

Exploring the role of personality traits in the imitation abilities of non-native speech in familiar and unfamiliar languages

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Abstract

Previous studies have explored the influence of sociopsychological factors on second language (L2) pronunciation, yet personality traits remain relatively underexplored in this context. Notably, the interplay between speakers' familiarity with the target L2 and the predictive role of personality traits in L2 speech production has not been thoroughly investigated. This study used a speech imitation task to assess the speech production abilities of 35 L2 speakers of English, who had no prior knowledge in Chinese, in both English (familiar L2) and Chinese (unfamiliar L2). Native speakers of English and Chinese rated the accuracy of sentences imitated by the participants. Personality traits were evaluated using the Multicultural Personality Questionnaire (short form) in five aspects: cultural empathy, flexibility, social initiative, open-mindedness, and emotional stability. The findings from a linear mixed-effects model revealed that only cultural empathy showed a significantly negative effect on speech imitation scores for Chinese, not for English. This implies that good cultural empathy may hinder individuals from accurately imitating the accent of an unfamiliar L2, possibly due to concerns about cultural misunderstandings. These results suggest that certain sociopsychological measures may pose challenges to initial encounters with a novel language.

Index Terms: personality traits, speech imitation ability, cultural empathy, second language speech acquisition, individual differences

1. Introduction

Individual differences in cognitive and psychosocial aspects have been shown to largely affect the second language (L2) speech acquisition [1]. While much attention has been paid to the role of cognitive aspects such as musical aptitude [2], auditory processing abilities [3], and working memory [4], relatively less research has investigated the role of psychosocial differences in L2 speech learning [1]. Especially the role of personality traits has received much less attention even though several studies suggest that L2 learners' personality affect L2 learning to a small extent [5]. Therefore, this study focused on how the personality traits affect individual's L2 speech production.

Personality refers to "psychological systems that contribute to an individual's enduring and distinctive patterns of experience and behavior." [6, p. 4]. Recent research in L2 speech acquisition assessed L2 learners' personality traits with a Multicultural Personality Questionnaire (MPQ) [7] and its

short form (MPQ-SF) [8] which are largely based on the "Big Five" model [9] but capture factors related to multicultural aspects [1]. Therefore, MPQ and MPQ-SF are relevant in L2 speech research as L2 learning often takes place in a multicultural context. MPQ-SF is a self-report questionnaire that measures five personality traits relevant to intercultural competence [7]. Hence, in this study, we will follow the previous research [1], [10] to evaluate the participant's personality traits with MPQ-SF. The questionnaire divides personality traits into five categories. (a) *Cultural empathy* refers to how well one can empathize with culturally different feelings, thoughts, and behaviors. (b) *Flexibility* measures how positively and easily one adapts to new cultural situations. (c) *Social initiative* involves proactively engaging in social situations and taking initiative in such interactions. (d) *Open-mindedness* measures the open and non-biased attitude towards new culture. (e) *Emotional stability* refers to the capacity of remaining calm in unusual or stressful situations.

Regarding the role of personality traits in L2 speech learning, previous studies revealed inconsistent results. On the positive end, extroverts show advantages in L2 speaking proficiency [10]–[12], while introverts may achieve more in reading and writing [13]. Similarly, open-minded learners actively engage in authentic communications with native speakers [14], which may favor their L2 oral proficiency. Moreover, learners with better empathetic abilities [15] and emotional stability [10] are more likely to achieve higher L2 oral proficiency. Nevertheless, the link between personality traits and L2 learning is not strong in some research. For instance, Sun et al. [1] found that although extroversion significantly predicted gains in comprehensibility of L2 learners' speech production, emotional stability, cultural empathy, and open-mindedness were not significant predictors, which was inconsistent with previous findings [10], [15]. Therefore, more research is needed to advance this topic.

