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PRESENTATION/POSTER

TONAL RECALL: MUSICAL ABILITY AND TONEME RECOGNITION

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Because music and language both involve aural patterns and segments, they are speculated to share cognitive processes. Previous studies into the possible link between language-learning ability and musical ability have had inconsistent results. The current project investigated a possible correlation between musical ability and phonological perception. Specifically, this project addressed the following research questions: Is there a correlation between musical memory and the ability to recognize Mandarin tonemes? If so, does this correlation differ by gender or age? Adult participants completed a tone-deafness assessment that measured their pitch perception and short-term musical memory. Participants then watched a YouTube video that explained the tones used in Mandarin. After watching the video, they played an online game to measure their ability to identify the Mandarin tones that they had just learned. Finally, participants recorded their scores and demographic information (language history, age, and gender) in an online survey. The correlation between participants' musical and toneme scores was calculated. The analysis showed a positive correlation between the two scores, with a slightly higher correlation for men than for women, and a higher correlation for older participants. The results suggest that musical ability is one of the individual differences that might confer a slight advantage on some second-language learners.

INTRODUCTION

Many people believe that musicians are better than non-musicians at learning languages. Speculation about links between music and language has occurred for nearly a century (Nakata, 2002), but little is known about what those proposed links entail. This project investigates a potential link between specific aspects of musical ability, namely pitch perception and melodic memory, and one aspect of language-learning ability, phonological perception.

It is logical to expect a link between musical and language-learning abilities. Music and language are both forms of cultural expression, and they both comprise hierarchical structures in which smaller units (notes and phonemes) make up larger units (chords and musical phrases; morphemes and words), which in turn make up even larger units (melodies and sentences).

Both music and language rely on listeners' predictions. According to Gibson's (2000) Dependency Locality Theory, listeners predict certain syntactic categories based on the words they have already heard (for example, in English, after hearing a determiner followed by an adjective, the listener expects a noun or another adjective, but not a verb), and listeners make a connection between an incoming word and the words that have preceded it (Patel, 2003). In a similar way, music listeners who hear certain chords have an expectation, based on the music's key signature and the preceding chord progression, of a limited set of chords to "resolve" the musical phrase. This expectation is

evidenced by research showing that "the processing of a musical target is faster and more accurate when it is harmonically related to the preceding prime context" (Tillmann et al., 2003, p. 145).

Some music and language functions have been found to use common parts of the brain. Listening to music activates the same brain regions (the temporal and fronto-temporal areas of both the left and right hemispheres) as language comprehension and production. There is evidence that neuroplasticity is involved in skill acquisition in both musical instrument playing and second language pronunciation, as both skills benefit from acquisition before puberty (Milovanov & Tervaniemi, 2011). In a 2002 study, participants who heard unexpected notes in chord sequences showed activation in the Broca and Wernicke areas, previously thought to be used for language processing only (Koelsch et al., 2002).

LITERATURE REVIEW

Until recently, relatively little of the research into individual differences in language learning addressed the potential relationship between music and language. Skehan (1989), for example, examined diverse individual differences (intelligence, age, anxiety, learning styles, introversion, and risk-taking) but did not address musical ability. More recent studies have had mixed results in showing a link between musical ability and language-learning ability. The following studies illustrate the complexity of this proposed relationship.

Peynircioğlu, Durgunoğlu, and Öney-Küsefoğlu (2002) found a link between musical ability and *phonological awareness*, a broad set of skills in recognizing and manipulating individual sounds in speech, including rhythm, rhyming, alliteration, and sound substitution. They conducted two experiments—one with Turkish-speaking children and one with English-speaking children—to determine whether children who scored high on musical aptitude tests would also score better on tasks that required them to delete phonemes from words and pseudo-words and to delete tones from familiar melodies. None of the children, aged six and younger, could read at even the most elementary level; influence from written forms of the words was thus prevented.

The researchers used data from the highest-scoring and lowest-scoring participants; participant scores closer to the middle of the scale were not included. Predictably, children who scored higher on the musical aptitude test did better at the tone deletion test (omitting notes from familiar songs). These same students also scored higher on the phoneme-deletion tasks (omitting certain sounds from words). The researchers inferred that auditory processing of phonology and music used the same analytical skills and that the similar findings in two very different languages suggest cognitive universals rather than language-specific features.

Nakata (2002) studied the relationship between musical abilities and language discrimination. Nakata did not examine other individual differences that might correlate with musical or language abilities.

