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Sing Chinese and tap Tagalog? Predicting individual differences in musical and phonetic aptitude using language families differing by sound-typology

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ABSTRACT

Musical expertise and working memory (WM) have been isolated as being the most important predictors of phonetic aptitude – meaning the ability to imitate unfamiliar speech material. Although the link between language functions and musical expertise has been subject to many investigations, specific languages and their individual link to musical expertise have largely been neglected. In this investigation, two typologically different languages and their relationship to musical abilities have been investigated in school children (ages 9–10). Results revealed that musical expertise and working memory contribute to the ability to imitate foreign speech material. However, musical abilities are recruited depending on the sound pattern of the language imitated. Children with improved WM and high ability for singing and discriminating tonal differences seem to imitate tone languages faster than their peers. For those who imitate syllable-based Tagalog best, WM and the rhythmical component of music perception influence their performances. Thus it can be suggested that (1) WM may be highly relevant for memorisation, reproduction and imitating speech. (2) Musical expertise (music perception and singing) leads to a positive transfer to language function and (3) individual differences in musical abilities (type of musicality, music discrimination and production) may predict language-dependent preferences for certain sound-structures or properties.

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Introduction

Language aptitude has been defined as a triarchic concept based on auditory, linguistic and memory ability (Skehan, 1998) and has increasingly gained interest in the past years aiming at developing new ways for facilitating the acquisition of learning multiple languages aside common educational strategies. In general, aptitude is a natural ability which is inherent and just marginally influenced by nurture and beside education one of the most important

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contributors of high language achievement. Understanding language aptitude therefore requires analysing other cognitive abilities which facilitate higher language achievement, which in turn, could be considered in educational contexts and disburden foreign language learning. Thus investigations on language aptitude focused on the link between musical expertise, working memory (WM) and second language (L2) proficiency, in particular in the phonological and phonetic domain. Studies (Christiner & Reiterer, 2013, 2015, 2016; Fonseca-Mora, Jara-Jiménez, & Gómez-Domínguez, 2015; Fonseca-Mora, Toscano-Fuentes, & Wermke, 2011; Milovanov, 2009; Slevc & Myake, 2006) have revealed significant correlations between musical skills, WM and second language (L2) proficiency, showing the close relationship between music and language but also that there are large overlaps for tonal and verbal material in the auditory working memory (Koelsch et al., 2009; Schulze & Koelsch, 2012; Schulze, Zysset, Mueller, Friederici, & Koelsch, 2011; Williamson, Baddeley, & Hitch, 2010). Generally speaking, discussions about the link between language and music are not new as already Darwin (1871) stressed that musical ability preceded the linguistic one and claimed that our early ancestors communicated through musical 'sung' sounds rather than through articulated language (Yule, 2010). Although evolutionary hypotheses will remain speculative as there are no fossil recordings available, it is undeniable that language and music possess several shared properties.

Musical abilities and phonetic language aptitude

In numerous neuroscientific studies (e.g. Oechslin, Meyer, & Jäncke, 2010; Seither-Preisler, Parncutt, & Schneider, 2014) evidence has been provided that music and language are also partially processed in the same brain regions. Learning a musical instrument also seems to affect learning abilities in general (Serrallach et al., 2016), and musical expertise leads to higher recall, memorisation and imitation ability of foreign language material (Christiner & Reiterer, 2015, 2016; Fonseca-Mora et al., 2015) stressing that the interconnectivity of both faculties may be one out of many reasons why high achievement in one of the two domains also explains high achievement in the other. Recent investigations have also shown that a lack of foreign language experience can be compensated by musical training 'by strengthening the neural encoding of important acoustic information' (Intartaglia, White-Schwoch, Kraus, & Schön, 2017), while other researchers concluded that long term musical training has a modulatory effect which has an impact on the linguistic organisation of the brain as well (Milovanov & Tervaniemi, 2011).

