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Individual differences in second language proficiency: Does musical ability matter?

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Abstract

This study examined the relationship between musical ability and second language (L2) proficiency in adult learners. L2 ability was assessed in four domains (receptive phonology, productive phonology, syntax, and lexical knowledge), as were various other factors that might explain individual differences in L2 ability, including age of L2 immersion, patterns of language use and exposure, and phonological short-term memory. Hierarchical regression analyses were conducted to determine if musical ability explains any unique variance in each domain of L2 ability after controlling for other relevant factors. Musical ability predicted ability with L2 phonology (both receptive and productive) even when controlling for other factors, but did not explain unique variance in L2 syntax or lexical knowledge. These results suggest that musical skills can supplement the acquisition of L2 sound structure and add to a growing body of evidence linking language and music.

There are substantial individual differences in second language (L2) proficiency. While learners' age of immersion has been known to influence their level of ultimate L2 attainment, striking individual differences still exist, especially among learners who started acquiring an L2 after childhood. Although some adult L2 learners attain near-native-level proficiency, others speak with strong foreign accents and frequent grammatical errors long after their immersion in the L2. Why do some adult learners acquire an L2 more successfully than others? What characteristics differentiate good L2 learners from not-so-good ones?

One common answer to these questions (at least among laypersons) is that musical ability is an important determinant of such variation. According to this account, being skilled at music means having a "good ear" for analyzing and discriminating foreign speech sounds, which in turn makes musically talented individuals better equipped to pick up various aspects of an L2, especially "authentic" pronunciations of L2 sounds.

There are good scientific reasons to expect a link between musical ability and L2 proficiency. First, like language, music is a human universal consisting of perceptually discrete elements organized into hierarchically structured sequences (Patel, 2003; Sloboda, 1985). Second, neuropsychological evidence indicates that some brain regions often assumed to be language-specific (e.g., the inferior frontal gyrus, including Broca's area) are also implicated in musical processing (Levitin & Menon, 2003; Maess, Koelsch, Gunter, & Friederici, 2001; Tillmann, Janata, & Bharucha, 2003), as are certain ERP signatures of language processing (Patel, Gibson, Ratner, Besson, & Holcomb, 1998). Third, musical ability can predict aspects of first language (L1) verbal ability, such as reading ability in children (Anvari, Trainor, Woodside, & Levy, 2002; Atterbury, 1985).

Given such evidence for a music–language link, it is surprising that little evidence is available regarding the hypothesized relationship between musical ability and L2 proficiency. Skehan (1989) provided a detailed monograph-length review of individual differences in L2 acquisition, but had nothing to say about the (ir)relevance of musical ability to L2 proficiency. Moreover, several studies that included self-ratings of musical ability failed to find a clear link to L2 ability (Flege, Munro, & MacKay, 1995; Flege, Yeni-Komshian, & Liu, 1999; Tahta, Wood, & Loewenthal, 1981; Thompson, 1991). Although two recent studies reported a positive link between musical ability and aspects of L2 pronunciation ability (Nakata, 2000; Tanaka & Nakamura, 2004), they did not control for effects of other potentially correlated variables. Thus, it is unclear whether musical ability makes a unique contribution to explaining variance in L2 proficiency.

Given this lack of evidence, it is tempting to conclude that the popular conjecture that musical ability matters for L2 learning is a myth. Drawing such a conclusion may be premature, however, because previous studies relied on subjective self-ratings, rather than objective, psychometrically validated measures, to assess musical ability.

The aim of the current study was to give the musical-ability hypothesis a more rigorous test than has been done before. To this end, we tested native Japanese speakers who were not immersed in their L2 (English) until after the age of 11 (*M*=25.0; Range: 11–47). No participant had achieved native-level L2 proficiency at the time of testing, but there was large variability in all four domains of L2 proficiency we tested (receptive phonology, productive phonology, syntax, and lexical knowledge). We focused on "late arrivals" because our goal was not to evaluate the intensively studied critical period hypothesis, but to address a previously neglected question—what factors underlie individual differences in L2 proficiency among late learners?

