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Musical Ability and Accent Imitation

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I. Introduction

There is a long-standing debate about how similar music and language are, and what properties they share. Singing and speaking are both mediums to communicate produced through phonation and the use of articulators in the oral and nasal cavity. Meanwhile, all musicians must be hyper-aware of motor control and auditory components of music. Some experts say that music and language are two completely different entities that evolved along separate paths. Some suggest music is a subset that developed from language itself. Conversely, others believe that language developed from music (see Levman, 1992 for discussion). These varying views bring light to the fact that researchers today do not actually know the right answer to this question. Through examining the intersection of music ability and speech, I seek to discover how perceptual musical ability and vocal experience influences accent imitation ability.

Varying schools of thought on language and music can be categorized into domain general and domain specific (Asaridou and McQueen, 2013). The domain general account states that musical skills and language ability share similar underlying skills, while the domain specific account suggests that they rely on different sets of abilities and that this correlation between them does not stem from shared properties (Asaridou and McQueen, 2013). In this study, I test the domain general approach and predict that music and language are parallel systems for communication and rely on shared skills. Both singing and speech have the same signal generation and share how they are produced. Both rely on phonation from the vocal folds, resonance from the oral and nasal cavities, and articulation by the articulators. They also share how they are received and perceived. Both have auditory properties and need to be received through the auditory system. Based on these facts, it is logical to predict that they both overlap in terms of the skills and capabilities they draw from. Through previous studies, we know that speech and song have similar spectral structures (Stegemööller, et al., 2008). In this study, we used accent imitation and tests of musical ability to understand whether these abilities rely on the same set of shared skills.

Accent Imitation

Perception and production of accented speech is a domain that requires a long list of language related skills. To fully understand speech and how different accents and language vary in sound it is important to know the components of speech. Among the components of speech that matter for accents, are differences in prosody and phonemic content as I discuss below.

Prosody plays a critical role in fluency and intelligibility of speech (Godde and Bailly, 2020). There is no single used definition of fluency of speech, but an easier definition by Richards, Platt, and Weber (1985, p. 108) incorporates the natural speech qualities, such as native-like use of pauses, rhythm, intonation, stress, and rate of speaking. On the other hand, intelligibility of speech is how easily the person receiving the communication can fully understand what is being said (Lehiste and Peterson, 1959). This includes the behavior of the talker and listener and the characteristics of their speaking (French and Steinberg, 1947). Prosody consists of intonation, emphasis, timing, and phrasing that speakers use to convey meaning (Godde and Bailly, 2020). Intonation has to do with pitch, the specific rises and falls in pitch, and how these change the meaning of what someone is saying (Kommissarchik & Kommissarchik, 2000). Stress pattern and placement, also known as emphasis, can affect not only intelligibility, but also semantics. One example of how stress changes the meaning of a word is through examining the English word "content." Depending on which syllable the stress is put on, it either means the contained material or to be satisfied. As related to intonation and stress, each language also has its own rhythm. The rhythm of speech is classified as the length of syllables combined with position and duration of pauses (Godde and Bailly, 2020). This speech rhythm can be characterized by a specific metrical, or rhythmic, structure for different languages, even in novel sentences (Brown et al., 2017). This means that those who have been exposed to a certain language have learned the unique metrical pattern for that language in order to be able to communicate effectively with it. If this order is not followed, understanding would be difficult for many listeners. Many languages use a variety of metrical structures, which are all unique and important for effective communication (Gasser et al., 1999). Phrasing is also essential for segmenting continuous speech into meaningful units to facilitate comprehension (Godde and Bailly, 2020). A correct usage of prosody is vital to the comprehension of a language. For example, an English speaker may be asking a question, but it would not be understood as a question unless they raised the pitch of their voice at the end of the sentence. Just like English has its own rules, every other language has its own known traits. Without knowing the prosody of a language, listeners' comprehension decreases, along with the readers' fluency (Godde and Bailly, 2020). For example, someone who has never heard a native speaker of a language speak and has only learned grammatical rules and words would not know the prosody of the language. Listeners must also be able to perceive prosodic differences in order to fully understand a language and its nuances. A non-English speaker listening to an English speaker might not understand the difference between a rhetorical or sarcastic question and an actual question due to intonation differences.

Accents can be a challenge for listeners to understand. When someone hears a different accent, they often struggle to comprehend it immediately (Zheng and Samuel, 2019). This is because accents differ at the phonemic and prosodic level, which means that both vital components of speech are different from the listener's own native accent. A phoneme is the smallest unit of sound that changes the meaning of a word and can be characterized by the changes observed in speech waveform (Ramteke and Koolagudi, 2019). For example, the words 'dog' and 'log' only differ by one sound, but this one sound changes the meaning of the word completely. The vowels of the words 'call' and 'coal' also are their distinguishing factor. This discrepancy is needed in order to properly understand the meaning of a word. The phonemes used in different native and non-native accents also differ. To understand, examine the British English /r/ as compared to the American English /r/. In British English, the /r/ sound is absent following a vowel, for example in the word 'park.' In Spanish-accented English, the /r/ is produced differently, through rolling the tongue. After some time of listening to an accent, perception shifts and the listener becomes accustomed to it, which allows the listener to understand more as time passes (Zheng and Samuel, 2019). Without this time for listeners to adapt, they will not improve at understanding these accents and new phonemes. However, no correlation between recalibration of phonemic boundaries and accent accommodation have been found (Zheng and Samuel, 2019). This shows that no structural or categorical shifts occur when hearing a new accent, meaning a new listener will continue to struggle with understanding the accent.

In order to properly be able to imitate an accent, many skills must come into play. In order to be successful at imitating an accent, you must combine perception, motor planning, and working memory skills (Christiner and Reiterer, 2013). It is necessary to not only perceive the accent correctly, but then produce it correctly. Perception involves noticing what is different about the accent, including the differences in prosody and phonemes. It is necessary to perceive the differences in the sounds and differences of the language you are imitating in comparison to your accent. Between perceiving the accent and producing it, the person must have an accurate memory of it to be able to remember it and duplicate it. Finally, the person must be able to produce it and call upon their working memory and articulators. Motor planning comes into play for articulation and knowing what movements must be made in order to achieve the desired sound. In this study, we test whether musical abilities (as well as other relevant skills like verbal articulation and speech perception skills) relate to individual differences in accent imitation. If we find that specific musical sub-skills correlate with accent imitation skill, then this supports the idea that domain-general skills are responsible for both musical skill and language ability. This would indicate that language skills in accent imitation is not the only factor in determining ability. This can mean that the processes for these specific musical sub-skills are similar to the processes for accent imitation. Music and language have an overlap of structures in the mind, but localization in the brain of specific musical sub-categories have not been studied (Christiner and Reiterer, 2015).

Components of Music

To understand how our accent imitation task links to potential skills in music, we first need to understand what the essential components of music are. The seven musical elements include rhythm, dynamics, melody, harmony, timbre, texture, and form (Bresler, 2005). Two of these can be tightly linked to language. Rhythm includes the duration and sequence of notes with their varying durations. It also encompasses the time signature and meter of a piece, which includes how many beats there are per measure and what note each of these beats is represented by. This changes the feel of the music and influences the tempo of a piece. Tempo goes with rhythm and refers to the speed that the music should be played. Melody references the pitch, which is the actual frequency in Hertz of a note, as well as if it is conjunct or disjunct. This means whether the pitches are next to each other, conjunct, or not, which is disjunct. This refers to if a note is within two semitones, or one step, of another note, or if an interval greater than one step is required.