Noteworthy at this stage, individual differences among musicians' perceptual-cognitive processing have also been observed (Schneider, Sluming, Roberts, Bleeck, & Rupp, 2005) which indicates that there might be different transfer effects from language to music and vice versa. Evidence has also been provided that perception and production cannot completely be equated as a matter of fact that improved music perception does not always lead to improved foreign language production (Christiner & Reiterer, 2013). The most obvious case can be observed among tone language speakers (e.g. Chinese) who at later age-of-onset, during adulthood, learn a European language. They usually face severe difficulties in acquiring especially pronunciation, despite the fact that it is well known that tone language speakers like musicians benefit from perceptual-cognitive processing of music and language (Bidelman, Hutka, & Moreno, 2013). Adaptive plasticity for reproducing new utterances, therefore, not only requires enhanced perceptual abilities but also vocal flexibility and enhanced somatosensory abilities which are more of motor-driven nature. The latter determines phonetic aptitude to be a composition of multiple perceptual cognitive processing strategies and motor abilities rather than a single specific ability (Christiner & Reiterer, 2015). Perception of musicians also varies according to the musical instrument they play, and even within the category of singers sopranos and altos appear to show differences in their fundamental pitch discrimination ability (Schneider et al., 2002). They stress that just few studies investigated individual differences of musical abilities and almost no investigation focused on specific languages and individual musical abilities. The most salient musical ability which is easily recognised as being different from instrument playing is singing. Thus singing expertise is said to improve the ability to generate unfamiliar language material resembling the learning situation of beginners (Christiner & Reiterer, 2013). Even learning a language by singing has been shown to have an effect (Ludke, Ferreira, & Overy, 2014). Singing includes the simultaneous processing of linguistic and musical information contributing to the persistence of memory and a later effective recollection especially in foreign language learning (Fonseca-Mora et al., 2015).

Working memory and phonetic language aptitude

Another cognitive ability which also contributes to high foreign language ability is the working memory capacity (Wen & Skehan, 2011). Large overlaps in working memory capacity processing for verbal and tonal material may be the underlying reasons why working memory and musical expertise are two of the most promising factors that can predict high second/third language achievement. Increased WM has not only been found in language talents but also in musically talented people stemming from alterations of the brain presumably partly induced by musical input (Christiner & Reiterer, 2013). Consequently, the link between WM and language acquisition in general, WM and foreign language aptitude in particular, as well as its interrelation with music is one of the most recent and most promising lines in SLA research (Dörnyei, Csizér, & Németh, 2006).

Working memory is age related and involved in learning new skills such as foreign language material (Loosli, Buschkuehl, Perrig, & Jaeggi, 2012). Working memory training has shown that children with attention deficits improved remarkably in trained and untrained tasks (Klingberg, Forssberg, & Westerberg, 2002).

Talented and exceptional foreign language learners are those, who – in a rather short period of time – become very fluent speakers showing significantly developed memory ability. It hence is considered that the 'temporary storage and manipulation of information that is assumed to be necessary for a wide range of complex cognitive activities', such as foreign language learning, is entailed in WM (Baddeley, 2003, p. 189). Baddeley's model of WM consists of several components, of which previous research (Juffs & Harrington, 2011; Linck, Osthus, Koeth, & Bunting, 2014) has identified two as rather central to L2 acquisition: the phonological loop and the central executive; the former allows for language learning, forms the basis of memorising linguistic material and is responsible for the temporary retention and processing of phonological information, while the latter directs attentional processes (Baddeley, 2002). Many scholars thus consider WM as the most central and essential factor affecting foreign language aptitude, whereas some even claim that it has potential to replace the whole aptitude construct as such. Similarly, Robinson (2002) stresses WM as a potential component of aptitude in his model of so-called aptitude complexes. In line with this, another study by Hummel (2009) investigated the interrelation between language aptitude and phonological WM and observed that WM plays a central role in processing acoustic and auditory input. Illustrating that, the faster individuals process, retain, and repeat new phonetic material, the better they are in processing and dealing with unfamiliar sound patterns in a language that is being learned.

Evidence for the significant relationship between WM and L2 achievement does not stop here since 'a more efficient WM allows learners to notice important aspects of the language input by freeing up necessary attentional resources that would otherwise be tied up in processing incoming material' (Sawyer & Ranta, 2001, p. 342). People with high WM capacities thus encounter less difficulty in second or foreign language learning (Rota & Reiterer, 2009). Another study by Yoshimura (2001) revealed that WM predicts not only overall language aptitude scores, but particularly is significantly related to the language analysis components of the aptitude construct. In a further study, Granena (2013) investigated the relationship of WM and the various subcomponents of language aptitude as measured by the Llama aptitude test (Meara, 2005) which was also used in the present study. Granena (2013) revealed that analytic language abilities correlated with WM, and concluded that grammar learning (as tested in the Llama F) requires not only memorising single items but also recognising and processing their interrelations. These findings, in fact, are in line with previous studies which have reported correlations between WM and Llama F scores (i.e. Granena, 2013; Yalcin, 2012; Yilmaz, 2013).