We assessed musical ability with several subtests from a well-known standardized test (Wing, 1968) that has been shown to reliably predict teachers' ratings of students' musical ability and students' grades in music (see Shuter-Dyson & Gabriel, 1981, for a review). We also measured other factors potentially relevant to L2 proficiency and used hierarchical regression analyses to examine whether musical ability could uniquely explain variance associated with these four L2 domains. Several of these additional measures have shown systematic relationships to L2 proficiency, such as learners' age of arrival (AOA; Hakuta, Bialystok, & Wiley, 2003; Johnson & Newport, 1989), length of residence (LOR; Flege & Liu, 2001; Flege et al., 1999), patterns of language use (Piske, MacKay, & Flege, 2001), and phonological short-term memory (STM) capacity (Baddeley, Gathercole, & Papagno, 1998; Ellis & Sinclair, 1996). If there is some truth to the popular musical-ability hypothesis, then musical ability should account for individual differences in L2 proficiency (especially pronunciation ability) even after controlling for the effects of other potentially relevant variables.

Method

Participants

The participants were 50 native speakers of Japanese (41 females), aged 19 to 52 (*M*=31.3). They were recruited from the Boulder, Colorado, area through flyers or word-of-mouth and were compensated $20 for participation. To be included in the study, they must have arrived in the U.S. after the age of 11 and had lived there continuously for at least 6 months at the time of testing. Participants were in the U.S. for a variety of reasons: 50% were students, 22% were spouses, and 28% were locally employed. For most participants, exposure to English before their arrival in the U.S. was restricted to formal classroom instruction emphasizing reading and grammar.

Materials

The tasks and measures are summarized in Table 1.

Receptive phonology. Participants first heard a pre-recorded list of 26 words, each of which was half of a minimal pair differing in phonemes that Japanese speakers find difficult to discriminate (e.g., *clown/crown*). They then heard 26 minimal-pair sentences, worded such that either word of the pair would make the sentence meaningful (e.g., “Some researchers believe that *playing/praying* is an important part of mental development.”). For both words and sentences, participants decided which of the words (printed on a written list) was presented.

Participants also listened to a recording of a short story and marked any mispronounced words on a written version. Out of 43 underlined words that they were instructed to focus on, 21 contained deliberate mispronunciations.

Productive phonology. Participants read aloud 26 minimal-pair words and then 26 minimal-pair sentences analogous to those created for the receptive version. The words and sentences were recorded and later presented to two native-English-speaking judges, who decided which word of the minimal pair they heard. A third native-English-speaking judge decided for all items on which the first two judges disagreed (9.2% of the words and 11.4% of the sentences).

Participants also read aloud a short English passage. Two native English-speaking judges listened to the recordings and rated the reader's overall pronunciation, intelligibility, and prosody on 9-point scales, ranging from "very strong foreign accent" to "no foreign accent."

Syntax. Participants heard 72 recorded sentences and decided whether each sentence was grammatically well-formed. The sentences were adapted from Johnson and Newport (1989) and tested nine syntactic rules (past tense, plural, third-person singular, determiners, pronouns, particle movement, subcategorization, yes/no questions, and wh-questions).

Lexical knowledge. Participants completed a 25-question multiple-choice vocabulary test, adapted from a practice book for the Test of English as a Foreign Language (TOEFL). They also completed a listening comprehension subtest from a past TOEFL exam in which they answered 30 multiple-choice questions primarily testing understanding of idiomatic and colloquial expressions.

Language history. Participants provided information about their language background, including their AOA, their LOR in the U.S., the extent of their use of and exposure to English (USE), and their motivation to learn and speak English.

Nonverbal intelligence. Participants completed the four subscales of Scale 3, Form A, of the Cattell (1963) Culture Fair Test, a measure of general fluid intelligence.

Phonological STM. In *digit span*, participants saw lists of numbers presented serially at the rate of one digit per second, read each number aloud in Japanese, and then attempted to recall each list. There were 24 lists, ranging from 4 to 11 digits long. In *nonword repetition* (Gathercole, Willis, Emslie, & Baddeley, 1991), participants heard and repeated 40 nonwords (1–4 syllables long) that obeyed the phonological rules of English. Recorded responses were scored for accuracy by a trained native-English-speaking judge.