Musical training seems to result in enhanced skills in several domains. These include more developed abilities in certain skills needed for both music and speech imitation. These may include motivation, auditory skills, and cognitive factors. One of the highest predictors of musical skill is self-regulated learning and motivation (Long et al., 2012). This may be because music provides intrinsic rewards, so less external incentive is needed. The motivation for this intrinsic reward is in the emotions it brings to the musician. Put simply, doing something they love makes them happy. There are countless changes that are made as a result of being a musician. Rhythm and pitch are two auditory skills that are vital to all musicians. Speech and music are both received by the same mediums, as well as having the same rhythmic organization. It is shown by Koelsch, Schröger, and Tervaniemi (1999) that musicians have a more enhanced ability to pre-attentively obtain more information out of musically relevant sounds. Kumar and Krishna (2019) added to this research by studying instrumentalists, vocalists, and non-musicians. They discovered that sensorineural auditory processing skills were greater in all musicians, with no significant discrepancy between vocalists and instrumentalists. Musical experience causes enhanced overall auditory perceptual abilities (Kumar & Krishna, 2019). Musicians are taking in more auditory information, therefore understanding more details about what they are listening to. Taking all of this a step further and applying it to speech directly, Kühnis et al. (2013) found that musicians have a special perceptual learning of speech sounds, which included an increased learning performance. In this EEG study, participants had to match pseudowords to pictures.

Through this, they supported the notion that musical training benefits the perception and recognition of pseudowords and gives musicians an advantage in processing spectral speech information (see Kühnis et al., 2013 for discussion). The link between speech and music largely lies in prosody. Prosody relates directly to pitch and melody through intonation of speech (Kommissarchik & Kommissarchik, 2000). This directly impacts accent imitation, because every accent, language, and dialect has its own unique prosody. Research has also shown that musicians' auditory cortexes have an increased responsiveness to vowels and simple consonant-vowel syllables (Kühnis et al., 2013b). Coumel, Christiner, and Reiterer (2019) found that singing ability and musical perception ability have a positive correlation to accent imitation skills, possibly due to heightened phonological awareness. They suggest this is due to memorization strategies that those with greater musical ability have had to learn and employ, which benefits them in storing and retrieving information (Coumel, Christiner, and Reiterer, 2019). A vast number of other cognitive factors have been shown to be superior in musicians as well, including verbal abilities, second language learning, non-verbal reasoning, and general intelligence (Miendlarzewska & Trost, 2014). Music influences various aspects of language so much that they should be studied together because they are so interconnected.

A major factor to take into consideration for accent imitation is what kind of musical ability and training the participant has had. Singers have the same musical training but they also use their vocal apparatus as their instrument. Motor control is necessary for both singing and speaking due to that they are both produced by the vocal tract. A proper coordination of articulators is required to speak effectively. Christiner and Reiterer (2013) concluded that motor flexibility and the ability to sing conjointly improve both language and musical function. They determined this through examining forty-one singers' singing, musical talent, working memory, and accent imitation skills. They discuss the need to make a discrepancy between perception and production of singing, and it is in the production that the increased vocal flexibility of singers increases their accent imitation ability. The kinesthetic awareness that singers have of their vocal tract gives them an advantage, even if their auditory system does not. (see Christiner and Reiterer, 2013 for discussion). Motor ability may also influence accent imitation through manipulation of the whole vocal tract, including the velum and pharynx. Vocalists improve their ability through practice and vocal exercises, whether they are aimed at articulation, manipulating resonance, or other necessary skills. The extra time spent on these exercises allows vocalists to have enhanced vocal motor control and freedom. This ensures that vocalists can sustain and modulate their voice as needed (Christiner and Reiterer, 2013). Erdemir and Rieser (2016) examined singers, instrumentalists, and non-musicians in how they sang “Happy Birthday” with no auditory feedback. They concluded that singers depended on auditory feedback less than both non-musicians and instrumentalists (Erdemir and Rieser, 2016). They were also better able to use kinesthetic feedback than the other two groups (Erdemir and Rieser, 2016). This shows how singers are more aware of the placement of their vocal tract and how to manipulate it to achieve the results they want. Body posture, emission, resonance and articulation are all part of the foundation of both singing and speaking (García- López and Gavilán Bouzas, 2010). Other findings suggest that musicians use both auditory and vocal-motor mechanisms to more thoroughly control their vocal production (Stegemööller, et al., 2008).

Just as melody and pitch are important in singing, they are also important in language. In English, we raise our voice at the end of a sentence to ask a question. Some other languages, such as Mandarin, are tonal languages. This means they require constant change of pitch to convey meaning. Having the ability to accurately recognize these pitch changes is important for imitating these languages. Those who have been exposed to and taken ear training classes may have advantages in this. Vocal performance itself is an auditory-motor task and requires the coordination of both systems (Erdemir and Rieser, 2016). Various research shows that long-term musical training improves the auditory system (Zhang et al., 2019; Stewert, 2018). It is reasonable to conclude that the skills acquired throughout musical training directly affect how a musician listens and what aspects of sound they listen for, and therefore may give musicians an advantage in accent imitation.

Both singers and instrumentalists have a higher ability to imitate foreign accents than non-musicians (Christiner and Reiterer, 2015). It is logical to assume that the auditory training both instrumentalists and singers receive passively and actively improves their ability to perceive pitch and melody. Reiterer et al. (2011) also showed a connection between high musicality, articulation, and pronunciation, with ability to sing being the most significant indicator. For instruments played using the mouth, advanced oral motor skills may influence their articulation ability. While instrumentalists in the study performed better than non-musicians, singers outperformed all of the other groups. Singers' musical abilities must then be different from those of instrumentalists. Based on the nature of their work and what their instrument is, singers have more practice and training with manipulating their voice than instrumentalists. Vocalists who have had more extensive training, such as classical voice training, may have received training in other languages. This can be through listening to operas and songs, language specific diction classes, or singing in the language. While not every vocalist is trained in other languages, vocal training, either solo or with a group, inevitably includes singing in non-native languages. It is proven that the ability to sing helps vocalists detect rhythmic cues in other languages (Christiner and Reiterer, 2013). In this study, the rhythm sub-component of singing had a large influence on a foreign language imitation task (Christiner and Reiterer, 2013). Martínez-Montez et al. (2013) shows that musicians are more sensitive to changes in syllabic pitch contours, even if they do not belong to the phonemic repertory of their own language. The stress of a specific syllable can not only change the meaning of word, but it plays into fluency and intelligibility of speech (Godde and Bailly, 2020). It is logical to say that from being exposed to and practicing various languages, English vocalists become more accustomed to and even learn how to pronounce other languages properly without knowing the meaning of the words. General singing exercises also help singers achieve openness to unfamiliar sounds, a larger vocal range, and higher vocal flexibility (Christiner and Reiterer, 2013). These factors result in better speech imitation (Christiner and Reiterer, 2013).

The Present Study and Predictions

It is already proven that musical ability influences accent imitation (Reiterer et al., 2011; Christiner and Reiterer, 2013). However, many studies have not compared singing ability and perceptual musical ability specifically to accent imitation ability. I use the word perceptual to make a discrepancy between the studies that test how good someone's singing sounded, which was not in the scope of this study. It is important to make a distinction between this when comparing musical ability to language ability because singing is closely tied to speech, while playing an instrument is not. One of the first studies to do this assessed singing ability on a self-rating questionnaire (Reiterer et al., 2011). In order to account for self-bias pertaining to ability, another study was conducted using a perceptual musicality test (AMMA) (Christiner and Reiterer, 2013). Christiner and Reiterer (2013) examine if singing ability improves accent imitation ability, however, all participants were vocally trained. It concluded that perceptual musical ability correlated with speech imitation performance, but not as much as singing ability did.