Nakata used only adult participants, reasoning that any link between musical ability and language-learning ability in participants who were past the *critical period* (the period, corresponding roughly to puberty, after which phonological acquisition becomes markedly more difficult) would provide a stronger predictor of learners' ability to acquire a new language's phonology. All participants

were native English speakers with little exposure to the Japanese language and no formal music training.

Nakata hypothesized that certain specific musical abilities would correlate with specific language skills: recognizing syncopation would correspond to identifying geminates (doubled consonants) in Japanese, recognizing musical time durations would correspond to identifying lengthened Japanese vowels, and recognizing musical pitch would correspond to identifying Japanese pitch accentuation.

Participants were assessed on musical abilities that corresponded to language perception and production tasks. Assessments of recognition of syncopation, suspended notes, and pitch differences corresponded, respectively, to tasks involving Japanese geminates (/kita/ 'arrived' vs. /kitta/ 'sliced'), lengthened vowels (/obasan/ 'aunt' vs. /oba:san. 'grandmother'), and spoken pitch differences (/ka↓ki/ 'oyster' vs. /kaki↓/ 'fence').

The results of the Nakata study were somewhat surprising. Participants' mean scores were similar for the paired music and language tasks, but the overall scores on both language and music tests were unexpectedly high. A correlation of .370 was found between musical rhythm recognition and geminate production, but no such correlation was found between musical ability and phonological perception. Nakata theorizes that this split might suggest separate cognitive operations for perception and production. Nakata's study concedes that study results might have been different if the tests in that study had used both short-term and long-term memory to gauge participants' language abilities.

Slevc and Miyake (2006) conducted a robust study of the relationship between musical ability and language-learning ability. 50 adult Japanese L1 learners of English took an extensive battery of tests of musical abilities, language-learning abilities, general intelligence, length of residence in the U.S., age of arrival, motivation, and extent of English exposure. All participants resided in the United States and arrived after the age of 11.

Researchers assessed and collected data about participants' English skills, nonverbal intelligence, phonological short-term memory, musical ability (chord analysis, pitch change identification, tonal memory, and tonal production), and language history (age of arrival, length of U.S. residence, extent of exposure, and motivation). In phonological perception tests, participants heard recorded words and sentences and were asked to distinguish between minimal pairs (for example, "flee' and "free"). In production tests, participants read aloud a story and a series of minimal-pair words, which were judged by native speakers.

Slevc and Miyake found that musical ability correlated significantly with phonological perception (Pearson correlation coefficient .52) and with phonological production (.45). In the case of phonological perception, musical ability correlated more closely than any other individual difference measured in the study. In the case of production, musical ability correlated similarly to age of arrival, extent of exposure, and length of residence.

Hierarchical regression controlled for the influence of other individual differences in the analysis of the music-language relationship. Slevc and Mikaye confirmed that musical ability predicted

differences in phonological perception and production. Their study provided empirical confirmation of the music-language link. From the results of their study, they theorized that any ability that aids in the analysis of sounds is "likely beneficial" in adult second language learning.

The most recent and extensive study, by Bowles, Chang, and Karuzis (2016), controlled for general language-learning ability to examine whether pitch ability can predict tonal word learning. Native English-speaking young adults took cognitive tests, foreign language aptitude tests, and musical aptitude tests. They took pitch ability tests, incorporating both linguistic and non-linguistic tones, to determine their ability to discriminate between tones, identify tones, determine whether two pitches were the same, and identify pitch contours.

Participants learned a set of Mandarin pseudo-words on which they were later retested. This retesting after an interval (up to two days) addressed a deficit in the Nakata study, which tested participants immediately.

Bowles et al. (2016) found stronger correlations than Nakata (e.g., a .440 correlation between one test of pitch ability and a test of phonological short-term memory). Tonal word learning in Mandarin was predicted by participants' linguistic pitch processing (ability to differentiate between spoken pitch contours) and musicality assessments. The strongest predictor, however, was the measurement of linguistic pitch processing, not musicality. The researchers inferred that nonverbal pitch processing skills contribute to the initial learning of tone by speakers of nontonal languages. They found that musicality, while it may facilitate tone distinction in beginning tonal language speakers, does not seem to confer any advantage on speakers once they have learned the basic tone distinctions.

Based on these studies, we cannot generalize a link between overall musical ability and the broad set of skills associated with language learning. More likely, there are specific musical abilities that predict equally specific aspects of language learning. It is also possible that the specific musical abilities and aspects of language learning vary based on the phonology of the language being learned. The current study looked specifically at pitch recognition and musical memory to determine whether they correlated with toneme recognition in Mandarin.