Another important aspect in L2 speech acquisition is the learners' experience in the target L2. Most of the previous research in individual differences focused on experienced L2 learners (e.g., [1], [10], [13], [14]). Only a couple of studies tested the speech production in novel or unfamiliar languages using imitation tasks and found that the predictive role of cognitive factors (e.g., musical aptitude, working memory, etc.) is subject to the imitator's L1 background, typology of the target L2, and the imitators' musical expertise [16]–[19]. However, very little research considered how personality traits play a role in individuals' first encounter with a novel language. More importantly, it is unclear whether psychosocial factors like personality traits would show similar or different effects on

the production of familiar and unfamiliar L2s. Here, the evaluation of an unfamiliar L2 would be based on speech imitation tasks.

In sum, there are clear gaps in the research on individual differences in L2 speech acquisition. First, the findings on the role of the five main aspects of personality traits identified by van der Zee et al. [8] in L2 speech acquisition were not consistent. Second, it is not clear how each of the five personality traits would interact with the L2 familiarity when influencing L2 speech production. Therefore, we have the following research questions in the current study.

- Do personality traits predict individuals' imitation abilities differently on familiar and unfamiliar L2s?
- If they do, then, which of the five aspects are significant predictors?

To answer these questions, we selected English as the familiar L2 and Chinese as the unfamiliar L2 to test the imitation abilities of L2 English speakers with no prior knowledge in Chinese. We hypothesize that the participants' imitation abilities will differ in English and Chinese, and the predictive value of personality traits will also differ depending on language familiarity. However, it will remain exploratory as to which component of personality traits will be the significant predictor.

2. Methods

2.1. Participants

Thirty-five non-native speakers of English with no prior knowledge of Chinese language participated in the study (20 female, $M_{age} = 29.14$ years, ranged 19-50). The participant's first language was not controlled to represent diverse linguistic profiles. The participants reported speaking Arabic, Dutch, German, Greek, Italian, Kurdish, Nepali, Newari, Norwegian, Polish, Serbian, Spanish, Swahili, Swedish, and Turkish as their first languages. The participants estimated their proficiency in English speaking and listening skills on a 7-point Likert scale. We averaged the English listening and speaking proficiency scores and converted the average score to a 0-1 scale. Overall, the participants showed advanced level English proficiency ($M = 0.86$, $SD = 0.14$). This means that the participants could well perceive spoken English and orally produce English sentences, which is essential for an imitation task. Note that the English proficiency report of one participant was missing, but this participant showed fluent English conversation skills during the oral interaction with the experimenters. Therefore, we decided not to exclude this participant. In addition, all the participants had no documented speech or hearing impairments. All participants signed written consent forms to allow the researchers collect and analyze their data.

2.2. Materials

2.2.1. Speech imitation task

The speech imitation task featured both familiar and unfamiliar L2s. We created 9 English (familiar L2) and 9 Chinese (unfamiliar L2) short sentences for the speech imitation task. The English and Chinese sentences were recorded by a native speaker in the respective languages. The syllable length was determined based on the average number (7 ± 2) of discrete items typically recalled in working memory tests [20]. Therefore, English sentences were 7, 9, or 11 syllables long.

However, we observed that syllable lengths beyond 8 in Chinese posed significant challenges for novice imitators in pilot trials. Therefore, we set the syllable length of the unfamiliar L2 lower than that of the familiar L2. Consequently, Chinese sentences were 4, 6, or 8 syllables long.

To enhance the difficulty of the task, the sentences incorporated challenging phonetic features for non-native speakers of both English and Chinese. Examples include the English /ð-θ/ and /i-ɪ/ contrasts, connected speech, and vowel reduction. In Chinese, the sentences included alveolo-palatal sibilants /tɕ, tɕʰ, ɕ/, approximants like “apical vowels” /ɿ, ʅ/, and other intricate elements [21].

2.2.2. MPQ-SF

We used the 40-item MPQ-SF in our study, which was extracted from the original 91 items of the MPQ and were proven effective [8]. The 40 questions belonged to five different categories, with each category containing eight questions. Each category targeted one personal trait, namely, cultural empathy, flexibility, social initiative, open-mindedness, and emotional stability. All the 40 questions were embedded in an online platform to collect the data.