While Christiner and Reiterer (2013) show the overall correlation, they do not venture into which factors cause this. Through our study, we aim to further this research and discover which specific perceptual musical elements influence accent imitation. We tested participants on accent imitation ability, musical ability, and articulation. Christiner and Reiterer (2013) did not conduct an articulation measure, which is an important element to analyze in our experiment. They also have a very different experiment set-up for their accent imitation measure. They solely assessed participants who already had a certain level of musical proficiency. We looked at a range of ability, in order to see the specific areas in which proficient musicians have a higher ability than non-musicians or novice musicians. We also had subjective and objective musical measures, while the previous study had only objective measures. I predict that the overlap between musical elements and the elements that make up varying accents and speech will mean that people who have better musical ability will also be better at accent imitation. I will determine this through examining the specific categories of a specific assessment of musical ability and matching it to vocal experience and accent imitation scores. I predict that those with high melody and accent scores on the Mini-PROMS objective perceptual musical assessment will also have the higher accent imitation scores. Beyond this, I predict those of this sub-group who are vocally trained will have even higher accent imitation scores. We measured articulation using the Diadochokinetic assessment. The Diadochokinetic assessment measured how quickly participants can say a certain consonant in a 5 second period (Gadesmann and Miller, 2008). This helps determine motor function and ability in each participant, which is important in seeing how they manipulate their mouths. This is not valid for clinical diagnostic assessment, but accuracy for diadochokinetic assessment is higher in the first 5 seconds of the trial (Gadesmann and Miller, 2008). I predict that the group with significantly higher scores on the DDK will contain many musicians, and therefore have higher musical ability. Working memory was not measured in our study, but it was found to be a significant predictor of speech imitation (Christiner and Reiterer, 2013).

If my predictions are correct, then this research supports the domain general approach to musical ability and accent imitation. If I am incorrect, then it supports the domain specific approach.

II. Methods

The total number of participants included in the statistics used for this study was 50 (n=50), which were the first 50 participants run on this study. There was a total of 92 participants run on this study, but the data from the other 43 was not used in these statistics. Out of the 50 participants, 12 identified as male and 38 identified as female. The mean age of the participants was 20.18, and the range of these ages was 18 to 47 years old. Three of these participants were considered "experts," who were theatre professionals. These three participants were paid, while the other 47 were given course credit. All tests were run in the David C. Phillips Communication Sciences Building on the University of Connecticut Storrs Campus. All participants gave informed consent before participating or giving personal information.

Procedures: Accent Imitation

The accent imitation task consisted of participants listening to a story read by 3 different accented voices. We used South African, Scottish, and Yorkshire (English) accents. These accents were chosen because they are fairly different from one another, and it is unlikely that participants has experience imitating these accents. These are recordings from the IDEA archive from the passage "Comma Gets a Cure" (McCullough et al., 2000). Speech samples were randomized. Participants then attempted to imitate the accents by saying short phrases from the story, as well as new phrases that were not said in the story. After each phrase, participants evaluated themselves on how well they think they imitated the accent. Directly after each accent, participants provided their opinions about the person speaking. At the completion of the study, participants were asked questions about their own prior vocal performance experience, dialect switching, and, if they identified as LGBT, how their sexuality affects their voice. However, these recordings were not a part of my analysis.

Procedures: PROMS

For the musical evaluation portion of the experiment, participants completed the Mini-PROMS test of musical skills, completed a survey about their musical training, and verbally spoke about their prior vocal music experience. The PROMS is the Profile of Music Perception Skills. This is an assessment that measures perceptual musical skills objectively through analyzing varying musical elements, such as timbre, tuning, melody, pitch, rhythm, and tempo (Zentner, 2019). The Mini-PROMS is a shortened version of this assessment that includes the sections, melody, tempo, accent, and tuning. In the Melody subsection, the ability to write out the musical phrase that the participant heard was measured. The tempo subsection is a timing-related task where notes of equal intensities were played in various rhythms and participants had to tell whether passages were played at the same speed. This will be referred to as Speed in this paper. The Accent subsection assesses how well someone can tell where the emphasis is given to certain notes in a rhythmic pattern, and participants had to match rhythmic passages that they think have the same stress (Zentner and Strauss, 2017). The "Accent" section will be referred to as "Beat" in the rest of the paper in order to not confuse it with the accent imitation task. The Tuning subsection assesses how well someone can tell a chord is in tune or out of tune by slightly changing one note in a chord. At the end, a composite score of general musical perception ability is shown, as well as the scores in each of these sections. Stauss (2015) calls it a brief objective measure of perceptual music ability that has reliable and consistent composite scores. As part of the Mini-PROMS, participants completed a questionnaire about their music experience and how frequently they engage in music of different forms. Participants then spoke about their prior vocal performance experience freely in the interview portion of the experiment. This included what kinds of performance experience they had (if any), how long they had been performing, and if they enjoyed performing in front of others. For the purposes of this thesis, participants were also coded as either "vocalists" or "instrumentalists" depending on their musical training experience.

Procedures: DDK

The Diadochokinetic assessment measures how quickly participants can say a certain syllable in a 5 second period (Gadesmann and Miller, 2008). Accuracy for diadochokinetic assessment is higher in the first 5 seconds of the trial, which is why only the first five seconds were used (Gadesmann and Miller, 2008). Participants were asked to first say "puh" as fast as they can while they were timed and recorded, followed by "tuh," and "kuh." Then, they are asked to put it all together and repeat "puhtuhkuh" as quickly as possible also in that five second period. Then, two raters listen to the recordings of these trials and count how many full segments the participant says within the time limit, and the scores of the two raters are averaged for each of the four categories.

Procedures: Other

Other procedures were completed that are not part of the scope of this paper. These included: questionnaire about prior language experience, a hearing test, the Big 5 Personality Assessment (John et al., 1991), test of native language speech perception, a vocabulary test, and a short interview.

Procedures: Accent Rating

As stated before, data from the first 50 participants run on this study was used. In order to determine how well each participant imitated the accented phrase, a group of participants from the online experimental platform Prolific rated the samples. Audio samples were posted on Prolific, grouped by phrase. Each rater heard the original accented phrase participants were trying to imitate, and then the 50 different attempts at that phrase. Each individual phrase was rated on a seven-point scale by between eight to twelve Prolific users. This was done for each phrase in all three accents. Raters were all from the United States and native speakers of English. Data for all raters who gave out the same rating of 7 to over 35 participants, timed out, or failed the headphone check were thrown out. Four online raters were removed, but they were replaced.

III. Results

Mean accent rating, mean DDK rate, and the total mini-PROMS score were submitted to a simple correlation analysis. Pearson correlation coefficients are displayed in Figure 1, above, with comparisons significant at $p<0.05$ highlighted in color. In brief, the mean accent rating showed a significant correlation with both the mean DDK rate (across the four different types of assessments), and the PROMS total score In Figures 1 and 2, blue blocks indicate a significant positive correlation, with the darker blue being a higher correlation. The accent imitation score had a significant positive correlation with both the PROMS and DDK. The overall PROMS score and accent imitation rating have a medium positive correlation. Among the best PROMS scores are some of the best accent imitators. Out of the three correlations, the DDK scores and the accent imitation scores have the strongest positive correlation. The results show that the articulation speed measure rates (DDK) and the overall PROMS scores have a weak positive correlation to each other that did not reach statistical significance.