In previous investigations we were able to explain around 60 % of the variability of language imitation talent by musical expertise, education and WM (Christiner & Reiterer, 2013). To find out further dimensions which might contribute to phonetic language talent, we used similar test designs of previous research but used different languages as stimulus material to see whether musical expertise (music perception and singing) contributes to high phonetic talent of Tagalog and Chinese two typologically quite distinctive languages. Here, we tested children before puberty, to see the influence of working memory and musicality before the controversial but still largely presumed phenomenon of a critical period in foreign language learning, which, basically says the earlier foreign languages are acquired, the better the proficiencies of speakers (Moyer, 2014; Pfenninger & Singleton, 2017). Additionally, we extended our research by adding IQ tests and two more components of the Llama test using rote memory learning (Llama B) and grammatical inferencing tests (Llama F).

Materials and methods

Participants

To replicate and extend previous research findings on a different age group, children of 9–10 years took part in our study. A sample of thirty participants was selected. All of them (16 females and 14 males) were in their fourth year of foreign language learning. 8 participants were German native speakers. The remaining native languages were Turkish, Serbian, Bosnian and Macedonian.

To elicit their socio-economic status, a questionnaire was handed out to the participants' parents. It revealed that 25% of the parents attended a compulsory school, 5% kept a secondary school degree, 40% went to a vocational school, 11% had a college degree, and 16% of the participants' parents finished university. The children had a single music lesson at school every week and their first language was German. Apart from German as main language, the children also had two lessons English whereby the focus of teaching relied on speaking activities and practicing simple conversational strategies. Turkish or any of the other languages spoken by the participants were not taught in the school environment. According to the Austrian primary school curriculum music is covered with one lesson every week. These lessons include practicing vocal, rhythmical and instrumental abilities. 13 of the participants played a musical instrument outside the classroom environment. Concerning foreign languages, teachers are required to integrate English as a language of instruction into other subject areas during the first two years of learning. Therefore, CLIL-based sequences of short length a day should be held. In year three and four the timetable additionally outlines one English lesson a week. After four years of learning pupils should have reached A1 level as described by the CEFR (Common European Framework of Reference for Languages). However, the main focus of teaching relies on listening and speaking activities and practicing simple conversational strategies.

Musicality and singing

For testing musical aptitude, the participants had to complete the IMMA (intermediate measures of music audiation) which has been designed by Gordon (1982) particularly for kindergarten to primary school-aged children. The IMMA is a computer-based musicality test and employs tonal patterns, i.e. tunes, and rhythmic patterns. In both sections, the participants have to listen to two musical statements and need to discriminate between them by either identifying them as 'same' or 'different'. Additionally, the participants had to sing 'Happy Birthday' which was recorded and rated by 7 musicians for voice quality, the tonal and rhythmic ability.

Language aptitude: speech imitation, rote memory and grammatical inferencing

For investigating the participants' speech imitation ability they had to repeat fifteen Chinese and Tagalog stimuli of 4 up to 11 syllables based on previous studies (Christiner & Reiterer, 2013). After listening to each stimulus the participants were asked to repeat it in their best accent they could manage. The overall performance was rated by four naïve native speakers of Tagalog and Chinese.

To test further components of language learning aptitude, participants had to complete two parts of the Llama Aptitude Test (Meara, 2005), both of which are said to be related to WM ability. First, the participants had to complete the Llama B, a vocabulary learning task, which is designed to measure the rote memory ability. Participants thus were asked to learn vocabulary (20 items) within 300 s. Furthermore, the grammatical inferencing ability was tested by the Llama F. Participants had 300 s to study 20 sentences along with matching illustrations and had to learn grammatical rules of the pseudo-language.

In order to test the participants' working memory, a WM test (Wechsler, 1939) was applied. The working memory test consists of two parts. In the first part, participants were asked to repeat strings of numbers forwards, in the second part participants had to repeat strings of numbers backwards.

CFT20-R

To reveal the general cognitive-analytic ability of the participants (IQ), a non-verbal intelligence test was employed. The CFT20-R (Weiß, 2008) has been designed for children from 8; 6 to 19 years. The CFT20-R consists of two parts. In consideration of the participants' age, they were asked to complete the first part only.