Musical ability. Participants completed three subtests of the *Wing Measures of Musical Talents* (Wing, 1968). In *Chord Analysis*, participants detected the number of notes played in a single chord. In *Pitch Change*, participants decided whether two chords played were the same and, if different, whether the altered note moved up or down. In *Tonal Memory*, two short tunes (3–10 notes long) were played that differed in a single note, and participants indicated the sequential position of that altered note.

Participants also completed a *Tonal Memory Production* test, which we modeled after the receptive Tonal Memory test. The task required participants to accurately sing short tunes (3–7 notes long) from immediate memory. Their singing was digitized and compared to the target tunes. Notes were considered accurate if the sustain portion was within one semitone of the target.

Results

Tasks designed to tap the same underlying ability were aggregated (by adding *z*-scores) to obtain stable measures of these abilities. Table 1 provides descriptive statistics for each measure. Zero-order correlations, presented in Table 2, suggest that musical ability may indeed be related to proficiency in L2 phonology and, to a lesser extent, syntax. To test whether this relationship persists even when controlling for other relevant factors, we conducted hierarchical regression analyses (see Table 3 for a summary of the results).[1] Measures of motivation and nonverbal intelligence were omitted because they did not correlate with any measure of L2 proficiency.

AOA, entered first into the analyses, significantly accounted for variance in L2 lexical knowledge (and marginally in syntax and receptive phonology). LOR, entered in Step 2, predicted all four domains of L2 ability even after controlling for AOA. Adding the aggregate

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[1] All analyses were rerun after eliminating one univariate and two multivariate outliers, but the pattern of results was unchanged.

measure of USE in Step 3 accounted for additional variance only in lexical knowledge (and marginally in syntax). Phonological STM, entered in Step 4, accounted for additional variance in receptive phonology and syntax (and marginally in lexical knowledge). These results are consistent with previous findings suggesting (a) that LOR may be a better predictor of L2 phonology and syntax than AOA for adult L2 learners (Flege et al., 1999; Flege & Liu, 2001) and (b) that phonological STM plays an important role in the acquisition of L2 phonology (MacKay, Meador, & Flege, 2001), lexicon (Baddeley et al., 1998), and syntax (Ellis & Sinclair, 1996).

Most important, the inclusion of musical ability in Step 5 accounted for additional variance in receptive and productive phonology, but not in syntax or lexical knowledge. Interestingly, self-ratings of musical ability, which we also collected, showed considerably weaker correlations with L2 proficiency (the zero-order correlations were .31, .24, .22, and .12 for receptive phonology, productive phonology, syntax, and lexical knowledge, respectively).[2] Had these self-rated measures been used, they would not have been a significant predictor for any measure of L2 proficiency at Stage 5 of the hierarchical regression analyses.

Table 3 also summarizes the final (post-Stage-5) standardized β weights for each measure included in the regression analyses. Comparison of final β weights further highlights the relative importance of musical ability in accounting for variability in L2 phonology, but not syntax and lexical knowledge. For these latter abilities, experience, language use, and phonological STM seem to matter more.

Discussion

The popular conjecture that musical ability is associated with L2 proficiency is not a myth. Although it may be restricted to L2 phonology, individuals who are good at analyzing, discriminating, and remembering simple musical stimuli are better at accurately perceiving and producing L2 sounds. To the best of our knowledge, this is the first study that rigorously tested

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[2] Participants rated their overall musical ability and their singing ability on five-point Likert scales; these two ratings were aggregated for analysis. The correlation between self-rated and objectively measured musical ability was .38 ($p < .05$).

the musical-ability hypothesis and provided clear evidence for it.

As one gets older, one's ability to acquire native-like proficiency in L2 pronunciation generally declines. Whether this trend reflects maturational constraints on the biological machinery dedicated to language acquisition or a more firmly established L1 phonology (for different perspectives, see Birdsong, 1999), late L2 learners are at a disadvantage and so may rely more on other nonlinguistic mechanisms and abilities to aid in L2 acquisition. In particular, any ability that helps analyze the novel L2 sound structure is likely beneficial, and musical ability appears to be a perfect candidate. Of course, musical ability is unlikely a *necessary* component of adult L2 phonological acquisition, given, for example, a report of an individual with exceptional talents in L2 acquisition who seems to lack comparable musical skills (Novoa, Fein, & Obler, 1988). Nevertheless, for more typical late learners, the ability to analyze musical sound structure would also likely facilitate the analysis of a novel phonological structure of an L2.