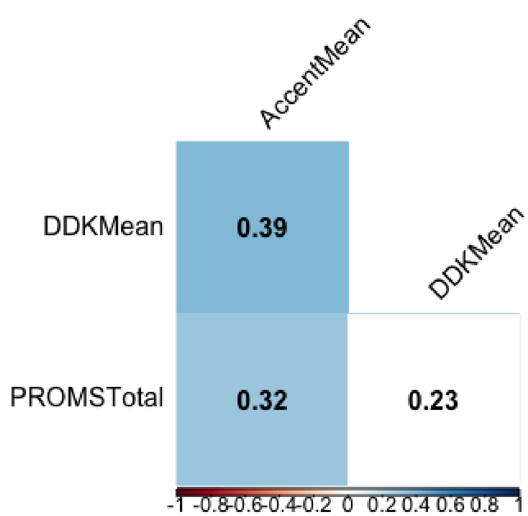

Figure 1: Pearson correlation coefficient values between mean Diadochokinetic Assessment score, mean Accent imitation score, and mean PROMS composite score

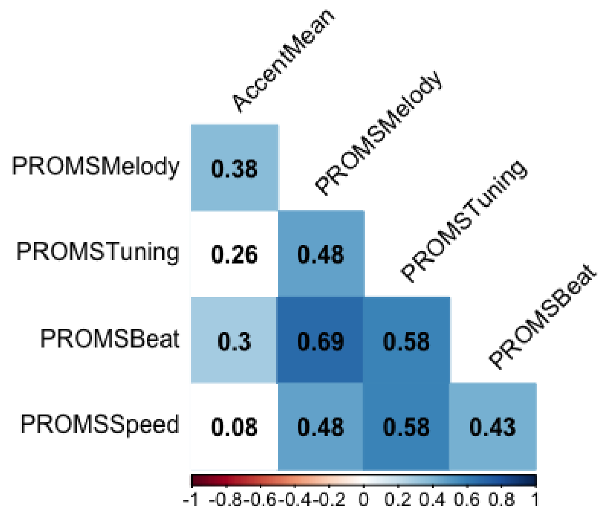

Figure 2: Pearson correlation coefficient values between accent imitation and each mini-PROMS subtest (Melody, Tuning, Beat, and Speed)

Next, we broke the mean PROMS score down into the musical sub-tests in order to determine whether specific musical skills predicted accent imitation ability. The individual mini-PROMS sub-scores and the mean accent rating were submitted to simple correlational analysis. Pearson correlations are displayed in Figure 2, with comparisons that are significant at $p<0.05$ displayed in color. Figure 2 shows the Pearson coefficients for the scores of the subsections of the mini-PROMS compared to each other and the mean accent imitation ratings. The Melody and Beat subsection had the highest positive correlation out of any of the other subtests. The only significant positive correlations found with the mean accent imitation ratings were the Melody and Beat subscores, with Melody being the highest. Melody and Beat are the best musical predictors of accent imitation ability. Figure 2 shows that Tuning and Speed are not significant factors in determining accent imitation ability.

While there was a significant correlation between musical skill and accent imitation, of interest is whether musicians outperform non-musicians in accent imitation. Out of the 50 participants, 24 stated that they were musicians (either sang or played an instrument) and 26 were non-musicians. The following compare musicians and non-musicians in the categories of accent imitation, articulation, and musical ability.

The mean accent imitation scores for each accent and the total mean for musicians are higher than those of non-musicians, as seen in Table 1 and Figure 3.

	Non-Musician	Musician
England	3.28	3.70
South Africa	3.19	3.57
Scotland	3.14	3.51
Accent Mean	3.20	3.60

Table 1: Mean accent imitation ratings for all three accents and total accent mean grouped by Musicians and non-musicians

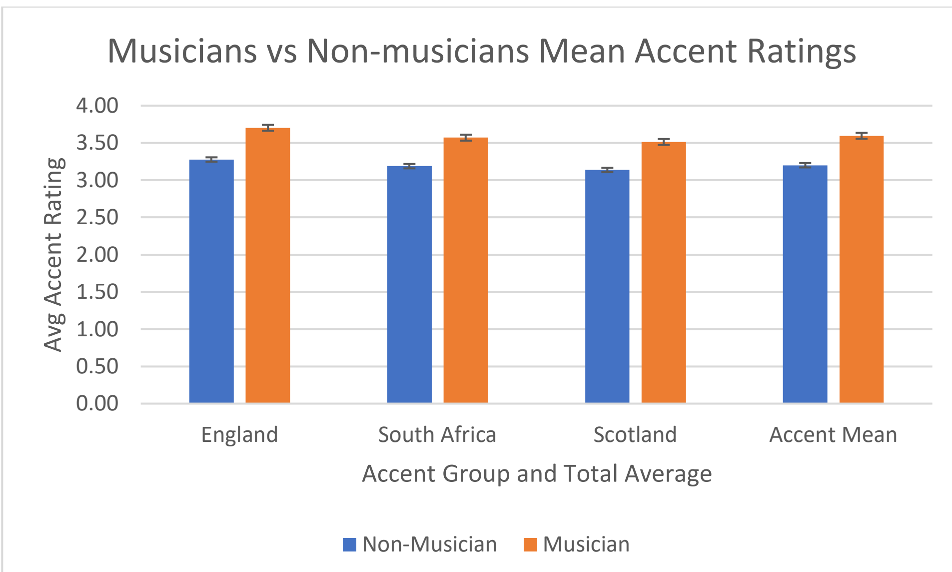

Figure 3: Mean accent imitation ratings for all three accents and the total accent mean grouped by Musicians and non-musicians

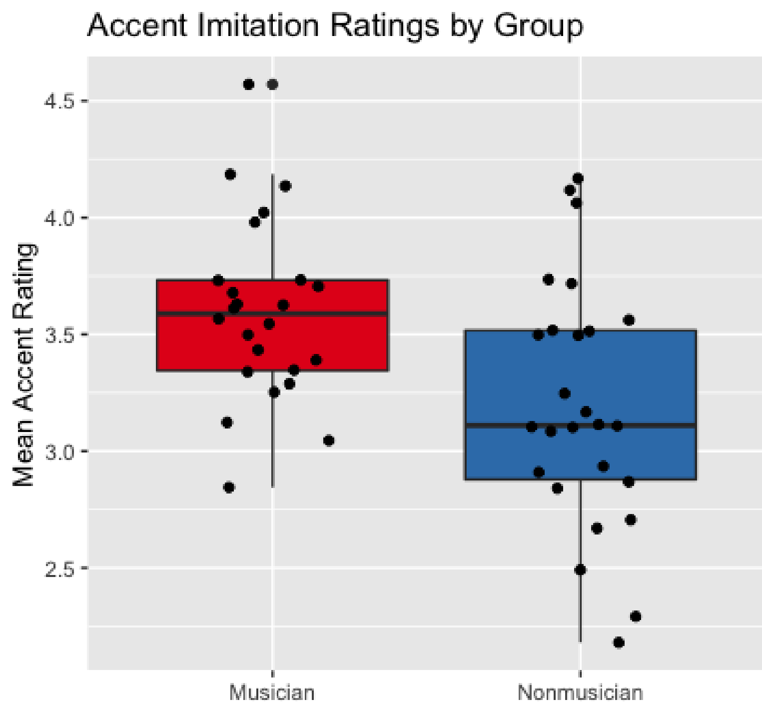

Figure 4: Mean accent rating across three accents (Yorkshire, South African, and Scottish) grouped by musicians and non-musicians

A two-sample t-test was conducted to compare accent imitation ratings between the musician and non-musician groups (Figure 4). Musicians had significantly higher accent imitation ratings $t(45)=3.0309$, $p<0.004$.

