Research Report

Individual Differences in Second-Language Proficiency

Does Musical Ability Matter?

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ABSTRACT—*This study examined the relation 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. Also assessed 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 explained any unique variance in each domain of L2 ability after controlling for other relevant factors. Musical ability predicted L2 phonological ability (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 may facilitate the acquisition of L2 sound structure and add to a growing body of evidence linking language and music.*

People exhibit substantial individual differences in second-language (L2) proficiency. Learners' age of immersion is known to influence their ultimate level of L2 ability, but even when this factor is taken into account, striking individual differences still exist, especially among people who started acquiring an L2 after childhood. Although some adult L2 learners attain near-native 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, so that musically talented individuals are better equipped than other people to pick up various aspects of an L2, especially 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 event-related potential 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 relation 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 relevance (or irrelevance) of musical ability to L2 proficiency. Moreover, several studies failed to find a clear link between self-ratings of musical ability and 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, 2002; 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.

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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 test the musical-ability hypothesis more rigorously 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 ($M = 25.0$ years, 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 rather 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 the four L2 domains. Several of these additional measures have shown systematic relations to L2 proficiency: learners' age of arrival (Hakuta, Bialystok, & Wiley, 2003; Johnson & Newport, 1989), length of residence in the L2 community (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), ages 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 had to have arrived in the United States after the age of 11 and to have been living there continuously for at least 6 months at the time of testing. Participants were in the United States for a variety of reasons: 50% were students in the United States, 22% were spouses of people living in the United States for work or school, and 28% were locally employed. For most participants, exposure to English before their arrival in the United States was restricted to formal classroom instruction emphasizing reading and grammar.

Materials and Procedure

The tasks and measures are summarized in Table 1.

Receptive Phonology

Receptive phonology was assessed at the word, sentence, and passage levels. Participants first heard a prerecorded 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 member of the minimal pair (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

Productive phonology was also assessed at the word, sentence, and passage levels. Participants read aloud 26 minimal-pair words and then 26 minimal-pair sentences analogous to those created for the receptive-phonology tasks. The words and sentences were recorded and later presented to two native English speakers, who decided in each case which word of the minimal pair they heard. A third native English speaker 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 speakers listened to the recordings and rated overall pronunciation, intelligibility, and prosody on 9-point scales, ranging from *very strong foreign accent* to *no foreign accent*.

Syntax

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

Lexical Knowledge

Lexical knowledge was assessed with two tasks: a 25-question multiple-choice vocabulary test, adapted from a practice book for the Test of English as a Foreign Language (TOEFL), and a listening comprehension subtest from a past TOEFL exam. The listening comprehension test consisted of 30 multiple-choice

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[a]			
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[a]			
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[a]			
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	Age of arrival in the United States (in years)	25.0 (7.1)	11–47
Length of residence	Length of residence in the United States (in years)	4.4 (5.3)	0.5–25
Self-reported L2 use and exposure[a]			
When first arrived			
Use	Percentage English use (vs. Japanese)	64.2 (29.7)	5–100
Exposure	Percentage English exposure (vs. Japanese)	68.1 (27.3)	10–100
At time of testing			
Use	Percentage English use (vs. Japanese)	64.4 (22.6)	10–99
Exposure	Percentage English exposure (vs. Japanese)	68.6 (21.5)	20–100
Motivation to use L2[a]			
When first arrived	Average self-ratings from 4 questions (1 = not motivated, 5 = very motivated)	3.0 (1.1)	0.75–5
At time of testing	Average self-ratings from 3 questions (1 = not motivated, 5 = very motivated)	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[a]			
Japanese digit span	Number of digits recalled (of 168)	113.7 (22.6)	71–166
Nonword repetition	Number of nonwords repeated accurately (of 40)	25.0 (4.7)	15–37
Musical ability[a]			
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. L2 = second language; STM = short-term memory.
[a]For each of these measures, scores on almost all the component measures were highly correlated, and a *z*-score aggregate was calculated. The pattern of results did not change when all analyses were rerun after eliminating component measures that did not correlate significantly with the others.

questions that primarily tested participants' understanding of idiomatic and colloquial expressions.

Language History

Participants provided information about their language background, including their age of arrival and length of residence in the United States. They also estimated the extent of their use of and exposure to English, and their motivation to learn and speak English, both for when they first arrived in the United States and at the time of testing.

Nonverbal Intelligence

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

TABLE 2
Zero-Order Correlations Among the Variables Examined in This Study

Variable	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	−.24†	−.24†	−.22	−.46**	—						
6. Length of residence	.43**	.51**	.53**	.46**	−.09	—					
7. L2 use and exposure	.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	.37*	.19	.48**	.27†	−.03	.26†	−.09	−.01	.13	—	
11. Musical ability	.52**	.45**	.35*	.26†	−.19	.29*	.04	.07	.12	.23	—

Note. Because of missing values, 1 subject was excluded from all correlations involving the measure of nonverbal intelligence. L2 = second language.
†$p < .10$. *$p < .05$. **$p < .005$.