Research questions

This project investigated a possible correlation between musical ability and phonological perception. Specifically, the study addressed these research questions:

1. Is there a correlation between musical ability (musical memory and pitch discrimination) and the ability to recognize Mandarin tonemes?
2. If this correlation between musical ability and phonological perception exists, does it differ by gender or age?

METHODOLOGY

Participants watched a video introducing the Chinese tonemes. Participants then completed two assessments related to Mandarin tonemes and one related to musical ability. In an online survey,

participants reported their scores and demographic information. A Pearson's correlation was calculated between the scores on the musical ability and phonological perception assessments.

Participant tasks

Participants watched an instructional video, completed 3 assessments, and completed a survey.

Instructional video. Participants viewed a video that explains Mandarin tones in beginners' terms. The video uses self-explanatory terms ("falling," "rising," "flat," "falling and then rising") instead of "tone 1, "tone 2," etc. This terminology helped to ensure that the test measured participants' recognition of tones, not their ability to remember arbitrary labels.

The video appeals to different learning/sensory preferences. The instructor uses hand gestures to indicate pitch contours (appealing to kinesthetic learners), color coding, pictures, and marks over vowels (appealing to visual learners), and spoken demonstrations of the tones themselves (appealing to auditory learners).

Musical memory and pitch perception test. Dr. Jake Mandell, M.D., developed the pitch perception test for research on neuro-anatomical correlates of congenital amusia, or "tone deafness." Mandell used the test to measure his patients' pitch discrimination and musical memory abilities, both key factors in musical ability. People with amusia score very low on assessments of both of these factors, while professional musicians typically score very high. In this study, the participants' task was to listen to 36 pairs of melodies and indicate whether the two melodies are the same or different. The test returns a score that represents the percentage of correct answers.

Mandarin tone games. The Mandarin tone games are part of the Chinese language-learning website developed by the British Broadcasting Corporation (BBC). The games were designed as a review for Mandarin learners. The game consists of 3 multiple-choice tests: Easy (ten 1-syllable words), Medium (ten 2-syllable words), and Hard (ten 3-syllable words). Players listen to a word and choose the correct pinyin representation of the word (example: má, mà, mā, mǎ). Participants first completed the Easy game in order to acquaint themselves with the process and user interface. Then they completed the Medium game, whose data was used for correlation with the musical assessments.

Participants reported their assessment scores and demographic data in an online survey. The survey asked for their scores on the musical ability assessment, scores for both of the Mandarin tone games, as well as age, gender, native language, other languages spoken and studied, and whether participants were linguistics majors (linguists were excluded from the study). A comments field allowed participants to make notations about any extenuating circumstances (hearing loss, tinnitus, problems accessing the assessments, etc.).

Participants. The survey was open only to adults with no tonal language background. Participants were recruited through convenience sampling, using social media and personal contacts. After the removal of "disqualified" responses (linguists, incomplete surveys, and obvious score errors), data were used from 107 participants, with the following demographic breakdown.

Table 1

Number of participants by gender

Gender	Number of participants
Men	48
Women	58
Other/No answer	1

The ages of participants ranged from 18 to 80, with a median age of 45.

Table 2

Number of participants by age range

Age range	Number of participants
18–25	22
26–35	15
36–45	17
46–55	18
56–65	25
66–80	10

RESULTS

Assessment scores

Scores on the musical ability assessment ranged from 26.1 to 100 (on a 100-point scale), with a mean of 74.5 and a median of 75.0. Scores on the medium Mandarin tone game ranged from 0 to 10 (on a 10-point scale), with a mean of 4.8 and a median of 5.

Table 3

Assessment scores

Assessment	Lowest score	Highest score	Mean	Median
Musical ability	26.1	100	74.5	75
Mandarin tones	0	10	4.8	5

Correlations

The correlation between the musical test scores and the Mandarin tone game for all participants was .340.

Gender

The correlation for men (.353) was only slightly higher than for women (.334), not constituting a statistically significant difference, and their average assessment scores were also comparable.

Table 4

Musical ability and toneme score correlations by gender

Gender	Correlation
Men	.353
Women	.334
Overall	.340

Table 5

Average scores by gender

Gender	Number of participants	Average scores	
		Musical ability	Toneme recognition
Men	48	75.8	5.1
Women	58	74.3	4.6
Other	1		
Overall	107	74.5	4.8

Age

The correlation varied by age, with the older participants showing the highest correlation. The median age of participants was 45.