The musicians' DDK scores for each section averaged out to be higher than all of the non-musician scores. Musicians have an overall faster DDK (PTK) rate than non-musicians, with a significant difference. See Table 2 and Figure 5 below.

	Non-Musician	Musician
DDK_P	26.81	30.48
DDK_T	25.27	31.90
DDK_K	23.27	28.19
DDK_PTK	10.12	11.37

Table 2: Mean Diadochokinetic assessment rate for pah, tah, kah, and pahtahkah for musicians and non-musicians

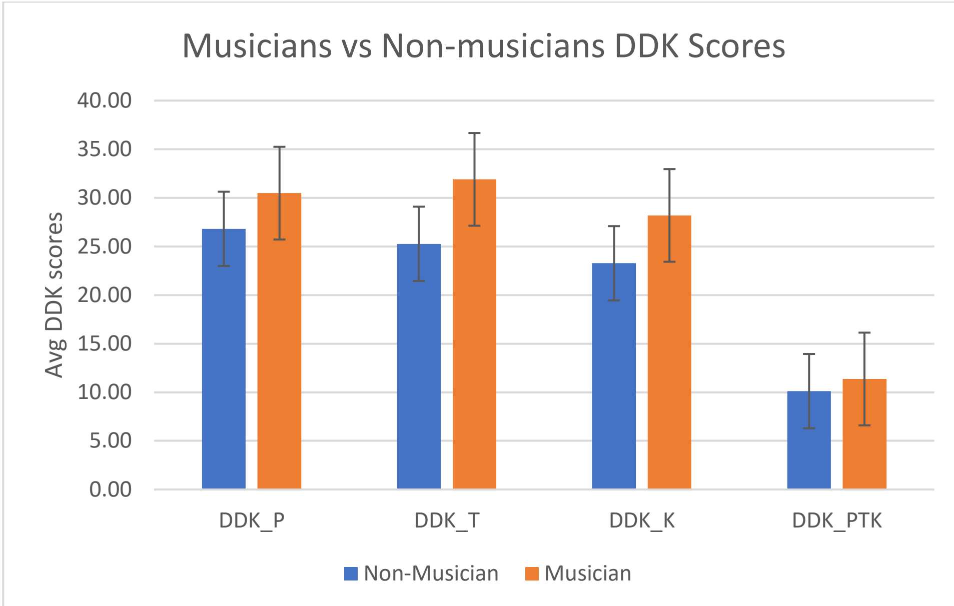

Figure 5: Bar graph of mean Diadochokinetic puh, tuh, kuh, and puhtuhkuh rate grouped by musicians and non-musicians

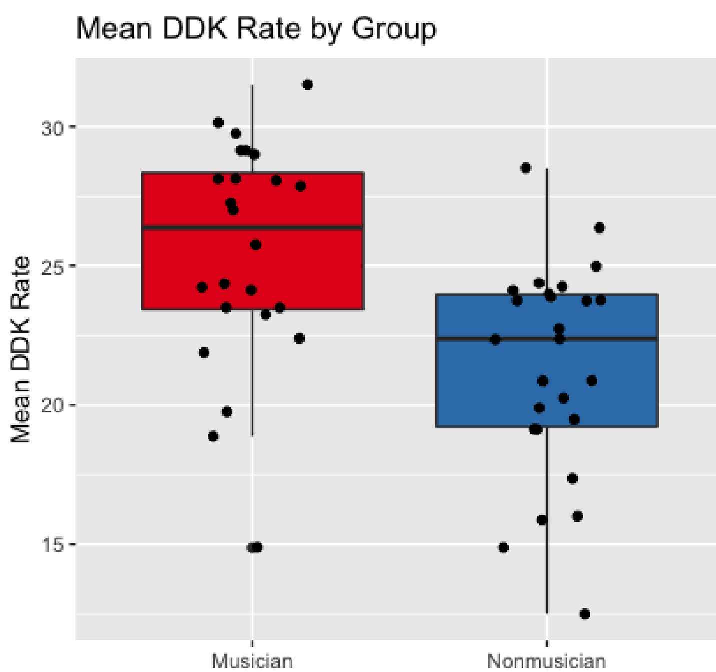

Figure 6: Mean Diadochokinetic assessment rating grouped by musicians and non-musicians

A two-sample t-test was conducted to compare the mean articulatory rate on the mean DDK rate across all syllable types (Figure 6). Musicians produced more syllables in the timed interval than non-musicians. This difference was significant $t(45)= 3.7013$ $p<0.001$.

The average PROMS scores per section and overall scores were higher for all musicians as compared to non-musicians. The data shows that musicians have better overall scores on the PROMS with a significant difference. See Table 3 and Figure 7 below.

	Non-Musician	Musician
Melody	3.85	6.02
Tuning	3.67	4.69
Beat	3.83	5.44
Speed	4.77	5.67
Overall	16.12	21.81

Table 3: Mean mini-PROMS subtest and composite scores for musicians and non-musicians

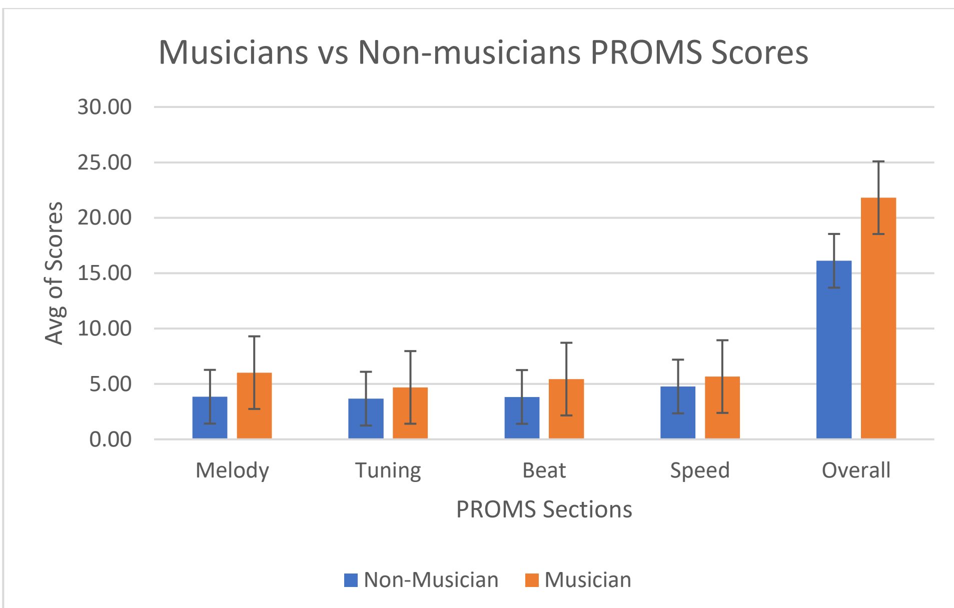

Figure 7: Mean mini-PROMS subtest and composite scores for musicians and non-musicians