Phonological STM

Phonological STM was assessed using two tasks. In the *digit-span* task, participants saw lists of numbers presented serially at the rate of 1 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 the *nonword-repetition* task (Gathercole, Willis, Emslie, & Baddeley, 1991), participants heard and repeated 40 nonwords (one to four syllables long) that obeyed the phonological rules of English. Recorded responses were scored for accuracy by a trained native English speaker.

Musical Ability

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

Participants also completed a production test that we modeled after the receptive Tonal Memory subtest. This tonal-memory production task required participants to accurately sing three- to seven-note tunes from immediate memory. Their singing was digitized and compared with the target tunes. A note was considered accurate if the sustained portion was within one semitone of the target.

RESULTS

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

Age of arrival, entered first into the analyses, significantly accounted for variance in L2 lexical knowledge (results for syntax and receptive phonology were marginally significant). Length of residence, entered in Step 2, predicted all four domains of L2 ability even after controlling for age of arrival. Adding the aggregate measure of English use and exposure in Step 3 accounted for additional variance only in lexical knowledge (results for syntax were marginally significant). Phonological STM, entered in Step 4, accounted for additional variance in receptive phonology and syntax (results for lexical knowledge were marginally significant). These results are consistent with previous findings suggesting (a) that length of residence may be a better predictor of L2 phonology and syntax than age of arrival for adult L2 learners (Flege & Liu, 2001; Flege et al., 1999) 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 knowl-

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

TABLE 3

Summary of Hierarchical Regression Results for Four Different Domains of Second-Language (L2) Proficiency

Step and independent variable	R^2	ΔR^2	*df*	*F*	Final β
L2 receptive phonology					
Step 1: age of arrival	.06	.06	1, 48	2.92†	−.14
Step 2: length of residence	.23	.17	1, 47	10.25**	.23†
Step 3: language use and exposure	.23	.00	1, 46	0.09	.08
Step 4: phonological short-term memory	.30	.07	1, 45	4.90*	.23†
Step 5: musical ability	.42	.12	1, 44	8.82*	.37**
L2 productive phonology					
Step 1: age of arrival	.05	.05	1, 48	2.49	−.13
Step 2: length of residence	.29	.24	1, 47	15.59**	.37*
Step 3: language use and exposure	.29	.00	1, 46	0.46	.10
Step 4: phonological short-term memory	.30	.01	1, 45	0.31	.03
Step 5: musical ability	.38	.08	1, 44	5.53*	.30*
L2 syntax					
Step 1: age of arrival	.06	.06	1, 48	3.06†	−.18†
Step 2: length of residence	.32	.26	1, 47	18.04**	.31*
Step 3: language use and exposure	.36	.04	1, 46	3.16†	.28*
Step 4: phonological short-term memory	.51	.15	1, 45	13.90**	.39**
Step 5: musical ability	.53	.02	1, 44	1.34	.13
L2 lexical knowledge					
Step 1: age of arrival	.21	.21	1, 48	12.94**	−.42**
Step 2: length of residence	.39	.18	1, 47	13.28**	.27*
Step 3: language use and exposure	.48	.09	1, 46	8.30*	.35**
Step 4: phonological short-term memory	.52	.04	1, 45	3.92†	.21†
Step 5: musical ability	.52	.00	1, 44	0.14	.04

Note. "Final β" indicates the standardized beta weight for each variable when controlling for all other variables (i.e., standard beta weights in Step 5).
†$p < .10$. *$p < .05$. **$p < .005$.

edge, respectively).[2] Had these self-ratings been used, they would not have been a significant predictor for any measure of L2 proficiency at Step 5 of the hierarchical regression analyses.

Table 3 also summarizes the final (post-Step 5) standardized beta weights for each measure included in the regression analyses. Comparison of the final beta 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 the link may be restricted to L2 phonology, individuals who are good at analyzing, discriminating, and remembering musical stimuli are better than other people at accurately perceiving and producing L2 sounds. To the best of our knowledge, this is the first study that rigorously tested the musical-ability hypothesis and provided clear evidence for it.

As one gets older, one's ability to acquire nativelike 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 a late L2 learner analyze the novel L2 sound structure is likely beneficial, and musical ability appears to be a perfect candidate. Of course, musical ability is unlikely to be a necessary component of adult L2 phonological acquisition, given, for example, the report of an individual who had exceptional talents in L2 acquisition but seemed 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 the novel phonological structure of an L2.

[2]Participants rated their overall musical ability and their singing ability on 5-point Likert scales; these two ratings were aggregated for analysis. The correlation between self-rated and objectively measured musical ability was .38 ($p < .05$).

Now that the relation between musical ability and L2 phonological ability has been demonstrated, an important future question is whether this relation 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 relations among 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., age of arrival, length of residence) 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 phonological 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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REFERENCES

Anvari, S.H., Trainor, L.J., Woodside, J., & Levy, B.A. (2002). Relations among musical skills, phonological processing and early reading ability in preschool children. *Journal of Experimental Child Psychology*, *83*, 111–130.