Results

Data analysis

For analysing the results, Pearson's correlation tests were conducted to find out whether language aptitude for Chinese and Tagalog imitation is related to musical ability, working memory, and other measurements included in the research design (Tables 1, 2 and 3). To detect the central cognitive abilities that predict the variance in phonetic aptitude for Chinese and Tagalog multiple linear regressions were performed.

Core results 1: multiple regression 1 (MLR 1)

To detect the cognitive abilities which influence the variability of phonetic aptitude a linear regression analysis was applied. Chinese imitation was the dependent variable. All other variables were entered into the MLR as independent and the criterion for entering the variables was reliant on their probability of F-change $< .05$. As shown in Figure 1 and Table 4, it could be revealed that 43% of the variance in Chinese imitation can be explained by musicality (IMMA tonal) together with WM and singing ability.

Core results 2: multiple regression 2 (MLR 2)

In MLR 2 Tagalog imitation was the dependent variable. All other variables were entered into the MLR as independent and the criterion for entering the variables was reliant on their probability of F-change $< .05$. As shown in Figure 2 and Table 5 , it could be revealed that 38% of the variance in Tagalog imitation can be explained by IMMA rhythm together with WM.

Table 1. The descriptives of the variables under consideration.

	Descriptives			
	M	*SD*	*min*	*max*
Tagalog imitation	4.02	0.69	2.75	5.53
Chinese imitation	3.18	0.67	1.83	4.61
IMMA (tonal discrimination ability)	31.40	4.31	22.00	39.00
IMMA (rhythmic discrimination ability)	28.60	4.27	21.00	36.00
IMMA (musicality)	60.00	7.43	46.00	73.00
Singing melody	4.61	1.41	2.71	8.00
Singing rhythm	4.96	1.35	2.29	8.00
Singing quality of voice	4.68	1.11	2.86	6.86
Singing overall	4.75	1.21	2.81	7.62
Working memory forward	5.17	1.29	3.00	9.00
Working memory backward	4.03	1.27	2.00	6.00
Parental education	5.27	2.51	3.00	10.00
LLAMA B	27.33	12.02	5.00	50.00
LLAMA F	16.83	18.03	0.00	50.00
IQ	95.63	10.78	77.00	127.00

Table 2. Correlations between the language imitation tasks and the musicality measurements.

	Correlations								
	Tagalog imitation	Chinese imitation	IMMA (tonal discrimination ability)	IMMA (rhythmic discrimination ability)	IMMA (musicality)	Singing melody	Singing rhythm	Singing quality of voice	Singing overall
Tagalog imitation	1	.64**	.58**	.52**	.63**	.23	.22	.17	.22
Chinese imitation	.64**	1	.53**	.31*	.48**	.40*	.44**	.31	.41*
IMMA (tonal discrimination ability)	.58**	.53**	1	.50**	.87**	.41*	.42*	.38*	.43**
IMMA (rhythmic discrimination ability)	.52**	.31*	.50**	1	.86**	.08	.17	.13	.14
IMMA (musicality)	.63**	.48**	.87**	.86**	1	.28	.34*	.29	.32*
Singing melody	.23	.40*	.41*	.08	.28	1	.80**	.85**	.95*–
Singing rhythm	.22	.44**	.42*	.17	.34*	.80**	1	.80**	.93**
Singing quality of voice	.17	.31	.38*	.13	.29	.85**	.80**	1	.93**
Singing overall	.22	.41*	.43**	.14	.32*	.95**	.93**	.93**	1

**Correlation is significant at the 0.01 level (1-tailed).
*Correlation is significant at the 0.05 level (1-tailed).

Table 3. Correlations between the language imitation tasks, the WM, education, LLAMA B and F.