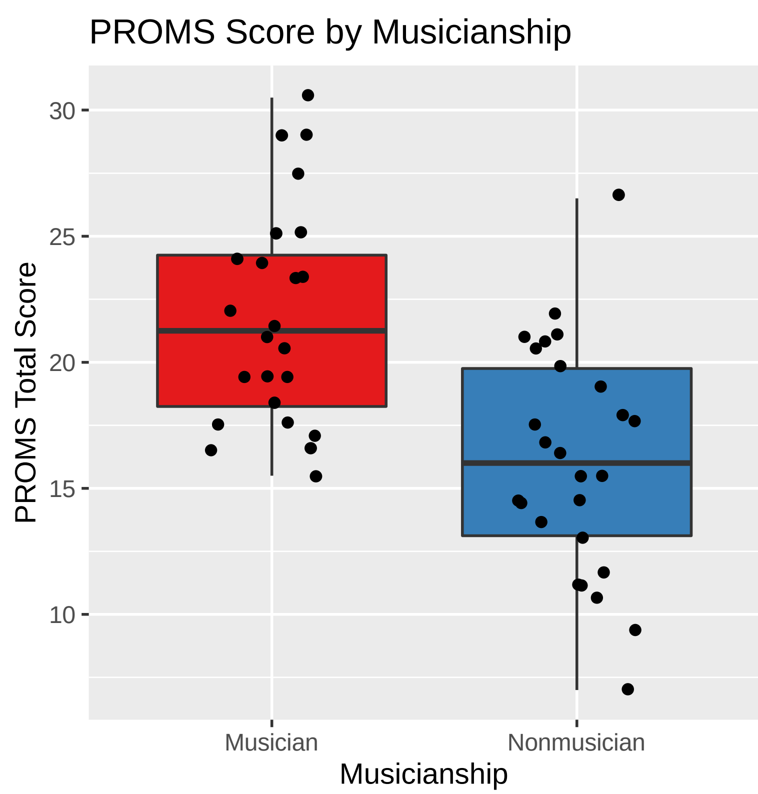

Figure 8: Means mini-PROMS composite scores grouped by musicians and non-musicians

A two-sample t-test was conducted to compare scores on the miniPROMS between musician and non-musician sub-groups. As expected, musicians outperformed non-musicians, and this difference was significant ($t(45)=4.5216$, $p<0.001$).

Out of the 24 musicians, nine of them were singers and 15 were instrumentalists. The following compare vocalists' and instrumentalists' mean accent imitation ratings, diadochokinetic assessment rate, and mini-PROMS scores. No statistics were run on the following data about vocalists due to a low number of participants, but I did examine the data for trends.

In Table 4 and Figure 9, it is shown that vocalists performed better on all of the accents, including the overall mean.

	Vocalist	Instrumentalist
England	3.93	3.56
South Africa	3.78	3.44
Scotland	3.70	3.40
Accent Mean	3.81	3.47

Table 4: Mean accent imitation ratings for each accent and total score grouped by vocalists and instrumentalists

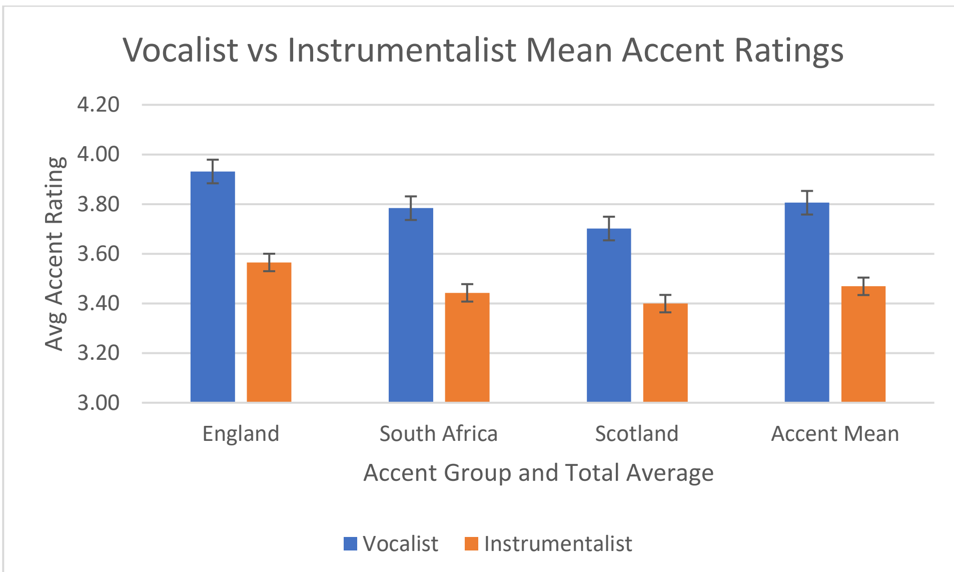

Figure 9: Mean accent imitation ratings for each accent and total score grouped by vocalists and instrumentalists

The difference between the vocalists and instrumentalists was greater than 0.03 for all of the accents.

As shown in Table 5 and Figure 10, vocalists had higher rates on the diadochokinetic assessment than instrumentalists. The vocalists were able to articulate faster on all four tasks.

	Vocalist	Instrumentalist
DDK_P	32.06	29.53
DDK_T	35.56	29.70
DDK_K	31.94	25.93

DDK_PTK	13.03	10.37

Table 5: Mean Diadochokinetic assessment rate for pah, tah, kah, and pahtahkah for vocalists and instrumentalists

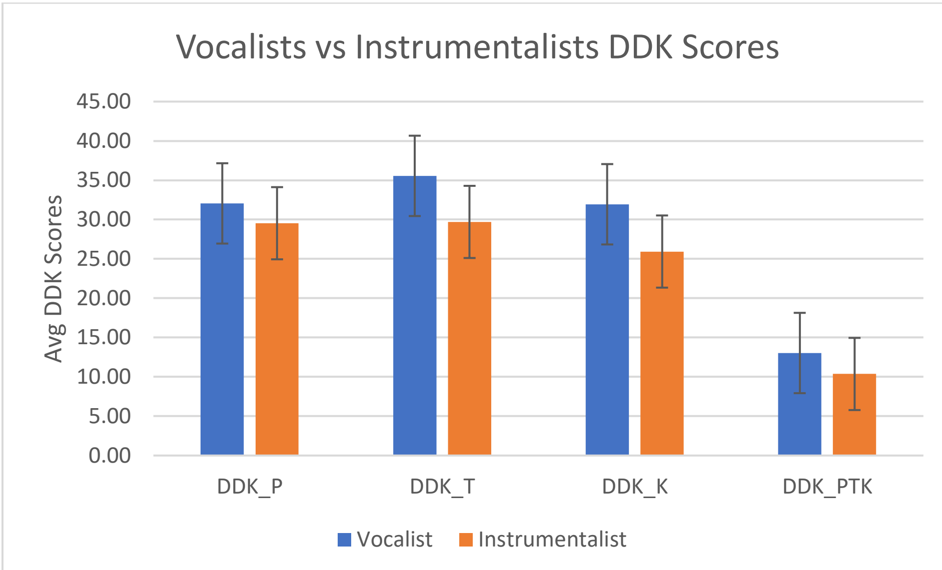

Figure 10: Mean Diadochokinetic assessment rate for pah, tah, kah, and pahtahkah for vocalists and instrumentalists

The vocalists did slightly better than the instrumentalists on each subsection of the mini-PROMS. However, the overall composite score shows more definitively that vocalists scored higher.