Now that the relationship between musical ability and L2 pronunciation ability has been demonstrated, an important future question is whether this relationship is mediated by individual differences in basic auditory ability, such as the ability to detect the presence of a subtle sound. Recent L1 research suggests that, at least among young normal-hearing adults, simple psychoacoustic measures of spectral and temporal acuity for nonspeech sounds are not related to individual differences in speech perception (e.g., Surprenant & Watson, 2001). It seems important, however, to further evaluate whether individual variation in auditory acuity or other basic auditory abilities underlies variation in the perception of L2 speech sounds and of complex musical stimuli (e.g., chords).

Another important issue to explore is whether ability in other domains of music can account for variability in other domains of adult L2 ability. Just as language ability consists of ability in separable (though related) domains, multiple domains of musical ability also exist (Peretz & Coltheart, 2003; Shuter-Dyson & Gabriel, 1981). Thus, in light of work showing similarities between linguistic and musical syntax (Levitin & Menon, 2003; Maess et al., 2001;

Patel et al., 1998), adult learners' acquisition of L2 syntax may be related to ability in musical tasks focusing on musical syntactic processes (e.g., hierarchical relationships between harmonic or melodic musical elements).

Previous research on variation in L2 proficiency has focused primarily on age-related variables and neglected to examine why there are still striking individual differences even after age-related variables (e.g, AOA, LOR) are taken into account. Because of its correlational nature, this study does not allow us to make any *causal* inference regarding the music–L2 link. Nevertheless, by demonstrating that musical ability can uniquely account for L2 pronunciation ability among late L2 learners, the current study not only confirms the hitherto empirically unsubstantiated musical-ability hypothesis but also offers new evidence illuminating the nature of the music–language relationship.

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Table 1
Dependent measures and descriptive statistics for the tasks used in this study

Task	Dependent Measure	Mean (SD)	Range
	Criterion (L2 Proficiency) Variables		
Receptive Phonology (*z*-score aggregates)			
Word Level	number correct (of 26)	21.6 (2.8)	13–26
Sentence Level	number correct (of 26)	20.1 (3.2)	12–26
Passage Level	number correct (of 43)	32.1 (6.1)	16–43
Productive Phonology (*z*-score aggregates)			
Word Level	raters' number correct (of 26)	22.1 (2.2)	17–26
Sentence Level	raters' number correct (of 26)	22.1 (2.2)	17–26
Passage Level	average ratings from 2 raters (1=strong accent, 9=none)	4.4 (1.9)	1.2–8.2
Syntax			
Grammaticality Judgments	number correct (of 72)	46.5 (6.4)	36–67
Lexical Knowledge (*z*-score aggregates)			
Vocabulary	number correct (of 25)	15.4 (4.4)	8–25
Listening Comprehension	number correct (of 30)	22.9 (5.9)	8–30
	Predictor Variables		
Age-Related Variables			
Age of arrival (AOA)	age of arrival in the U.S. (in years)	25.0 (7.1)	11–47
Length of residence (LOR)	length of residence in the U.S. (in years)	4.4 (5.3)	0.5–25
Self-Reported L2 Use and Exposure (USE; *z*-score aggregates)			
When first arrived in the U.S.			
Use	percent English use (vs. Japanese)	64.2 (29.7)	5–100
Exposure	percent English exposure (vs. Japanese)	68.1 (27.3)	10–100
At the time of testing			
Use	percent English use (vs. Japanese)	64.4 (22.6)	10–99
Exposure	percent English exposure (vs. Japanese)	68.6 (21.5)	20–100
Motivation (*z*-score aggregates)			
When first arrived	average self-ratings from 4 questions (1=not, 5=very)	3.0 (1.1)	0.75–5
At time of testing	average self-ratings from 3 questions (1=not, 5=very)	4.5 (0.6)	2.5–5