	Correlations							
	Tagalog imitation	Chinese imitation	Working memory forward	Working memory backward	Parental education	LLAMA B	LLAMA F	IQ
Tagalog imitation	1	.64**	.42*	−.08	.11	.10	−.08	.28
Chinese imitation	.64**	1	.54**	−.14	−.09	.31*	.10	.30
Working memory forward	.42*	.54**	1	−.19	.31*	.11	−.05	.18
Working memory backward	−.08	−.14	−.19	1	.06	−.05	.15	.19
Parental education	.11	−.09	.31*	.06	1	.37*	.08	.25
LLAMA B	.10	.31*	.11	−.05	.37*	1	.17	.19
LLAMA F	−.08	.10	−.05	.15	.08	.17	1	.15
IQ	.28	.30	.18	.19	.25	.19	.15	1

**Correlation is significant at the 0.01 level (1-tailed).
*Correlation is significant at the 0.05 level (1-tailed).

Discussion

The study's findings are consistent with previous investigations on phonetic ability, musical expertise (e.g. Christiner & Reiterer, 2013, 2015, 2016) and working memory (e.g. Roehr & Gánem-Gutiérrez, 2009; Sáfár & Kormos, 2008; Yoshimura, 2001). Thus, it could be replicated that musical abilities (music perception and singing) and working memory are most relevant for explaining phonetic aptitude, while most of the other components failed to reach significance for explaining the variances in Chinese and Tagalog

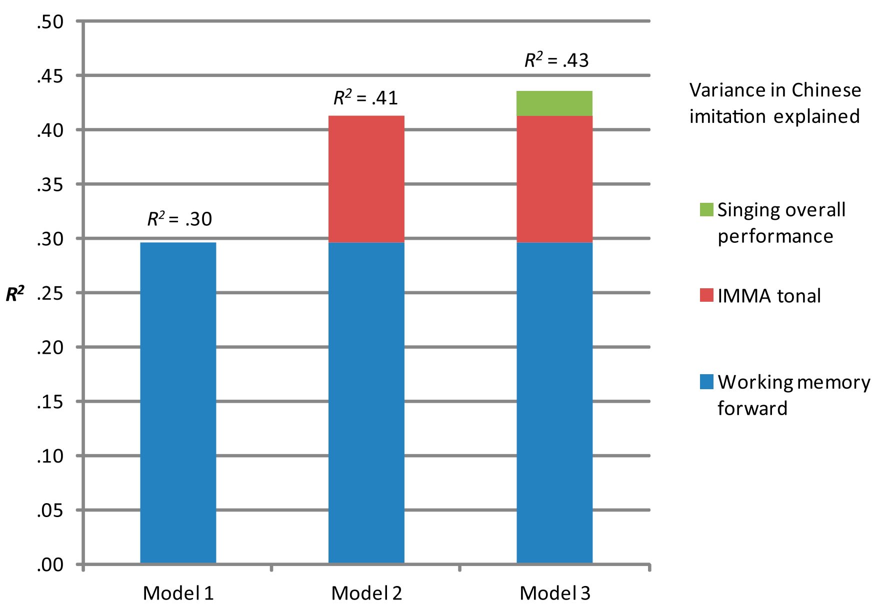

Figure 1. Three models predicting the variance in Chinese imitation.

Table 4. Multiple regression models explaining the variance in Chinese imitation.†

		R	R^2	F Change	Sig. F Change	B	$SE\ B$	β	p
Model 1		.54	.30	11.33	0.002				
	Constant					1.74	0.45		
	Working memory forward					0.28	0.08	.54	<.01
Model 2		.64	.41	5.16	0.032				
	Constant					0.33	0.74		
	Working memory forward					0.19	0.09	.38	<.05
	IMMA (tonal discrimination ability)					0.06	0.03	.38	<.05
Model 3		.66	.43	0.98	0.330				
	Constant					0.25	0.75		
	Working memory forward					0.18	0.09	.35	<.05
	IMMA (tonal discrimination ability)					0.05	0.03	.32	<.05
	Singing performance					0.09	0.09	.17	<.05

†Dependent variable: Chinese imitation.

imitation. Although further research is required, the study's findings have implications for early foreign language teaching and learning.

Music perception: tone languages versus non-tone languages

Measuring phonetic aptitude is first and foremost concerned with speech prosody and suprasegmental information of languages. Pitch, duration and rhythmic cues are most important to differentiate between prosodic units in language. Prosodic variations of oral language share acoustic features with tone transitions in melodies (Oechslin et al., 2010) and prosodic information is strongly activated in the right cortical areas (Meyer, Alter, Friederici, Lohmann, & von Cramon, 2002) when linguistic information is reduced (Perkins, Baran, & Gandour, 1996) suggesting a close relationship between processing of musical signals and unintelligible speech. Processing and memorisation of unintelligible

