Musical Aptitude and Phonemic Processing of English as L2 by Arabic Speakers

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Abstract: It is suggested that there is a connection between musical aptitude and the ability to process phonemes in a second language (L2) through acoustic processing. Previous research indicates that musical ability might aid in the processing of L2 vowel sounds, while findings regarding musical ability and L2 consonant processing are inconsistent. While some argue that musical aptitude can facilitate the processing of consonant phonemes, others contend that there is no correlation between musical ability and consonant phonemic processing. To address this issue, the present study examined whether the musical aptitude of Arabic speakers is closely linked to their processing of L2 English consonant phonemes, focusing on two English consonant phonemes absent in Arabic. Results indicated a strong correlation between Arabic speakers' musical aptitude and their accuracy in processing of English consonant phonemes. These findings suggest that individuals with better musical skills among Arabic speakers are more adept at perceiving English phonemes that do not exist in Arabic. These results have implications for the potential use of music as a pedagogical tool in L2 classrooms.

Keywords: Arabic**,** musical aptitude, perception, phonemic processing, second language

1. Introduction

Musical aptitude refers to the ability to structure acoustic material (Karma 1984), which is often measured through a musical aptitude test. While scores on musical aptitude tests mainly offer an individual learner's musical aptitude profile (Gordon 1967), the connection between musical aptitude and language has been extensively explored in the literature on music training. The rationale for investigating musical aptitude in connection with language processing or acquisition lies in the assumption that music and language share certain features in common. Both music and language are said to be generative in their nature (Zatorre, Belin and Penhune 2002: 37). They are hierarchically organized, rule-based systems that depend on how acoustic events unfold over time (Lerdahl and Jackendoff, cited in Cason and Schön 2012). More specifically, music and language rely on auditory learning and a hierarchical organization of elements. For example, in music, this progression can be observed from individual sounds to melodies, while in language, it extends from phonemes to sentences. They also share auditory pathways (Neves et al. 2022).

There is much evidence showing that music and language overlap in the networks of the brain. Using various functional neuroimaging techniques such as magnetoencephalography (MEG) or functional magnetic resonance imaging (fMRI), researchers have found that there is a common brain region within the temporal lobes which is activated in response to music and language stimuli (Maess et al. 2001; Meyer et al. 2002; Zatorre et al. 2002; Levitin and Menon 2003; Fadiga, Craighero and D'Ausilio 2009). There also seems to be a significant neural overlap between the process of music and various aspects of language, including syntactic processing (Patel et al. 1998; Maess et al. 2001; Patel 2003), semantic processing (Koelsch et al. 2004), and phonological processing (Besson et al. 2007; Patel 2007; Cason and Schön 2012; Magne, Jordan and Gordon 2016).

Musical aptitude has also been discussed with reference to second language acquisition (SLA). Based on the premise that music and language utilize similar fundamental processing mechanisms, researchers have explored whether musical aptitude or training affects one's capacity to perceive or perform more effectively in a second language (L2). A growing body of evidence suggests that musical aptitude is related to a speaker's proficiency in L2 phonology (Nakata 2002; Magne et al. 2006; Slevc and Miyake 2006; Marie et al. 2011; Sadakata and Sekiyama 2011; Jekiel and Malarski 2021) and it further facilitates the acquisition of non-native phonology (Chobert and Besson 2013). However, research on musical aptitude and L2 phonology has mostly focused on the processing or acquisition of suprasegmental features of L2 such as tone (Gottfried and Riester 2000; Schön et al. 2004; Delogu, Lampis and Belardinelli 2006, 2010; Marques et al. 2007; Wong et al. 2007; Marie et al. 2011).

There are several studies that investigated the processing of L2 segments, particularly consonant and vowel phonemes challenging for non-native speakers to process, yet the findings are varied (Nakata 2002; Slevc and Miyake 2006; Milovanov et al. 2010; Marie et al. 2011; Sadakata and Sekiyama 2011; Jekiel and Malarski 2021). While some studies demonstrate a positive correlation between music and the processing of L2 phonemes, others lack substantial evidence to support this perspective.