2.3. Procedure

Participants underwent individual testing in a quiet room, beginning with the signing of a consent form. They completed the speech imitation task and filled out a language background questionnaire and MPQ-SF. Note that we also measured the participants' working memory capacities, domain-general auditory processing abilities, and music perception abilities. The entire process lasted approximately 1 hour. The analysis and reporting of psycholinguistic measures (working memory, auditory processing, and musical aptitude tests) will be addressed separately.

2.3.1. Speech imitation task

The speech imitation task contained two blocks: English and Chinese. The order of the blocks was counterbalanced. That is, half of the participants began by imitating Chinese sentences, while the other started with English sentences. Within each block, the order of sentences was randomized for each participant. Two practice trials were provided for each language before the main task. The sentences in the practice trials were not used in the experimental trials. We did not analyze the practice trials but used 10 of the recordings from each language for training raters (see section 2.4.1). After the participant indicated that they had understood the procedure, the experimenter started the main task. The audio file of each of the sentences spoken by the native model speaker was played twice, and the participants had to imitate it after the second play. Participants were only allowed to imitate each sentence once. Audio recordings of participants' imitations were saved for subsequent analysis.

2.3.2. MPQ-SF

After completing the speech imitation task and the psycholinguistic tasks, the participants were given a link which directed them to the online MPQ-SF questionnaire. At each trial, participants had to respond to the question on a 5-point Likert scale: 1 = *totally not applicable*, 2 = *hardly applicable*, 3 = *moderately applicable*, 4 = *largely applicable*, 5 =

completely applicable. Twelve questions were reverse ordered. The responses were automatically recorded by the platform.

2.4. Data coding

2.4.1. Rating of imitated sentences

The speech imitation task yielded 623 audio recordings after the exclusion of 7 missing trials. We recruited three Chinese native speakers and three English native speakers to rate the participant's imitation data. The rating was conducted in two sessions, one for each language, with the same three phases. Each session was guided by an experimenter native in the target language. (a) In the familiarization phase, the raters received instructions on the rating task. Concretely, they would rate each spoken sentence on a 9-point Likert scale with 1 being *very bad imitation* while 9 signifying *perfect imitation*. (b) In the exercise phase, the raters rated 10 sentences imitated by the participants from the practice trials but not the experimental trials. The raters listened to each sentence and gave ratings individually. Upon finishing the 10 exercises, the raters communicated their rating scores to each other. If there were large discrepancies between them, they would listen to the audio clips again and discuss their understanding of the rating criteria until they reached an agreement on all the 10 exercised sentences. Then, they proceeded to the rating phase. (c) In the rating phase, raters rated all the sentences in a randomized order individually. During this phase, no discussion or communication was allowed. In total, each rating session lasted around 2 hours.

We checked the Intraclass Correlations (ICC) to estimate the inter-rater reliability. The raters showed good consistency on the rating in both English (ICC = 0.88, 95% CI [0.86, 0.91]) and Chinese (ICC = 0.88, 95% CI [0.86, 0.90]). Therefore, we averaged the three rating scores of each sentence and coded this variable as "imitation score" for statistical analysis.

2.4.2. Coding of MPQ-SF

The MPQ-SF were divided into five categories, each category for one personality trait. Within each personality trait, we checked the reliability between the eight responses with Cronbach's alpha. All the personality traits revealed good reliability ($\alpha > .70$, see table 1). Then, the score for each category was the mean score for the eight questions in that category. This coding method yielded five scores: Cultural empathy, Flexibility, Social initiative, Open-mindedness, and Emotion stability. Note that we flipped the responses to the reverse-ordered questions before the calculation.