Table 6

Musical ability and toneme recognition score correlations by age (by median)

Age	Correlation
18-44	.278
45-80	.396
Overall	.340

The average test scores for the two groups were not statistically different, although the younger half of the participants scored slightly higher on both tests:

Table 7

Average test scores by age (by median)

Age range	Average test scores	
	Musical ability	Toneme recognition
18-44	75.5	5.0
45-80	73.6	4.6
Overall	74.5	4.8

Breaking the age ranges down into smaller groups shows that the oldest participants (ages 66 through 80) had the highest correlation between their musical and toneme recognition scores. However, given the smaller size of this portion of the participant sample, it is possible that the correlation for this group is not representative of the overall population.

Table 8

Musical ability and toneme recognition score correlations by age

Age range	Number of participants	Correlation
18-25	22	.348
26-35	15	.057
36-45	17	.469
46-55	18	.331
56-65	25	.287
66-80	10	.599
Overall	107	.340

While the oldest participants had the highest correlation between their scores, they also had the lowest scores on both assessments.

Table 9

Average scores by age

Age range	Number of participants	Average scores	
		Musical ability	Toneme recognition
18-25	22	73.0	5.2
26-35	15	78.3	5.1
36-45	17	75.7	4.7
46-55	18	73.0	4.3
56-65	25	76.0	5.2
66-80	10	69.3	3.9
Overall	107	74.5	4.8

Summary

As the correlations listed above demonstrate, there is a positive correlation (.340) between scores on musical ability tests and Mandarin toneme recognition assessments. The correlation is very slightly higher for men (.353) than for women (.334) and somewhat higher for participants who are older than the median age (.396) than for younger participants (.278).

DISCUSSION

This study reinforces findings by previous researchers, provides new insight into phonological perception variation across adult age groups, and suggests a need for additional research on the effects of age and gender on adult language learners.

The current study, because it relied on convenience sampling to recruit participants, did not have as homogeneous a participant population as the Nakata study, whose adult participants included only those without formal music training; or the Slevc and Miyake study, which included only Japanese-L1 participants; or the Bowles, Chang, and Karuzis study, whose participants were all young adults. The weaker correlation in the current study might suggest that the participants' linguistic diversity was a confounding variable that dampened the correlation.

The current study did, however, begin to explore whether the correlation between musical ability and language-learning ability differ by gender or by age. While no significant difference in correlation was found by gender, the current study suggests that the link between musical ability and language-learning ability may change over the adult lifespan. The differences in correlation did not exhibit a consistent change from decade to decade, but the differences in correlation between the participants above and below the median age suggest that more research, with participants who are more homogeneous in factors other than age (for example, with the same language background), is needed to determine more clearly how age affects the correlation between musical ability and language-learning ability.

Further research

The discrepancies between groups within this study's participant population—most notably by age range—suggest a need for further study of the effects of age differences in language learning. While a great deal of research has been done comparing children and adults in terms of their language-learning outcomes, little research has been done to compare language learning between younger adults, middle-aged adults, and older adults. Further studies would need to control for general cognitive factors to isolate the changes in language-learning ability, independent of potential decline in general cognitive abilities. With the growing popularity of language-learning apps, such research could inform the design of better language-learning tools for adults.

CONCLUSION

This experiment demonstrated that short-term musical memory and pitch perception correlated positively with the ability to distinguish between Mandarin tonemes, providing some support for the belief that there is a positive relationship between musical ability and language learning.

However, a wide range of individual differences, and complex interactions between these individual differences, also have an influence on language-learning achievement, and it is important not to oversimplify the effect of any one influence in isolation from the others.

While the study of these other factors was beyond the scope of this project, it would be useful to find a correlation that could be used, even cautiously, to predict success in specific aspects of second-language learning, in this case, phonological perception. Such predictions could influence language learning strategies and teaching methods to benefit from learners' musical ability or compensate for a lack thereof, based on pretests. Extra exercises might be designed to help students develop their perception skills.

Previous research indicated a need for more research into the music-language link. While this study provides insights into the effects of age on this link, more research is needed to understand how age influences language learning. Because both musical ability and language-learning ability comprise several specific sub-skills, it remains to be established which of these musical sub-skills correlate with specific language sub-skills.

ABOUT THE AUTHOR

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