Nonverbal Intelligence			
Cattell Culture Fair Test	summed scores from the 4 subscales (of 50)	28.4 (4.7)	17–35
Phonological STM (*z*-score aggregates)			
Japanese Digit Span	number of digits recalled (of 168)	113.7 (22.6)	71–166
Nonword Repetition	number of nonwords accurately repeated (of 40)	25.0 (4.7)	15–37
Musical Ability (*z*-score aggregates)			
Chord Analysis	number correct (of 20)	11.1 (2.8)	5–19
Pitch Change	number correct (of 30)	20.2 (4.8)	13–30
Tonal Memory	number correct (of 30)	20.4 (3.8)	13–28
Tonal Memory Production	number correct (of 75)	42.0 (20.3)	0–72

Note: For *z*-score aggregates, scores on almost all of the component measures were highly correlated. Even if all analyses were rerun after eliminating component measures that did not significantly correlate with the others, the pattern of results did not change.

Table 2
Zero-order correlations between the variables examined in this study

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. L2 Receptive Phonology	--										
2. L2 Productive Phonology	.77**	--									
3. L2 Syntax	.63**	.62**	--								
4. L2 Lexical Knowledge	.57**	.49**	.70**	--							
5. Age of Arrival (AOA)	-.24~	-.24~	-.22	-.46**	--						
6. Length of Residence (LOR)	.43**	.51**	.53**	.46**	-.09	--					
7. L2 Use and Exposure (USE)	.14	.20	.33*	.40**	.00	.25~	--				
8. Motivation to use L2	.19	.09	.03	.14	-.08	-.02	.11	--			
9. Nonverbal Intelligence	.01	.09	.20	.20	-.29*	.13	.11	-.16	--		
10. Phonological Short-Term Memory (STM)	.37*	.19	.48**	.27~	-.03	.26~	-.09	-.01	.13	--	
11. Musical Ability	.52**	.45**	.35*	.26~	-.19	.29*	.04	.07	.12	.23	--

** $p < .005$, * $p < .05$, ~ $p < .10$

Note: Due to missing values, one subject was excluded from all correlations involving the nonverbal intelligence measure.

Table 3
Summary of hierarchical regression results for four different domains of L2 proficiency

Model	IV	R^2	ΔR^2	df	F	Final β
			L2 Receptive Phonology			
Step 1	Age of Arrival (AOA)	.06	.06	1,48	2.92~	-0.14
Step 2	Length of Residence (LOR)	.23	.17	1,47	10.25**	0.23~
Step 3	Language Use and Exposure (USE)	.23	.00	1,46	0.09	0.08
Step 4	Phonological STM	.30	.07	1,45	4.90*	0.23~
Step 5	Musical Ability	.42	.12	1,44	8.82*	0.37**
			L2 Productive Phonology			
Step 1	Age of Arrival (AOA)	.05	.05	1,48	2.49	-0.13
Step 2	Length of Residence (LOR)	.29	.24	1,47	15.59**	0.37*
Step 3	Language Use and Exposure (USE)	.29	.00	1,46	0.46	0.10
Step 4	Phonological STM	.30	.01	1,45	0.31	0.03
Step 5	Musical Ability	.38	.08	1,44	5.53*	0.30*
			L2 Syntax			
Step 1	Age of Arrival (AOA)	.06	.06	1,48	3.06~	-0.18~
Step 2	Length of Residence (LOR)	.32	.26	1,47	18.04**	0.31*
Step 3	Language Use and Exposure (USE)	.36	.04	1,46	3.16~	0.28*
Step 4	Phonological STM	.51	.15	1,45	13.90**	0.39**
Step 5	Musical Ability	.53	.02	1,44	1.34	0.13
			L2 Lexical Knowledge			
Step 1	Age of Arrival (AOA)	.21	.21	1,48	12.94**	-0.42**
Step 2	Length of Residence (LOR)	.39	.18	1,47	13.28**	0.27*
Step 3	Language Use and Exposure (USE)	.48	.09	1,46	8.30*	0.35**
Step 4	Phonological STM	.52	.04	1,45	3.92~	0.21~
Step 5	Musical Ability	.52	.00	1,44	0.14	0.04

** $p < .005$, * $p < .05$, ~$p < .10$

Note: "Final β" indicates standardized beta weights for each factor when controlling for all other factors (i.e., standard β weights in Step 5)