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## TEACHER EDUCATION & DEVELOPMENT | RESEARCH ARTICLE

# Musical aptitude, working memory, general intelligence and plurilingualism: When adults learn to read fluently in a foreign language

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**Abstract:** Studies over the past two decades have provided relevant data on the relationship between music and reading abilities although they fundamentally refer to aspects of the first language reading process of young children. The foreign language reading acquisition process of adult learners has, in this sense, been less explored. Research in this area refers to working memory as a “common cognitive marker” for musical aptitude and reading ability, but little is known about the relationship between musical aptitude and silent reading fluency of adult foreign language learners, the hallmark of skilled readers. Specifically, this study seeks to determine whether musical aptitude as well as cognitive factors such as working memory, general intelligence and plurilingualism could contribute to the understanding of adults’ silent reading abilities in a foreign language. For this purpose,



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### PUBLIC INTEREST STATEMENT

Our project investigated the influences of musical aptitude (commonly called “musical talent”) on early stages of adult foreign language reading processes, at the example of Spanish as a foreign language. Our paper aims at better understanding the various factors that influence reading abilities in adult learners of a foreign language, in this case native German-speakers learning Spanish. Results showed that among the different factors that were examined, musical aptitude, working memory and general Intelligence were best correlated with silent reading fluency and that musical aptitude and number of foreign languages known best predicted silent reading fluency. This is in part the result of a collaborative R +D research project “Musical aptitude, reading fluency and intercultural literacy of European university students” (FFI2016-75,452-R, Ministerio de Economía, Industria y Competitividad) between University of Huelva, (Spain) and the University of Vienna, Austria, among other European universities.

thirty-eight undergraduates, native speakers of German and learners of Spanish, were tested. Additionally, their FL reading comprehension level and their musical training were controlled to categorise the learners. Our data shows a strong association of musical aptitude, working memory, general intelligence and plurilingualism with learners' foreign language silent reading fluency. In addition, a multiple linear regression analysis reveals that musical aptitude and knowledge of different foreign languages influence their silent reading fluency. But when in a second linear regression the lower reading proficiency level (A2) was introduced as a controlling variable, only musical aptitude is significant. In conclusion, further studies on the silent reading capacity of adult foreign language learners need to consider abilities such as musical aptitude and plurilingualism to better understand the whole reading acquisition process.

**Subjects:** Applied Linguistics; Psycholinguistics; Language Acquisition; Language Teaching & Learning

**Keywords:** adults' FL reading; musical aptitude; silent reading fluency; plurilingualism; working memory; intelligence

## 1. Introduction

Reading is recognized as one of the crucial skills necessary for successful academic and professional development but being a skilled reader in one's native language is no longer sufficient to achieve success in a globalized world. Therefore, one of the Key Competences for Lifelong Learning defined by the European Commission (2019) is that of communicating in a foreign language where learners' foreign language (FL) reading ability becomes relevant. In spite of the emphasis on plurilingual programmes developed at primary and secondary educational levels, some university students still experience difficulties in FL reading, exhibiting poor reading comprehension skills and even low language proficiency on the whole (Gorsuch & Taguchi, 2010). Understanding of the aetiology of FL reading ability in adults has, however, not developed sufficiently. Although it is taken for granted that reading implies visual skills (Grabe & Stoller, 2011), it is less known that reading fluently texts aloud or silently requires learners' auditory sensitivity (Kraus & Anderson, 2015; Mueller et al., 2012), word identification and segmentation capacity and their ability to recover the intonational and rhythmical properties of the written text and that all these variables affect their reading comprehension proficiency (Khateb & Bar-Kochva, 2016). When referring to adults' reading abilities in a foreign language, some studies also point to the fact that most 21st c. language learners are plurilinguals as acknowledged by the multilingual reading theory (Fitzgerald, 2003). Knowing more than two languages can influence the learning of a new foreign one. For instance, Peyer et al. (2010) stated a positive correlation between French students' "overall foreign language reading competence" and their reading performance in German as a foreign language (FL).