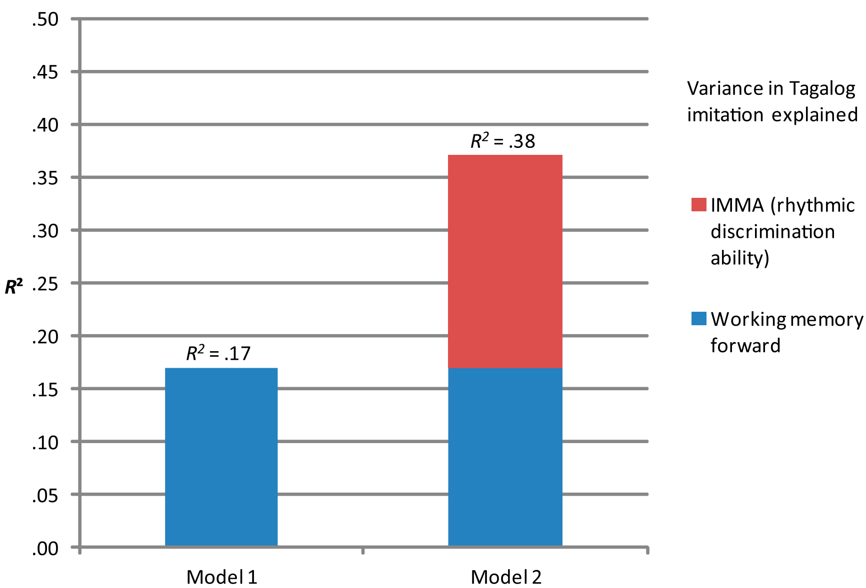

Figure 2. Two models predicting the variance in Tagalog imitation.

Table 5. Multiple regression models explaining the variance in Tagalog imitation.[†]

	R	R^2	F Change	Sig. F Change	B	$SE\ B$	β	p
Model 1	.42	.17	5.92	0.022				
Constant					2.87	0.49		
Working memory forward					0.22	0.09	.42	<.05
Model 2	.61	.38	8.76	0.006				
Constant					0.98	0.77		
Working memory forward				0.18	0.08	.34	<.05	
IMMA (rhythmic discrimination ability)					0.07	0.02	.46	<.01

[†]Dependent variable: Tagalog imitation.

utterances may force naïve listeners to treat them similarly like musical statements whereby they need to rely on specific more music-resembling language features (e.g. speech melody) which are in the foreground of the target language. The results of MLR 1 show that WM, the ability to discriminate tonal differences as well as singing ability were crucial for the imitation of Chinese. In marked contrast, for Tagalog, WM and the rhythmic discrimination ability for musical statements contributes to explaining the variability of the imitations of the participants, illustrating that there are individual differences in the positive transfer from music to languages. Thus pitch discrimination ability is more important for tone languages than for non-tone languages, especially as in those languages where pitch fine-tuning is necessary to determine meaning (Marie, Delogu, Lampis, Belardinelli, & Besson, 2011). This suggests that those who learn tone languages as a second language may benefit from musical aptitude and musical training as this impacts pitch perception abilities of tone languages in general (Besson, Schön, Moreno, Santos, & Magne, 2007). As the language imitation tasks were direct tasks whereby pupils were instructed to directly repeat unfamiliar language material without any kind of interference in-between, it can be assumed that this way of measuring abilities directly focuses on their aptitude rather than on training.

The difference between Tagalog and Chinese, however, also indicates a shift in dominant feature recognition of languages, while tonal predominance may be recognised by naïve participants in tone languages, in non-tone languages, such as in Tagalog, rhythmical organisation may be predominantly recognised, thus segmentation – end and starting points of utterances – may be more important. This, however, could also lie in the rater judgements as raters of tone languages may put more emphasis on tonal aspects than the raters of non-tone languages where tonality/pitch do not assign meaning.

Considering the results, musical perception training or pre-existential increased musicality levels may be effective for facilitating phonetic foreign language acquisition processes. The easiest way thus is the learning of a musical instrument to sharpen perceptual-cognitive processing, or to sing, as generally speaking, musicians' Heschl's gyri in the auditory cortex show alterations, more specifically multiplications (Benner et al., 2017) improving auditory abilities allowing them to discriminate pitch variations far better than non-musicians (Schneider et al., 2002). However, auditory models have also argued that primary capacities influence musical aptitude, while secondary musical skills are environmentally shaped by the culture and individual training received (Karma, 1994). Evidence that musical aptitude is based on primary capacities that are gene related leading to an improvement of processing of auditory input, and to alterations of the auditory pathway, has already been provided (Oikkonen et al., 2015).