Atterbury, B.W. (1985). Musical differences in learning-disabled and normal-achieving readers, aged seven, eight and nine. *Psychology of Music*, *13*, 114–123.

Baddeley, A., Gathercole, S., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review*, *105*, 158–173.

Birdsong, D. (Ed.). (1999). *Second language acquisition and the critical period hypothesis*. Mahwah, NJ: Erlbaum.

Cattell, R.B., & Cattell, A.K.S. (1963). *Test of "g": Culture Fair Scale 3, Form A*. Champaign, IL: Institute for Personality Testing.

Ellis, N.C., & Sinclair, S.G. (1996). Working memory in the acquisition of vocabulary and syntax: Putting language in good order. *Quarterly Journal of Experimental Psychology*, *49A*, 234–250.

Flege, J.E., & Liu, S. (2001). The effect of experience on adults' acquisition of a second language. *Studies in Second Language Acquisition*, *23*, 527–552.

Flege, J.E., Munro, M., & MacKay, I.R.A. (1995). Factors affecting strength of perceived foreign accent in a second language. *Journal of the Acoustical Society of America*, *97*, 3125–3134.

Flege, J.E., Yeni-Komshian, G.H., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of Memory and Language*, *41*, 78–104.

Gathercole, S.E., Willis, C., Emslie, H., & Baddeley, A.D. (1991). The influences of number of syllables and wordlikeness on children's repetition of nonwords. *Applied Psycholinguistics*, *12*, 349–367.

Hakuta, K., Bialystok, E., & Wiley, E. (2003). Critical evidence: A test of the critical-period hypothesis for second-language acquisition. *Psychological Science*, *14*, 31–38.

Johnson, J.S., & Newport, E.L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive Psychology*, *21*, 60–99.

Levitin, D.J., & Menon, V. (2003). Musical structure is processed in "language" areas of the brain: A possible role for Brodmann area 47 in temporal coherence. *NeuroImage*, *20*, 2142–2152.

MacKay, I.R.A., Meador, D., & Flege, J.E. (2001). The identification of English consonants by native speakers of Italian. *Phonetica*, *58*, 103–125.

Maess, B., Koelsch, S., Gunter, T.C., & Friederici, A.D. (2001). Musical syntax is processed in Broca's area: An MEG study. *Nature Neuroscience*, *4*, 540–545.

Nakata, H. (2002). Correlations between musical and Japanese phonetic aptitudes by native speakers of English. *Reading Working Papers in Linguistics*, *6*, 1–23.

Novoa, L., Fein, D., & Obler, L.K. (1988). Talent in foreign languages: A case study. In L.K. Obler & D. Fein (Eds.), *The exceptional brain: Neuropsychology of talent and special abilities* (pp. 294–302). New York: Guilford Press.

Patel, A.D. (2003). Language, music, syntax and the brain. *Nature Neuroscience*, *6*, 674–681.

Patel, A.D., Gibson, E., Ratner, J., Besson, M., & Holcomb, P.J. (1998). Processing syntactic relations in language and music: An event-related potential study. *Journal of Cognitive Neuroscience*, *10*, 717–733.

Peretz, I., & Coltheart, M. (2003). Modularity of music processing. *Nature Neuroscience*, *6*, 688–691.

Piske, T., MacKay, I.R.A., & Flege, J.E. (2001). Factors affecting degree of foreign accent in an L2: A review. *Journal of Phonetics*, *29*, 191–215.

Shuter-Dyson, R., & Gabriel, C. (1981). *The psychology of musical ability* (2nd ed.). London: Methuen.

Skehan, P. (1989). *Individual differences in second-language learning*. London: Edward Arnold.

Sloboda, J.A. (1985). *The musical mind: The cognitive psychology of music*. New York: Oxford University Press.

Surprenant, A.M., & Watson, C.S. (2001). Individual differences in the processing of speech and nonspeech sounds by normal-hearing listeners. *Journal of the Acoustical Society of America*, *110*, 2085–2095.

Tahta, S., Wood, M., & Loewenthal, K. (1981). Foreign accents: Factors related to transfer of accent from the first language to a second language. *Language and Speech*, *24*, 265–272.

Tanaka, A., & Nakamura, K. (2004). Auditory memory and proficiency of second language speaking: A latent variable analysis approach. *Psychological Reports*, *95*, 723–734.

Thompson, I. (1991). Foreign accents revisited: The English pronunciation of Russian immigrants. *Language Learning*, *41*, 177–204.

Tillmann, B., Janata, P., & Bharucha, J.J. (2003). Activation of the inferior frontal cortex in musical priming. *Cognitive Brain Research*, *16*, 145–161.

Wing, H.D. (1968). *Tests of musical ability and appreciation: An investigation into the measurement, distribution, and development of musical capacity* (2nd ed.). London: Cambridge University Press.

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