Adult FL reading skills have not been fully explored but research in adult L1 reading acquisition has revealed interesting data. Tighe & Schatschneider's meta-analysis (Tighe & Schatschneider, 2016) was the first attempt at a systematic synthesis on the understudied adult L1 literacy. Their meta-analysis focused on reading component skills closely associated with reading comprehension. They identified significant linguistic factors such as morphological awareness, language comprehension, fluency, oral vocabulary knowledge, word decoding and working memory. 16 of the analyzed studies concluded that word reading, fluency and oral vocabulary exhibited strong relations with reading comprehension. Among these reading components, reading fluency has been described as the "hallmark of skilled readers" (Lyon et al., 2003). In the case of adults, one way that reading performance of skilled readers differs significantly is that they normally read in

silence, being silent reading fluency a non-directly observable behavior and therefore, more challenging to gauge than assessing oral reading fluency (Ciuffo et al., 2017).

In the case of second language learning, Frost et al. (2013) stated that literacy acquisition in a second language is predicted by learners' capacity of picking up the new set of statistical regularities that characterize the L2 lexical system, but they did not analyse learners' abilities that could contribute to this "picking up". Literature review points to educational, psychological and cognitive reasons.

While Westwood (2008) emphasized that "improper teaching instruction" is one of the most powerful reasons of poor reading skills, Biancrossa and Snow (2006) described the "insufficient amount of time exposed to reading practice" as the main negative effect on FL reading development and Saville-Troike and Barton (2017) point to the lack of learner's motivation or concentration.

From a cognitive perspective, Johnson et al. (2005) raised the question if reading comprehension in adults would be more related to general intelligence than to reading performance measures. They assessed the fluid general intelligence of twins, their siblings and their spouses, and their reading performance through reading aloud and retelling, spelling and word recognition skills. They concluded that "a separate reading performance factor was necessary to explain the relationships among measures of general intelligence and reading performance" but that general intelligence and reading performance was clearly and strongly related. In the second language context, Motallebzadeh and Yazdi (2016) study with 84 English FL university students also revealed a significant correlation of fluid intelligence with second language reading comprehension although they did not consider adults' silent reading abilities.

Degé et al. (2015) indicated a strong association between working memory and children reading performance. By contrast, Talwar et al. (2018) who analyzed adult struggling readers' short term and working memories and their reading comprehension ability, only found a moderate relation when considering L1 readers' age, word reading, fluency and oral vocabulary. They proposed that oral language skills should also be considered. In a similar vein, Shin et al. (2019), studied Korean university students' working memory and background knowledge in the process of English reading comprehension. They did not find significant FL reading results between high—and low-working memory groups. However, adult foreign language readers with higher working memory capacity benefited more from the provision of background knowledge. Adams and Shahnazari-Dorcheh (2014) also reported limited evidence of a relationship between working memory capacity and FL reading comprehension when considering adult learners' proficiency level. Working memory was found to be a fine predictor in explaining FL reading ability but only at the beginning level where language processing requires more control and effort. Readers with a high proficiency level rely on other cognitive resources, probably because high proficient readers are more fluent readers and this fluency involves more automaticity while reading and therefore, less memory demand.

Highly relevant is also research that explains how auditory processing is fundamental for reading development (Barbaroux et al., 2019; Kraus & Anderson, 2013; Mueller et al., 2012). Reading (aloud or silently) requires identifying and discriminating sounds, discriminating rhythmic and tonal patterns as research has shown. Barbaroux et al. (2019) found that music training with Démos program positively influences cognitive functions in children from low socio-economic backgrounds and this had an effect on their concentration abilities and reading precision. Forgeard et al. (2008) observed that children with dyslexia had deficits in melody discrimination, while Anvari et al. (2002) concluded that children who are more sensitive in discriminating sounds due to music training are better on phonological awareness and reading tests. D'Imperio et al. (2018) add to all these auditory features the description of how melodic variations may determine by themselves the pragmatic meaning of a statement.

L1 reading acquisition studies point to the effect of musical stimuli on early young readers' phonological awareness (Zuk et al., 2013), or that singing or playing an instrument regularly may help disadvantaged children to develop their literacy skills (Barbaroux et al., 2019; Slater et al., 2014). Swaminathan et al. (2018) studied the relationship between musical training and adults' reading performance and concluded that this association, in the case of English as a native language, is a consequence of adults' general cognitive abilities such as nonverbal intelligence, short-term memory, and working memory.