Three studies specifically focused on musical aptitude and phonemic processing, encompassing both consonants and vowels, in Mandarin Chinese as a foreign language (FL), testing against native Italian speakers (Delogu et al., 2006, 2010) and native French speakers (Marie et al., 2011). While Delogu et al.'s findings indicated that L2 phonemic discrimination remained unaffected by musical proficiency, musicians outperformed non-musicians in L2 phonemic variation tasks in Marie et al.'s study.

Apart from Mandarin Chinese, the processing of L2 phonemes concerning musical aptitude has been investigated in a few other languages such as Japanese and

English. Nakata (2002) examined Japanese consonant phonemes (e.g., geminates/double consonants) and long vowel phonemes through both perception and production tasks against adult native English speakers who had no formal training in music or Japanese. The study's outcomes varied depending on the task type (perception vs. production) and the L2 phoneme category (consonants vs. vowels), suggesting the need for further validation.

Similarly, research outcomes on English phonemic processing have been diverse. For instance, Slevc and Miyake (2006) explored how Japanese speakers process English phonemes in relation to musical aptitude. They tested English phonemes challenging for Japanese speakers to differentiate (e.g., */l/* vs. */r/* as in *clown* vs. *crown*) and found that musical ability predicted L2 phonological proficiency both in perception and production tasks. Jekiel and Malarski (2021) also observed a correlation between musical aptitude and the production of English vowels among Polish learners of English as an L2. Conversely, Molovanov et al. (2010) found mixed results concerning English consonant and vowel processing by Finnish speakers, indicating that while musical aptitude correlated with production, it did not necessarily do so with perception. This suggests that musical aptitude might not be a robust predictor of English phonemic perception among L2 speakers.

Overall, experimental research on musical aptitude and SLA suggests a strong connection between musical aptitude and suprasegmental features in L2 learning, whereas the association between music and L2 segmental or phonemic processing is less definitive. Especially, there is a scarcity of research specifically examining how musical aptitude influences the processing of L2 consonants, and the findings so far have been inconclusive. To address discrepancies in existing research and explore the potential relationship between musical aptitude and L2 consonant processing, this study investigates how Arabic speakers with varying levels of musical proficiency perceive English consonant phonemes absent in their native language.

2. The present study

To explore the potential correlation between the musical aptitude of Arabic speakers and their processing of L2 English phonemes, our study concentrated on two specific consonant phonemes, /v/ (a voiced labiodental fricative) and /p/ (a voiceless bilabial plosive), neither of which exist in the sound system of any Arabic dialects (Alfehaid 2015; Alshalaan 2020; Elwahab 2020). Therefore, these two phonemes might present difficulties for Arabic speakers in terms of perception or articulation. For instance, Alshalaan (2020) reports that Arabic speakers find it difficult to pronounce /v/ sound and use /f/ instead. Similarly, they may also use /b/ instead of /p/.

Drawing from this premise, the current study aimed to address the following research question: How is the L2 phonemic processing of learners influenced by their musical aptitude? Our hypothesis posited that individuals with greater musical aptitude would demonstrate superior L2 phonemic processing compared to those with lower musical aptitude. This would be evidenced by quicker processing times and reduced error rates on L2 phonemic assessments.

3. Method

3.1 Participants

A total of 34 Arabic speakers (10 males) participated in the study, (mean age = 20, range: 18-22) in exchange for a gift card. All participants had an intermediate level of English proficiency and scored lower than 6.5 (out of 9) on the IELTS (International English Language Testing System) or 80 (out of 120) on the TOEFL (Test of English as a Foreign Language).

3.2 Materials and procedures

The participants took a musical aptitude test followed by a phonemic discrimination test. On average, they took 40 minutes to complete both tests.

3.3 Musical aptitude test

The participants' musical aptitude was evaluated using the Profile of Music Perception Skills (PROMS), a comprehensive test battery designed to objectively assess musical abilities (Law and Zentner 2012). Specifically, we employed the mini-PROMS, a condensed version of the PROMS, which has been validated and shown to be reliable (Zentner and Strauss 2017). The Mini-PROMS assesses a wide range of musical skills and aptitude of people with no musical training and has been used to investigate a relationship between musical aptitude and other linguistic and non-linguistic disciplines (e.g., Malzer 2018; Georgi et al. 2023; Hunsacker 2023).