2.5. Statistical analyses

We used R software [22] to do the statistics. We built a linear mixed model (LMM) using *lme4* package [23]. The dependent variable was imitation score. The independent variables included the five personality trait scores and a categorical variable, language (Chinese vs. English). We included two-way interactions between each of the personality trait scores and language. The random intercepts were participant and item (the sentences). Language was added as a random slope for participant. Before the analysis, all the continuous variables were scaled by their standard deviations and centered at 0.

3. Results

Table 1 summarizes the descriptive statistics of the dependent and independent variables before z-score transformation.

Table 1: Descriptive statistics of the independent variables (personality traits) and dependent variable (imitation score)

	<i>M</i> (<i>SD</i>)	Cronbach's α	Range
Personality traits			
Cultural empathy	4.0 (0.6)	.84	2.0 - 5.0
Flexibility	2.8 (0.6)	.81	1.4 - 4.1
Social initiative	3.4 (0.7)	.84	1.9 - 4.9
Open-mindedness	3.7 (0.5)	.70	2.4 - 4.8
Emotional stability	2.9 (1.0)	.91	1.4 - 4.6
Imitation score			
Chinese	3.1 (1.7)	-	1.0 - 8.3
English	5.0 (1.9)	-	1.0 - 9.0

The LMM analysis (Table 2) revealed a significant main effect of language, which suggests that the imitation score in English (familiar L2) was significantly higher than in Chinese (unfamiliar L2). Regarding the personality traits, only the cultural empathy revealed a significant main effect on the imitation score in Chinese. The negative slope indicates that individuals with better cultural empathy ability show lower imitation abilities in imitating an unfamiliar language.

Interestingly, the significant two-way interaction of Cultural Empathy \times Language suggests that the predictive value of cultural empathy on L2 imitation score depends on the language familiarity. The positive slope means that the coefficient of cultural empathy on imitation score was higher for English than for Chinese. However, post-hoc comparisons using *emtrends()* function from *emmeans* package [24] showed that cultural empathy was not a significant predictor of English imitation score, because the 95% confidence interval of the estimated coefficient included zero ($\beta = 0.18$, 95% CI [-0.18, 0.53]). Figure 1 plots the two-way interaction.

The rest personality traits did not reveal any significant main effect or interaction with language. The independent variables in total explained 22.2% of the variance, which was a small effect size [25] while the whole model accounted for 78.2% of the variance.

Table 2: Linear Mixed Effects Model predicting L2 speech imitation score from personality traits and language familiarity.

	Fixed effects			Random effects	
	β	<i>t</i>	<i>p</i>	subj <i>SD</i>	item <i>SD</i>
(Intercept)	-0.5	-3.3	.001	0.44	0.35
CE	-0.2	-2.3	.023		
FL	0.08	0.93	.352		
SI	0.11	1.23	.218		
OM	0.06	0.67	.506		
ES	-0.1	-0.8	.409		

Language	0.9	3.94	<.001	0.91
CE × Lang [En]	0.38	2.13	.034	
FL × Lang [En]	-0.1	-0.5	.648	
SI × Lang [En]	-0.1	-0.5	.644	
OM × Lang [En]	-0.2	-0.8	.418	
ES × Lang [En]	0.14	0.74	.458	

Note. CE = cultural empathy; FL = flexibility; SI = social initiative; OM = open-mindedness; ES = emotional stability. Chinese is the reference level. Significant results are boldfaced.

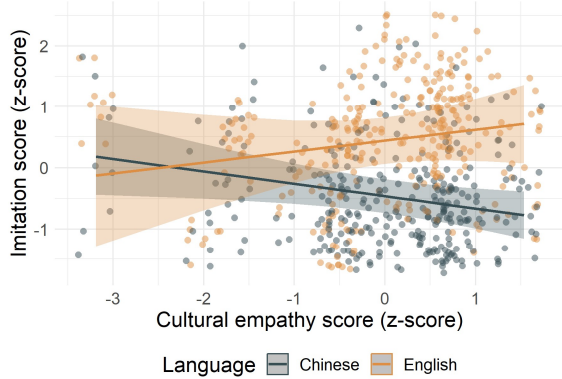


Fig. 1: Interaction between cultural empathy score and language on the imitation score. The shaded area indicates 95% confidence interval. The dots plot individual data points jittered to show overlapped values.