In our study we did not deal with musical training per se but with musical aptitude, understood as a range of genetic abilities for music that could improve through musical training but that also could be possibly shaped by informal exposition to music (Gingras et al., 2015; Oikkonen et al., 2015). Our focus is the average foreign language learner with any type of musical competence. The idea that musical and language abilities strongly influence one another or even more, perhaps co-evolve, is not new and evidence is accumulating that they have common either genetic or developmental origins (Couvignou et al., 2019; Milovanov & Tervaniemi, 2011; Politimou et al., 2019; Seither-Preisler et al., 2014). The link between musical aptitude and second language learning, especially in the realm of pronunciation has already been tested and found as early as in the seventies of the past century (Arellano & Draper, 1972). The connection between adult learners' musical aptitude and their reading abilities is also partly based on the notion that musical aptitude has been considered as one factor of individual differences in foreign language learning that clearly affects adults' pronunciation, which is one basic sublevel of language learning (Christiner & Reiterer, 2015; Slevc & Miyake, 2006). Moreover, Foncubierta et al. (2020) report on the effect of musical aptitude on fluent silent reading. In their model where, Italian freshmen studying Spanish as a foreign language were assessed, musical aptitude reveals to be even stronger than phonological awareness or auditory working memory when describing learners' silent reading fluency. In conclusion, FL reading is a highly complex skill where adults' silent reading performance, the gate to reading comprehension, may be related to different factors that remain underexplored.

In this study, we examined adults' silent reading fluency skills in a foreign language, their general intelligence, their working memory, their musical aptitude and the number of foreign languages they know. Participants' reading comprehension levels and their previous musical training were controlled to categorize our population. We studied two transparent languages, both with grapheme-phoneme correspondence although belonging to different language families of the Indo-European stock. Thus, we assessed German undergraduates who were studying Spanish as a foreign language.

In summary, the purpose of our study was to address the following 3 questions:

(1) How do these cognitive factors (General Intelligence, Working Memory, Musical Aptitude and Plurilingualism -operationalized as number of foreign languages) correlate with adults' foreign language silent reading fluency? (correlations)

(2) Are there significant differences between these factors as regards foreign language reading comprehension levels and musical training? (contrasts)

3) Do General Intelligence, Working Memory, Musical Aptitude and Plurilingualism influence adults' foreign language silent reading fluency? (regressions)

## 2. Materials and methods

### 2.1. Procedure

The participants were recruited via social networks, with the assistance of language teachers and a call-for-participants flyers at the university premises. Participants' profiles were then controlled

to fit the objectives of the study, and only students aged between 18 and 20 in their first years of university with German as their first language and Spanish as a foreign language were chosen to participate in the study. The participants were ensured that their data would be processed anonymously, and the test results would be encrypted by a code.

## **2.2. Participants**

The sample included thirty-eight students of two Viennese public universities whose first language was German, and Spanish their foreign language. With regards to the gender distribution, 16 participants were female (52.6%). According to the entrance requirements of the universities in Austria, the students should have acquired advanced beginner or beginner-intermediate levels according to the Common European Reference Frame (CERF) which comprises 6 levels in total (A1, A2 for beginners; B1, B2 for intermediate-advanced; C1, C2 for proficient levels in order of ascending proficiency). Thus, we expected participants to be equal to A2–B1 level of Spanish as attested by the school-leaving exam of high schools in Austria. Nevertheless, a reading comprehension test was administered to confirm participants' reading comprehension levels. Apart from Spanish, the participants were proficient in several other foreign languages such as English and French ( $Md = 2$ ). At the moment of the testing procedures the subjects attended one of the following programmes at university: (1) Bachelor's degree at the Department of Romance Studies (University of Vienna); (2) Spanish teaching degree in secondary education at the Department of Romance Studies (University of Vienna); (3) Bachelor's degree in Business, Economics and Social Sciences (Vienna University of Economics). Considering the academic settings and prerequisites for passing the course, motivation in learning the language was taken as a given.