The test comprised a total of 36 items, with the participants typically requiring an average of 15 minutes to complete it. The participants listened to a brief music excerpt twice, followed by another music excerpt. Subsequently, they were tasked with determining whether the third excerpt matched the ones they had heard previously. Five answer choices were presented: (a) definitely same, (b) probably same, (c) I don’t know, (d) probably different, and (e) definitely different (refer to Figure 1). The participants were instructed to select the most appropriate response. If they provided a correct answer with full confidence by selecting either (a) or (3), they were awarded one point. Conversely, selecting (c) resulted in zero points. Responses falling within the middle range, (b) and (d), were assigned 0.5 points. Thus, the maximum attainable score on the test was 32 points. Participants’ behavior data (error rates and reaction time) were recorded to assess their musical aptitude.

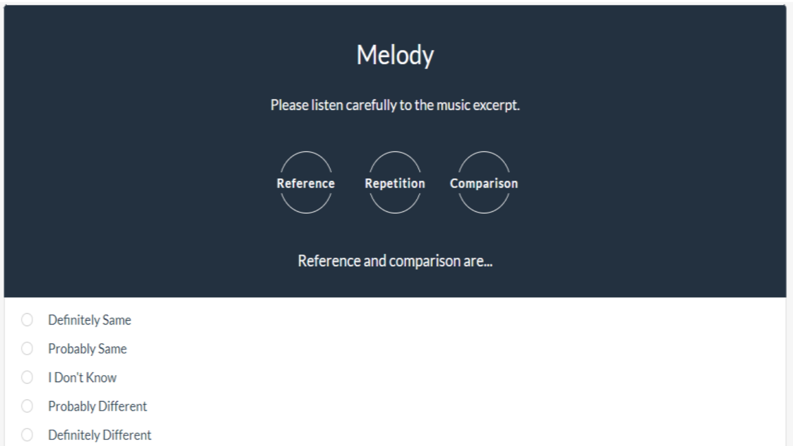

Figure 1. A sample question in the musical aptitude test

3.4 Phonemic discrimination test

We selected 32 English words that incorporate two consonant phonemes absent in Arabic, 16 with /v/ and 16 with /p/. Half of the test items had the target phoneme at the word-initial (or onset) position and the other half at the word-final (or coda) position (see Table 1). We closely matched the 32 words by replacing /v/ and /p/ with /f/ and /b/ respectively, the latter of which exist in both Arabic and English. The matched phonemes shared the place of articulation with the two target phonemes but contrasted with the voice feature: /v/ (voiced labiodental fricative) vs. /f/ (voiceless labiodental fricative) and /p/ (voiceless bilabial plosive) vs. /b/ (voiced bilabial plosive).

In the experiment, each of 32 words with a target phoneme appeared twice, once paired with the same word (e.g., van – van) and once with the word including the matched phoneme (e.g., van – fan). Thus, there was a total of 72 test items. Following a single listening session of a paired word list, participants were tasked with determining whether the paired words sounded identical or different. Examples as provided in Table 1.

Table 1. Examples of test items for the L2 English phonemic discrimination test

	WORD-INITIAL	**WORD-FINAL**
/v/ vs. /f/	vast vs. fast	save vs. safe
/p/ vs. /b/	pig vs. big	rope vs. robe

Additionally, we constructed 32 filler items including the phonemes /m/ or /n/ occurring at the beginning or end of words. Unlike /p/ and /v/, both sounds are present in both English and Arabic. Like the test items, half of these items comprised pairs of identical words (e.g., mere – mere, team – team), while the other half consisted of pairs of words closely resembling each other, differing only in the phonemes /m/ and /n/ (e.g., mere vs. near, team vs. teen).

All test items and filler items were randomized. The experiment was administered using Gorilla, an online platform (https://gorilla.sc/). Prior to commencing the test, participants were presented with five practice questions to ensure a thorough understanding of the experiment's instructions. To assess the participants' L2 phonemic processing, their behavioral data, including error rates and reaction times, were recorded.