4. Discussion

This study assessed the predictive role of personality traits in the imitation abilities of familiar (English) and unfamiliar (Chinese) L2s. The personality traits involved five aspects: cultural empathy, flexibility, social initiative, open-mindedness, and emotional stability. We found that the only significant predictor was cultural empathy. Cultural empathy showed a negative effect on the imitation abilities of the unfamiliar L2 but did not reveal significant effect on the familiar L2.

Particularly regarding cultural empathy, Sun et al. [1] and Dewaele and Al-Saraj [10] found that cultural empathy did not significantly predict the oral proficiency of the experienced learners. Our findings are thus in line with their conclusions as the imitators in our study are high-proficiency L2 English speakers and therefore are experienced learners of English. The non-significant results of cultural empathy in relation to English imitation score are therefore not surprising.

Strikingly, participants with better cultural empathy performed worse in imitating Chinese, the unfamiliar L2. This is contrary to the previous research which showed that better empathetic abilities positively correlate to more nativelike pronunciation [15]. We explain this result as follows. First, the positive findings in previous research were from the formal L2 learning context where the L2 speakers were experienced learners. Therefore, those who could better capture the feelings, thoughts, and behaviors of people from a different culture would enjoy more benefits in detecting the subtle phonetic details to achieve better speech production outcome in the target L2. Second, it is important to bear in mind that being able to

perceive phonetic details does not entail willingness to reproduce it in speech production, especially when the target language is unfamiliar to the imitator. Individuals with high level empathetic abilities would be cautious to imitate a “foreign accent” in the concern of being offensive. In other words, due to their good empathetic skills, they may feel uncomfortable to imitate an unfamiliar accent, especially when they are fully aware that their speech will be evaluated by native speakers of this unfamiliar language.

Our study is among the first research which focused on the interplay between personality traits and L2 familiarity in the speech imitation abilities. Our regression model showed a small effect size (Conditional $R^2 = 0.222$), which is consistent with the results of previous meta-analysis, where personality traits have a small effect on individuals’ learning outcomes and performances in L2 [5]. Moreover, flexibility, social initiative, open-mindedness, and emotional stability did not show any significant effect on the imitation score. We interpret the non-significant findings as follows. First, These results are in line with previous empirical studies, where open-mindedness and flexibility are not predictive of L2 speech performance [1], [10]. Second, since the English sentences were understandable for the participants given their high English proficiency, the imitation outcome was largely affected by the participants’ actual English accentedness. This is in turn affected by many factors, among which, experiential factors like L2 use would play an important role. Therefore, compared to cognitive factors, the role of psychosocial factors may play a confounding role rather than acting alone. For instance, active interaction with native speakers, which resulted in better speech production abilities, might have been partly driven by open-mindedness. As a personality trait, open-mindedness may have played an indirect role. However, due to the lack of assessment on experiential factors, it is difficult to directly test this hypothesis with the current data.

5. Conclusions

To conclude, this study is a first attempt to investigate how personality traits play a different role in the individual’s speech production abilities of a well-experienced languages and a first-exposed language. We contributed new empirical data to further understanding the predictive role of psychosocial factors in L2 speech acquisition. Personality traits do not always play a positive role throughout all the L2 learning stages. The imitation abilities in an unfamiliar language well represent how a learner would perform in their first encounter with an L2. Our results thus have important implications for L2 teaching and learning. In teaching practice, it is important to consider the learners’ personality for L2 speech training and especially at the initial stage.