Multigenerational family studies were also able to demonstrate that predisposing genes or variants are linked to musical aptitude (e.g. Pulli et al., 2008). The link between musical aptitude and phonetic language abilities in this investigation shows that both faculties do not completely deviate from each other, which raises the idea that multigenerational family studies might yield similar results for phonetic aptitude which should be subject to future research.

Singing, WM, and language learning

To recap, musical perception abilities contributed significantly to the ability to imitate unfamiliar speech material (in this case Chinese and Tagalog), while singing ability did only correlate and contribute to the variances of the performances of Chinese, the tone language in this investigation. In previous research we also used new song material which was completely unfamiliar and thus resembled a learning condition similar to learning new language material (Christiner & Reiterer, 2013). Similarly to our previous research, Ludke et al. (2014) also revealed that singing is a more effective tool in learning new languages in a learning condition. In this investigation we used 'Happy Birthday' to measure the general singing ability, a song which was familiar to all participants, and thereby loaded low on working memory. The individual predictors which explained the variances of the two imitation performances in Chinese and Tagalog indicate that different musical abilities are recruited dependent on language typology.

Singing ability and working memory also showed no correlation in this investigation similarly to previous research where new song material yielded strong correlations to working memory capacity but not to familiar song singing (Christiner & Reiterer, 2013). This gives rise to new speculations of why aphasics can still sing songs they are familiar with (long term memory, automatic processing) and are unable to reproduce new utterances (Peretz, Gagnon, Hébert, & Macoir, 2004). Hence, singing very familiar songs is possibly deeply rooted in motor memory which does not require high loads of cognitive abilities for monitoring acoustic signals although familiar song singing is perceived as an acoustic phenomenon.

General cognitive learning abilities that are concerned with learning of both verbal and tonal material seem to rely on high loads of WM capacity as long as linguistic information is reduced. This is also facilitated in correlations between WM and new utterances versus already acquired utterances. For the learning of new utterances high correlations between WM and utterances were found, while already acquired utterances do not require high loads of WM capacity at all. Even though singing ability contributed to Chinese imitation only, it could support foreign language learning in general. Research has demonstrated that singing and instrument playing, both improve music and speech perception (Christiner & Reiterer, 2015). Singing in the early classroom environment is therefore not only beneficial for supporting music and language development (Ludke et al., 2014) but can also release dopamine (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011) leading to a rise in enjoyment. In marked contrast to the instrument playing, singing activities can be executed by language teachers as well as a large number of people, that is to say, an entire class can participate at the same time making it to an ideal tool to teach phonetic patterns effectively. Singing is slower in production and exaggerated compared to speech putting emphasis on motor specific elements of speech. Singing includes the simultaneous processing of linguistic and musical information and contributes to the persistence of memory and a later effective recollection in foreign language learning (Fonseca-Mora et al., 2011; Fonseca-Mora et al., 2015).

Working memory and phonetic aptitude

As to WM and phonetic aptitude the current findings are equally in line with previous research that has identified WM as a composite construct, with the phonological loop and the central executive being key factors in L2 language processing (Juffs & Harrington, 2011; Linck et al., 2014; Rota & Reiterer, 2009). The study's findings confirm the close relationship between phonetic aptitude and WM capacity. WM is characterised as the attentional control and the explicit and conscious processing of input (Ercetin & Alptekin, 2013). Hence, exceptional language learners are those who are excellent at processing large amounts of unfamiliar linguistic material and at storing it while interacting (Skehan, 1998). Pedagogical conclusions that can be drawn from this ongoing research are that regular WM training should take a vibrant part in the early foreign language classroom as research has shown that working memory training leads to an improvement of tasks which were trained and untrained (Klingberg et al., 2002). The findings of this investigation cannot confirm that WM could replace language aptitude as claimed by Miyake and Friedman (1998), although it is a very tempting argument. As shown in previous research and in this investigation, WM has an enormous impact on phonetic aptitude and might be one of the driving forces for being talented in imitating foreign language material. However, phonetic aptitude should not only be equated with the ability of acquiring new language material fast and accurately, but also consider proficiencies at later stages of learning. As a matter of fact, there are no studies that could inform about whether aptitude as measured in this investigation can also predict achievement after years of learning new languages. In this respect, we also want to mention that phonetic aptitude as measured in this investigation informs about the potential of individuals but not about achievement. Hence, this and previous research has shown that there are no correlations to be found between linguistically acquired language material and WM as the shift from unintelligible to intelligible utterances includes a shift of cognitive strategies as well. This, however, still does not mean that successful speakers completely have acquired native-like accents but are still recognised as non-native speakers. The ideal is reached by a rather limited number of exceptional language learners (5%–15%).

