accuracy as they advance in language exposure and experience, as shown by the older participants in this study. The reasons are enhanced cognition and prior knowledge that help them achieve this state. Moreover, segmental and suprasegmental cues are used by bilinguals to draw the fine line between native and near-native speech, indicating that the negotiation between L1 and L2 phonologies is complex.

To summarize, three main points emerged. First, bilingual participants were able to clearly distinguish between segmental and non-segmental consonants, demonstrating that English has separate phonological categories for each. Second, there are changes in how participants distinguish foreign accents with age, with older bilinguals being particularly adept at distinguishing segmental consonants. Finally, acoustic analysis revealed clear differences in the pronunciation of NS and NN in terms of duration, articulation quality, and VOT, which served as perceptual cues. In other words, these results support the theoretical model that early bilinguals are able to maintain their own distinct phonological systems and that perceptual accuracy improves with experience.

5. Conclusion

The study shows that bilinguals can correctly identify a foreign accent in their L2. It also appears that they use separate phonotactic categories to identify correct or incorrect productions of L2 words. As presented in the previous section, almost all of the bilingual subjects were able to identify native and non-native productions of the correctly and incorrectly pronounced L2 words. On the other hand, there are some recommendations to be made. Analysis of the data of this study suggested that it would be beneficial to increase the number of words in the stimulus to make the results more generalizable. Although it is not easy to increase the number of participants in similar studies, it is recommended to replicate this study with more participants to include as many variables as possible. This study establishes that Arabic bilinguals are sensitive to English phonology, as they develop a separate and unique system for it with little or no interference from L1. They can distinguish between native and near-native accents since they adapt their phonological perceptions and

restructure knowledge with every added language exposure. Further, age plays a role in the development of this ability, as older subjects in this study demonstrated better discernment and discrimination skills. Earlier studies have upheld bilinguals maintain and polish two phonological systems (one for each language), and segmental and suprasegmental cues aid them as much as prolonged exposure.

6. Limitations

This study has several limitations that should be considered when interpreting the results. The most significant of these is the small sample size of 12 participants and the limited number of stimulus words (4), which limit the generalizability of the findings. Furthermore, the absence of a monolingual Arabic control group makes it difficult to fully isolate the specific effect of participants' native language on their perceptions.

7. Recommendations for Future Research

To build on these findings, it is strongly recommended that future studies use a larger, more diverse group of participants. Most importantly, increasing the number and phonemic variety of stimulus words is essential to validate the results. Furthermore, longitudinal studies that follow the same individuals over a long period of time will provide a clearer picture of how second-language phonology develops. Finally, comparing these results with data from bilinguals from diverse first-language backgrounds would help determine whether the observed effects are universal or language-specific. Since age and exposure play a role in enabling bilinguals to develop the skill to identify native accent characterized by unbroken clusters, phonological stimulus (in terms of number and variety) should be maximized across phonotactic situations. Learners should be provided with a more nuanced understanding through language exposure, and longitudinal studies to record bilinguals' abilities should be conducted.

Ethical approval statement

This study follows all ethical guidelines as mandated by the university concerning participant rights, data privacy, and ethical use of information gathered.

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Authors' contributions

Dr. Abdullah Alotaibi is responsible for the conceptualization and design of the study, data collection, data analysis, and manuscript drafting. The author also revised and approved the final version of the manuscript.

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The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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