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7. References

- [1] H. Sun, K. Saito, and J.-M. Dewaele, "Cognitive and Sociopsychological Individual Differences, Experience, and Naturalistic Second Language Speech Learning: A Longitudinal Study," *Language Learning*, vol. n/a, no. n/a, 2023, doi: 10.1111/lang.12561.
- [2] J. Chobert and M. Besson, "Musical expertise and second language learning," *Brain Sciences*, vol. 3, no. 2, pp. 923–940, 2013, doi: 10.3390/brainsci3020923.
- [3] K. Saito, "How does having a good ear promote successful second language speech acquisition in adulthood? Introducing Auditory Precision Hypothesis-L2," *Lang. Teach.*, pp. 1–17, 2023, doi: 10.1017/S0261444822000453.
- [4] A. Juffs and M. Harrington, "Aspects of working memory in L2 learning," *Language Teaching*, vol. 44, no. 2, pp. 137–166, 2011, doi: 10.1017/S0261444810000509.
- [5] X. Chen, J. He, E. Swanson, Z. Cai, and X. Fan, "Big Five Personality Traits and Second Language Learning: a Meta-analysis of 40 Years' Research," *Educ Psychol Rev*, vol. 34, no. 2, pp. 851–887, Jun. 2022, doi: 10.1007/s10648-021-09641-6.
- [6] D. Cervone and L. A. Pervin, *Personality: Theory and Research*, 14th ed. Hoboken, NJ: John Wiley & Sons, Inc., 2019. [Online]. Available: <https://lcn.loc.gov/2018031126>
- [7] "The multicultural personality questionnaire: a multidimensional instrument of multicultural effectiveness - van der Zee - 2000 - European Journal of Personality - Wiley Online Library." Accessed: Dec. 10, 2023. [Online]. Available: [https://onlinelibrary.wiley.com/doi/abs/10.1002/1099-0984\(200007/08\)14:4%3C291::AID-PER377%3E3.0.CO;2-6?casa_token=F4L3R0XAjxEAAAAA:6F1SmrJ6GKr-7GkAGPPXvvTwpkw9w-7DdQM84xYARB9X3iZijj004sqwZbWfSkeAGXS6JkVXyBrcPFwQ](https://onlinelibrary.wiley.com/doi/abs/10.1002/1099-0984(200007/08)14:4%3C291::AID-PER377%3E3.0.CO;2-6?casa_token=F4L3R0XAjxEAAAAA:6F1SmrJ6GKr-7GkAGPPXvvTwpkw9w-7DdQM84xYARB9X3iZijj004sqwZbWfSkeAGXS6JkVXyBrcPFwQ)
- [8] K. van der Zee, J. P. van Oudenhoven, J. G. Ponterotto, and A. W. Fietzer, "Multicultural Personality Questionnaire: Development of a Short Form," *Journal of Personality Assessment*, vol. 95, no. 1, pp. 118–124, Jan. 2013, doi: 10.1080/00223891.2012.718302.
- [9] P. T. Costa, Jr. and Robert R. Mc Crae, "The revised NEO personality inventory (NEO-PI-R)," in *The SAGE Handbook of Personality Theory and Assessment: Personality Measurement and Testing*, vol. 2, G. J. Boyle, G. Matthews, and D. H. Saklofske, Eds., SAGE, 2008, pp. 179–198.
- [10] J.-M. Dewaele and T. M. Al-Saraj, "Foreign Language Classroom Anxiety of Arab learners of English: The effect of personality, linguistic and sociobiographical variables," *SSLT*, vol. 5, no. 2, pp. 205–228, Jan. 2015, doi: 10.14746/ssl.2015.5.2.2.
- [11] B. A. Hassan, "Extraversion/Introversion and Gender in Relation to the English Pronunciation Accuracy of Arabic Speaking College Students," 2001. Accessed: Dec. 12, 2023. [Online]. Available: <https://eric.ed.gov/?id=ED454740>
- [12] M. Nowbakht and A. M. Fazilatfar, "The Effects of Working Memory, Intelligence and Personality on English Learners' Speaking Ability," *Journal of Asia TEFL*, vol. 16, no. 3, pp. 817–832, Autumn 2019, doi: 10.18823/asiatefl.2019.16.3.4.817.