4. Results

4.1 Accuracy

Figure 2 illustrates the percentage of correct discrimination of the word pairs as a function of musical aptitude score. As depicted in the figure, participants demonstrated improved performance in phoneme discrimination as their musical aptitude score increased. This is confirmed by the statistical analysis. We conducted a mixed-effects logit regression analysis to examine the participants' performance (correct discrimination = 1, incorrect discrimination = 0) with musical aptitude score as a continuous predictor (centered around its mean). To investigate potential variations in participants' performance across different phoneme pairs, we included phoneme pairs as an additional predictor in our analysis (/v/ vs. /f/ = 0.5, /p/ vs. /b/ = -0.5) and fitted maximal random effects structure (Barr et al., 2013). The results of the analysis revealed a significant effect of musical aptitude score ($\beta = 0.11$, SE = 0.02, $z = 6.31$, $p < .001$). There was no effect of phoneme pairs, however ($\beta = -0.33$, SE = 0.23, $z = -1.45$, $p = .15$). These results suggest that there is a significantly beneficial influence of the musical aptitude score on L2 phoneme discrimination.

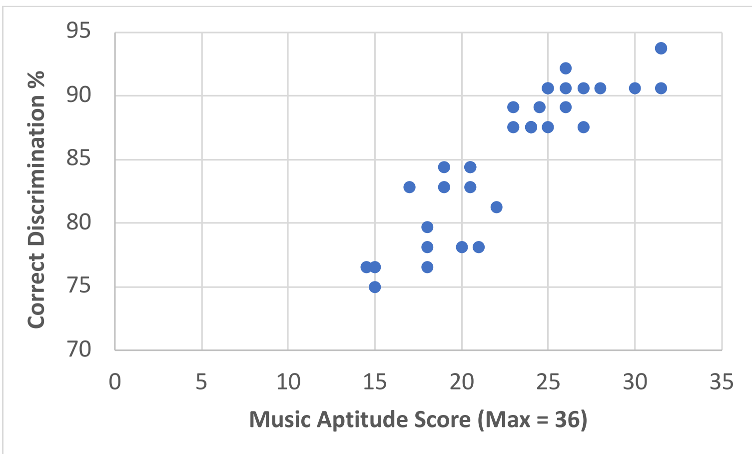

Figure 2. Phoneme discrimination accuracy as a function of musical aptitude score

4.2 Reaction times

For the analysis of reaction times, we initially omitted incorrect responses (315 trials). Subsequently, we eliminated all data points with residuals surpassing three standard deviations (106 trials). This resulted in 1,755 trials being included in the analysis. Figure 3 illustrates reaction times as a function of musical aptitude score. We examined the impact of musical aptitude score on reaction times by analyzing reaction times as a function of musical aptitude score in a linear mixed model. To ensure a normal distribution of reaction times, we log-transformed them. Similar to the accuracy analysis, we incorporated phoneme pairs as a predictor. The model included random intercepts for participants and items. The results revealed that reaction times were not affected by the musical aptitude score or the phoneme pair. Thus, we did not find any evidence that the musical aptitude score facilitates reaction times in the phoneme discrimination task.

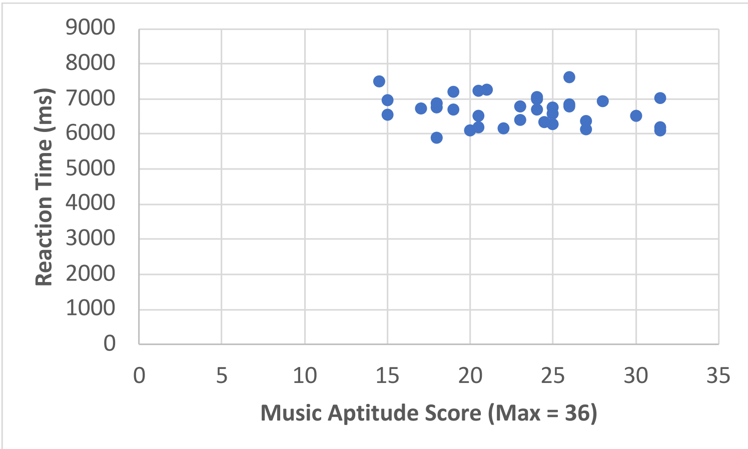

Figure 3. Reaction times as a function of musical aptitude score

5. Discussion

The purpose of this study was to explore whether musical aptitude of Arabic speakers learning English as an L2 promotes their proficiency in L2 phonemic processing, with a specific focus on two consonants absent in their native Arabic. Findings from a cohort of 34 adult Arabic speakers residing in the UAE revealed a strong correlation between their musical aptitude and accuracy in processing L2 English consonant phonemes, suggesting a potential role of musical ability in facilitating L2 phonemic processing.