Grammatical inferencing, IQ, rote memory learning, and speech imitation ability

Concerning IQ and phonological ability, research (Rota & Reiterer, 2009) suggests that there is no correlation between general non-verbal IQ and phonetic L2 language aptitude. This claim is supported by the present results since IQ showed no correlations with language aptitude, musicality or working memory.

The Llama F which was used in the present study has been designed to test the participants' ability to induce grammatical rules that operate in an unknown language. Correlations between analytic language ability as tested by the Llama F and WM have been identified several times (Granena, 2013; Sáfár & Kormos, 2008; Yalcin, 2012; Yalcin, Cecen & Ercetin, 2016; Yilmaz, 2013). The present study, however, cannot confirm a relationship between WM and grammatical inferencing (Llama F).

In the same vein, rote memory ability which was the second linguistic aptitude component in our research did not reveal any correlations with L2 phonetic ability or WM. This is consistent with previous studies which showed inconclusive results on WM and the Llama B (Sáfár & Kormos, 2008; Winke, 2013; Yoshimura, 2001).

Education and IQ

In this investigation we could neither find parental educational influence nor IQ differences in relation to Chinese and Tagalog imitation. Cognitive and linguistic development of children is significantly related to and also dependent on educational and social status. Linguistic input correlates with output which suggests that children of lower social status are poorer in diverse verbal production than children of a higher social status (Korecky-Kröll et al., 2015; Korecky-Kröll, Uzunkaya-Sharma, & Dressler, 2017). As the unfamiliar language material used in this investigation was completely new to the participants we could not detect a direct relationship between the parental educational and social background and speech imitation showing that testing unfamiliar language material informs about people's potential/phonetic aptitude and excludes educational differences which is in line with previous research and the findings of the MULT/AP test (Christiner & Reiterer, 2017).

Conclusion

In line with previous research our findings support that musical expertise/ability and WM are essential factors which can partly explain the variability of phonetic aptitude.

Musical expertise (music perception and singing) is linked to phonetic aptitude of individuals. However, the typologically distinct languages we used revealed differences in musical abilities predicting their imitation skills. This demonstrates that individual musical abilities are recruited depending on the target language which is imitated. While training pitch perception ability and singing may improve tone language production, rhythmic abilities seem to influence Tagalog imitation. This shows that interdisciplinary research on musical expertise and its link to language functions has just reached a starting point.

Based on the study's findings it can be concluded that WM adds another dimension to the whole language aptitude construct but cannot be put in place of it. Furthermore, whether phonetic aptitude as measured in this investigation can predict achievement in later stages of language learning has also been neglected so far.

Yet, the present study has its limitations and thus should be a starting point for future work which should especially reinvestigate whether bi- or multilinguals perform better in imitation tasks compared to monolinguals. Furthermore, if language typologies are responsible for recruiting different musical abilities, further investigations will be required testing various typologically different languages and their relationships to different musical abilities (instrument playing, singing ability, music perception etc.).

As shown in previous investigations the use of music and songs in the classroom 'increases sensibility, aid memory, improve concentration, help developing reading and writing abilities, favour physical development and give rise to enjoyment when learning' (Fonseca-Mora et al., 2011, p. 4). Furthermore, music in language teaching can help learners to 'connect with the learning activities and activate linguistic information stored in memory' (Fonseca-Mora et al., 2011, p. 9). However, musical ability and aptitude affects especially phonetic abilities facilitating to sound native-like, one of the most desired language skills. Whether the musical abilities of the participants were influenced by music education or their musical aptitude cannot be explained and clarified in this investigation. It may be justified to incorporate more musical input as well as an intensified facilitation of cognitive and working memory practice into early foreign language learning, since children at this young age are not only highly responsive to the sound of foreign languages and music in general, but unquestionably own potential to deeply engage with complex cognitive tasks.

Disclosure statement

No potential conflict of interest was reported by the authors.

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