- [13] J.-M. Dewaele, "Personality: Personality Traits as Independent and Dependent Variables," in *Psychology for Language Learning: Insights from Research, Theory and Practice*, S. Mercer, S. Ryan, and M. Williams, Eds., London: Palgrave Macmillan UK, 2012, pp. 42–57. doi: 10.1057/9781137032829_4.
- [14] K. Ożańska-Ponikwia and J.-M. Dewaele, "Personality and L2 use: The advantage of being openminded and self-confident in an immigration context," *EUROSLA Yearbook*, vol. 12, no. 1, pp. 112–134, Jan. 2012, doi: 10.1075/eurosla.12.07.oz.
- [15] R. Ibrahim, Z. Eviatar, and M. Leikin, "Speaking Hebrew with an accent: Empathic capacity or other nonpersonal factors," *International Journal of Bilingualism*, vol. 12, no. 3, pp. 195–207, Sep. 2008, doi: 10.1177/1367006908098566.
- [16] P. Li, Y. Zhang, F. Baills, and P. Prieto, "Musical perception skills predict speech imitation skills: Differences between speakers of tone and intonation languages," *Language and Cognition*, 2023, doi: 10.1017/langcog.2023.52.
- [17] P. Li, Y. Zhang, X. Fu, F. Baills, and P. Prieto, "Melodic perception skills predict Catalan speakers' speech imitation abilities of unfamiliar languages," in *Proceedings of the 11th International Conference on Speech Prosody*, S. Frota, M. Cruz, and M. Vigário, Eds., 2022, pp. 876–880. doi: 10.21437/SpeechProsody.2022-178.
- [18] M. Christiner and S. M. Reiterer, "A Mozart is not a Pavarotti: Singers outperform instrumentalists on foreign accent imitation," *Frontiers in Human Neuroscience*, vol. 9, no. AUGUST, pp. 1–8, 2015, doi: 10.3389/fnhum.2015.00482.
- [19] M. Christiner, S. Rüdigger, and S. M. Reiterer, "Sing Chinese and tap Tagalog? Predicting individual differences in musical and phonetic aptitude using language families differing by sound-typology," *International Journal of Multilingualism*, vol. 15, no. 4, pp. 455–471, 2018, doi: 10.1080/14790718.2018.1424171.
- [20] G. A. Miller, "The magical number seven, plus or minus two: Some limits on our capacity for processing information," *Psychological Review*, vol. 101, no. 2, pp. 343–352, 1994, doi: 10.1037/0033-295X.101.2.343.
- [21] N. F. Chen, V. Shivakumar, M. Harikumar, B. Ma, and H. Li, "Large-scale characterization of mandarin pronunciation errors made by native speakers of European languages," in *Proceedings of the Annual Conference of the International Speech Communication Association, INTERSPEECH*, F. Bimbot, C. Cerisara, C. Fougeron, G. Gravier, L. Lamel, F. Pellegrino, and P. Perrier, Eds., Lyon, France, 2013, pp. 2370–2374.
- [22] R Core Team, "R: A language and environment for statistical computing." R Foundation for Statistical Computing, Vienna, Austria, 2014. [Online]. Available: <http://www.r-project.org/>
- [23] D. Bates, M. Mächler, B. Bolker, and S. Walker, "Fitting linear Mixed-Effects Models using {lme4}," *Journal of Statistical Software*, vol. 67, no. 1, pp. 1–48, 2015, doi: 10.18637/jss.v067.i01.
- [24] R. Lenth, H. Singmann, J. Love, P. Buerkner, and M. Herve, "Emmeans: Estimated marginal means, Aka Least-Squares means." R package 1.5.1, 2020. [Online]. Available: <https://cran.r-project.org/package=emmeans>
- [25] L. Plonsky and H. Ghanbar, "Multiple Regression in L2 Research: A Methodological Synthesis and Guide to Interpreting R2 Values," *The Modern Language Journal*, vol. 102, no. 4, pp. 713–731, 2018, doi: 10.1111/modl.12509.