	Vocalist	Instrumentalist
Melody	6.72	5.60
Tuning	4.94	4.53
Beat	6.11	5.03
Speed	6.11	5.40
Overall	23.89	20.57

Table 6: Mean mini-PROMS subset and composite scores grouped by vocalist and instrumentalist

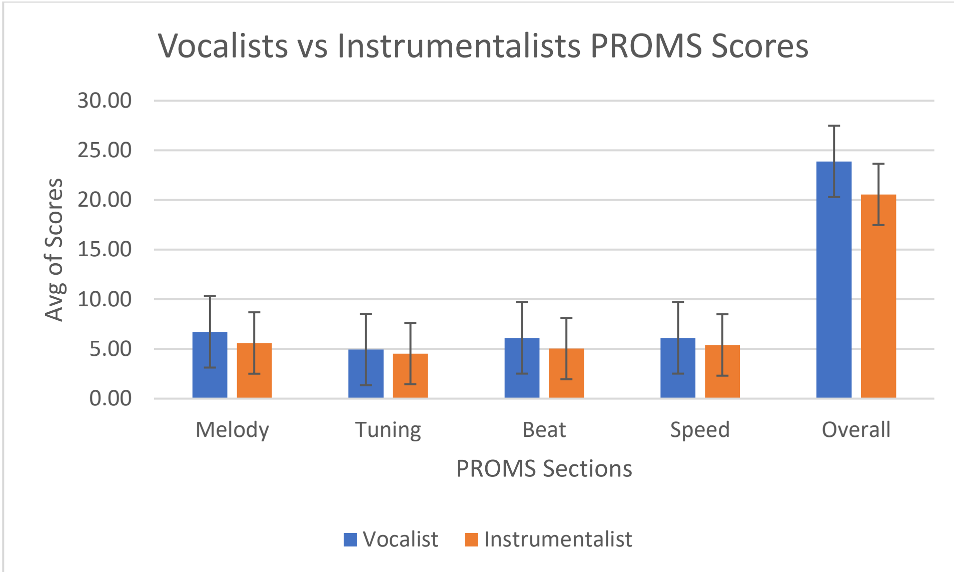

Figure 11: Mean mini-PROMS subset and composite scores for vocalists and instrumentalists

Three of the nine singers were experts (professional actors and musicians), while the other six vocalists were college-aged students who were not experts. In order to account for a possible skew in the data by the three vocal experts, I compared the average PROMS and DDK scores of the group of the non-expert vocalists to the instrumentalists as well as to the group of all of the vocalists. The following show the differences between the vocalists group scores without the experts scores and the instrumentalists.

We found that there is little to no difference in the mean accent imitation ratings for the vocalist group including and excluding the experts. This means the theatre experts were minimally better or no better at imitating accents than other vocalists. Table 7 and Figure 12 show the mean accent imitation ratings of the 6 non-expert vocalists as compared to the instrumentalists.

	Vocalist (no experts)	Instrumentalist
England	3.85	3.56
South Africa	3.78	3.44

Scotland	3.78	3.40
Accent Mean	3.81	3.47

Table 7: Mean accent imitation scores for all three accents grouped by non-expert vocalists and instrumentalists

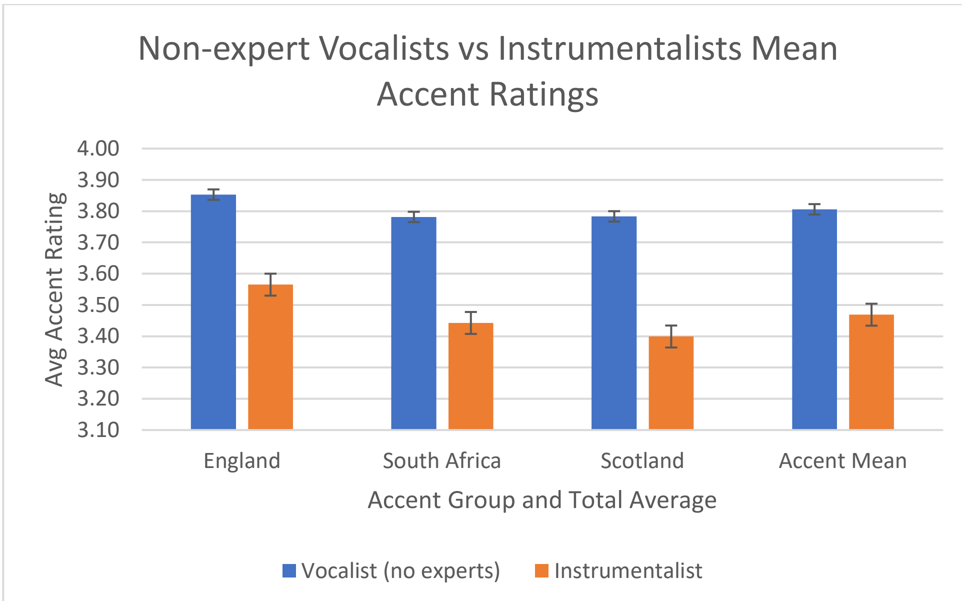

Figure 12: Mean accent imitation scores for all three accents grouped by non-expert vocalists and instrumentalists

The only differences between the scores of all of the vocalists and the non-expert vocalists are in the England (Yorkshire) and Scotland accents by less than .08. The experts scores caused the mean scores to minimally increase for the vocalist group. However, the non-expert vocalist group still had significantly higher scores than the instrumentalists on all three accents and the total mean.

In Table 8 and Figure 13, you can see how the group of non-expert vocalists had rates that were still higher than the instrumentalist group for the diadochokinetic assessment. The vocalist group including the experts had higher scores on the “tuh,” “kuh,” and “puhtuhkuh,” while the vocalist group excluding the experts had a slightly higher score on the "puh." Because of this, there is no clear trend for the expert vocalists and non-expert vocalists.

	Vocalist (no experts)	Instrumentalist
DDK_P	32.75	29.53
DDK_T	35.25	29.70
DDK_K	30.67	25.93
DDK_PTK	12.63	10.37

Table 8: Mean DDK subset and composite scores grouped by non-expert vocalists and instrumentalists

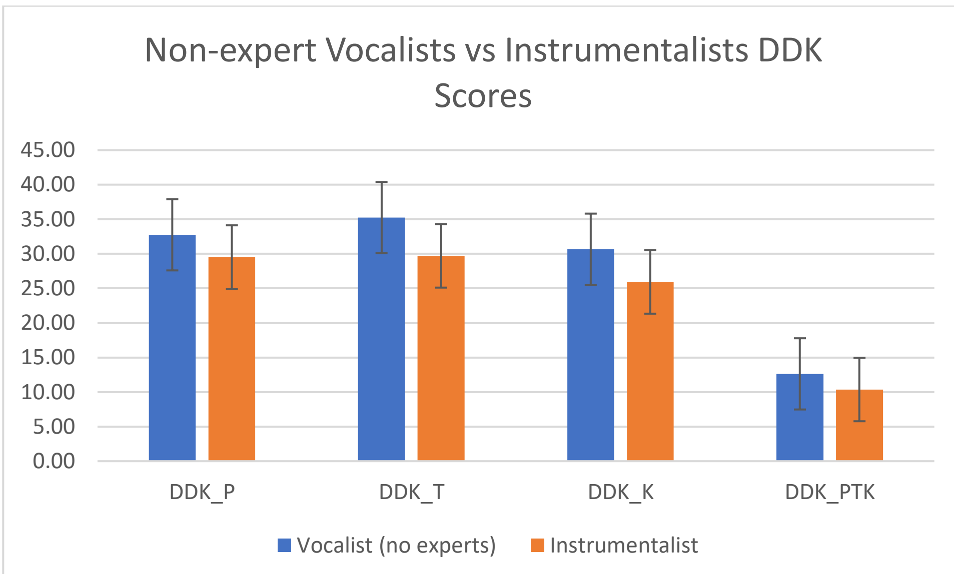

Figure 13: Mean Diadochokinetic Assessment rate for puh, tuh, kuh, and puhtuhkuh grouped by non-expert vocalists and instrumentalists

The non-expert vocalists still did better than the instrumentalists.