Our findings contrast with the outcomes of Milovanov et al. (2010), who similarly examined the processing of L2 English consonants by Finnish speakers using a phonemic discrimination task akin to ours. In their investigation, no significant association was observed between musical aptitude and English consonant processing among L2 speakers. The disparate findings between the two studies may be attributed to various factors, such as differences in test materials and the linguistic backgrounds of participants.

First, there are differences between the two studies in terms of the test materials employed. In our study, we focused on two English consonants, /v/ and /p/, which are absent in the participants' native language Arabic (L1). Moreover, these two phonemes were presented in both the onset and coda positions of words. In contrast, Milovanov et al. (2010) investigated six English phonemes that are not present in the participants' native Finnish, including five consonants and one vowel. All six phonemes were examined collectively in their analysis; thus their results were not specifically confined to consonant phonemic processing. Furthermore, it remains unclear whether the position of these six phonemes was controlled for, as was done in our study.

In addition, there are discrepancies between the two studies regarding the control of participants' proficiency in L2. In our research, we assessed both the participants' English proficiency and their prior exposure to the L2 using IELTS or TOEFL scores, as well as a self-reported language history questionnaire. However, Milovanov and his colleagues simply noted that all their participants at the college level had received the same amount of English language education before enrolling in college, without providing any official L2 test scores. Thus, these variations in the methodologies employed in the two studies may have contributed to the differing results obtained. Given our careful control over the positioning of the target phonemes within words and the participants' proficiency in L2, our findings might provide a more accurate portrayal of how musical aptitude correlates with L2 phonemic processing among a uniform group of L2 speakers.

Our results further contribute to expanding the empirical foundation on musical aptitude and L2 phonemic processing. While existing literature has extensively examined the relationship between musical aptitude or training and language acquisition, there has been relatively little focus on the musical aptitude of L2 learners and its impact on their processing of the L2, particularly in the context of English as an L2 (e.g., Jekiel and Malarski 2021; Milovanov et al. 2010; Nakata 2002; Slevc and Miyake 2006). Our study thus adds to the understanding of L2 English consonant processing, an area that has received limited attention in the field.

Finally, the outcomes of our study offer valuable insights for language educators on the potential of music as a pedagogical aid in L2 learning environments. Incorporating music into language instruction and employing scaffolding methods that blend music and language lessons may effectively bolster the acquisition of second and foreign languages (Murphy 1992; Rosóva 2007; Ludke et al. 2014; Picciotti et al. 2018; Piri 2018; Al-Yasin and Hamdan 2023). “Being skilled at music means having a good ear for analyzing and discriminating foreign speech sounds, so that musically talented individuals are better equipped than other people to pick up various aspects of an L2” (Slevc and Miyake 2006: 675). This may suggest that music serves as an effective tool to enliven and facilitate the process of language acquisition.

However, we also acknowledge the limitations inherent in our study. We focused on two English consonant phonemes absent in Arabic, which were integrated into monosyllabic words positioned in both the onset and coda. While this deliberate choice aimed to ensure minimal pairing of test items, there is potential for further exploration with multisyllabic words, given research indicating that multisyllabic words may pose greater challenges in L2 production compared to monosyllabic words (Griffin 2003; Gilbert Cousineau-Perusse and Titone 2020).

Future studies could also explore the processing of English vowels by Arabic speakers. Arabic is known to have a relatively restricted vowel inventory, consisting mainly of /a:/, /i:/, and /u:/. Consequently, similar to the challenge posed by the two English consonants absent in Arabic, English vowels absent in Arabic are likely to present difficulties for Arabic native speakers to process. Therefore, it would be valuable to investigate whether musical training can assist Arabic speakers in processing L2 vowels. Including different aspects of L2 phonemes in future research endeavors will further elucidate the complex relationship between language processing and musical aptitude.

Notwithstanding these constraints, our study yields novel findings demonstrating a beneficial impact of musical aptitude on L2 consonant processing, a relationship not previously identified in prior research.

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