In Table 9 and Figure 14, you can see how the non-expert vocalists' scores on the PROMS are still better than the instrumentalists. The difference between the non-expert vocalist group and the vocalist group including experts is minimal. In all of the subset categories the difference between both vocalist groups is less than 0.50. In fact, in all categories but Melody the experts brought down the average scores of the vocalists. The negative number in Table 9 represents this.

	Vocalist (no experts)	Instrumentalist
Melody	6.50	5.60
Tuning	5.42	4.53
Beat	6.58	5.03
Speed	6.25	5.40
Overall	24.75	20.57

Table 9: Mean mini-PROMS subset and composite scores grouped by non-expert vocalists and instrumentalists

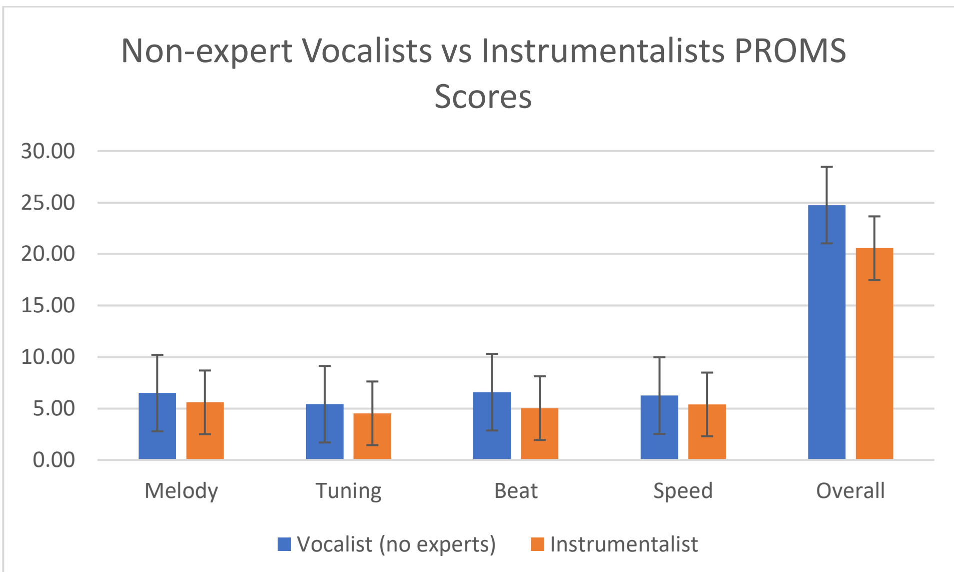

Figure 14: Mean mini-PROMS subset and composite scores for non-expert vocalists and instrumentalists

IV. Discussion

The results show evidence for my prediction that musical ability and accent imitation share underlying skills. The results suggest that the skills and capabilities that music and language share are very similar due to the fact that musicians average scores were higher on the articulation measure, the musical measure, and the accent imitation measure. Clearly, the skills needed for both are similar and overlap because higher musical ability predicts higher accent imitation ability.

Melody and Beat are musical elements. Through the correlational analysis, we found that accent imitation correlates significantly with both Melody and Beat, which is in line with my prediction. Because these specific musical sub-skills correlate with accent imitation skill, it supports the idea that domain-general skills are responsible for both musical skill and language ability. Both Melody and Beat relate directly back to prosody though their definitions. Melody deals with pitch, which is the equivalent of intonation when speaking. Beat deals with the accent on a note, which is the same as stress on a word when speaking. This may suggest that the processes used for Melody and Beat are similar to the processes for accent imitation, therefore showing overlap between music and language. Accent imitation did not show a significant relationship with Tuning or Speed, possibly because in order replicate speech, these aspects are not as important. Tuning and Speed are not major factors contributing to prosody, and therefore do not translate over to speech like Melody and Beat do.

We showed that an objective test of musical skills (miniPROMS) significantly related to accent imitation. We were also interested in whether musicians performed differently in accent imitation. Some of the highest accent imitation scores were the musicians, who also had high scores on the PROMS. However, we know that Melody and Beat are the only significant subsections of the PROMS that influenced the accent imitation scores. Because the musicians performed better on all sections of the PROMS and accent imitation, we know that they had both the higher accent imitation scores and the higher Melody and Beat scores. Out of the musician group, the vocally trained participants had higher scores on all sections of the accent imitation task and the PROMS, and also had higher Melody and Beat scores as well as accent imitation ratings. This tells us that the musicians, especially the vocalists, are better at Melody and Beat for some reason, and are therefore better at accent imitation.

We considered the possibility that including three experts who were professional actors in the vocalist group might have led this group to have higher performance on all measures. Instead, there was no evidence that the expert vocalists brought up the average score of the vocalist group for the DDK, PROMS, and accent imitation task. Results were inconsistent and varied, but from this current data it does not seem like the experts were significantly better than the non-expert vocalists on any of the tasks. However, due to the small participant pool, statistics would not have been very accurate, and therefore were not run. Something further to be done with this research is to examine if the highest accent imitation scores are those of vocalists with a larger participant pool.

Without the experts, the rest of the vocalists were still better than the instrumentalists at all three tasks. This hints that there may be something in the training of a vocalist that the instrumentalists do not receive. This may be training the actual vocal folds and voice, which would benefit vocal motor control as well as kinesthetic ability. This also shows that expert training is not needed to reap the benefits of musicianship. The groups of college students are not experts, but still outperform the non-musician group.

By examining the data, we found that articulation speed ability is not a good predictor of musical skill, but it is the best predictor of accent imitation ability. My prediction of a significant positive correlation existing between articulation ability and musicianship did not come out to be true. Further research could examine the factors behind why articulation had such an influence on accent imitation and what the overlapping skills for this are.

Possible confounding variables in this experiment include those who are bilingual, or early bilingual. To ensure this was not a major factor, participants completed a Mini Language Experience and Proficiency Questionnaire. Participants also received a basic audiological assessment so outcomes were not influenced by hearing levels. Even for those who are not bilingual, many vocalists have extensive training in various languages. This is not something truly measurable and may cause some variation. Though speaking in another language is very different than speaking in English with an accent, the prosodic elements are varied from language to language. Those with training may pick up more easily on the differences and how to manipulate their voice to sound like the accent.

Those with musical training might also be more aware of the pitch of their voice when they are speaking. This would be an indirect factor connecting musical ability and accent imitation. This does not necessarily mean anything about the individual's personal musical ability or how "good" they are, but only that they have had musical training. In the interview portion of the experiment, many participants did not think of other ways in which to change their speech expect for word choice. Those with musical training might be more likely to think of pitch as a contributing factor, as opposed to the most common answer of word choice.

This research shows only some of the many benefits of musical training and musical involvement. Specifically related to accents, musical training, especially vocal training, could increasing one's awareness of sound production. This would facilitate second language pronunciation acquisition, perceptual skills, and ability to store more accurate sound representations (Coumel, Chirstiner, and Reiterer, 2019).

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