Several testees had not received musical training ( $n = 18$ , 47.4%). Musical training was elicited via a questionnaire self-reporting on whether or not they played a musical instrument. However, all the subjects enjoyed different musical activities such as singing or listening to music also while studying.

## **2.3. Data collection instruments**

### **2.3.1. Biographical questionnaire**

A simple version of a biographical questionnaire that included basic information about the participants was chosen. The questionnaire included data concerning age (mean age: 19.1 yrs;  $SD = .81$ ), gender (20 females, 18 males), what languages the participant could speak and understand and if they had received any musical training, based on self-reported musical instrument playing.

### **2.3.2. Reading comprehension**

A reading test (DIALANG Test) was used to assess the participants' reading comprehension level of Spanish. This test checks reading comprehension according to the language proficiency levels established by the Common European Reference Frame for language learning (Alderson & Huhta, 2005). This test was used to check whether the participants had the A2 or B1 levels appropriate for entering the university. The test consists of thirty items, multiple-choice questions, short-answer questions and gap-filling tasks. The online test directly provides participants with their reading comprehension level according to CEFR. The administration of this test took around 40 minutes.

### **2.3.3. FL silent reading fluency**

The Spanish contextual word recognition or in brief, FL silent reading fluency test, is an adapted version of the Test of Silent Contextual Reading Fluency (Hammill et al., 2006). The test measured the participants' level of reading fluency by counting a number of printed words that can be identified and segmented by a participant within 3 minutes in a text without blank spaces nor punctuation marks. The participants were presented with fragments of the text of Human Rights (available in 70 languages), where a Spanish version was selected. The difficulty of the text was

controlled by the Spanish Flesch Reading Formula. In the Spanish Flesch Reading Formula, as in the Flesch Reading Ease Formula, scores of 60 to 70 are considered the native adult “normal range”. The adapted version used in this study (S-FRF = 45.6) confirmed the suitability of the test for low level foreign language learners.

The final score of this test was the total number of correct words in Spanish identified within 3 minutes.

#### *2.3.4. Musical aptitude*

Mini PROMS (a short version of the Profile of Music Perception Skills) test was used to measure undergraduates’ musical aptitude. Mini PROMS (Zentner & Strauss, 2017) test allows assessing the musical competence of an individual regardless of their musical training. This test employs neutral and abstract music stimuli rather than contextualized musical compositions. The Mini PROMS version offers a final musical aptitude score based on the results of four subtests that assess participant’s specific musical skills in Melody, Tuning, Accent, and Tempo. Before taking the test, each participant had a practice trial in order to get acquainted with the procedure. Then, the task was to listen to the presented melody twice (first Reference and then Repetition) and to identify whether the Repetition melody differed. Since the second melody of the pair may differ from the first reference melody, this is a same-different task. The answers were on a Likert scale and could be as follows: definitely same, probably same, I don’t know, probably different and definitely different. The use of headphones during the sessions was recommended for better sound recognition. At the end of the test the participant received the feedback-profile on their musical aptitude. The Mini PROMS test took around 20–25 minutes.

#### *2.3.5. Working memory (digit span and non-word span)*

The working memory index (Wechsler et al., 2008) consists of three subtests: Digit Span, Arithmetic and Letter-Number Sequencing. The Digit Span subtest is a core working memory subtest that measures mental manipulation, cognitive flexibility, attention, encoding, and rote memory and learning. The Digit Span subtest includes Digit Span Forward and Digit Span Backward tasks. In the Digit Span Forward task, the subject was read a sequence of numbers and asked to reproduce the numbers in the same order. In the Digit Span Backward task, the subject was read a sequence of numbers and asked to reproduce them in a reverse order. The test took approximately 10 minutes. For Non-Word Span sequencing, the examinee was read a sequence of non-existing words according to German phonotactic rules (Benner, 2005) and s/he should recall and repeat them in ascending order. The tasks should be completed under the careful supervision of the instructor. The items were read slowly with a monotonous voice. Each item of the tasks allowed two trials with the same span length. Each task included seven lines of digits and non-words to process. At the end, the instructor calculated the scores according to the guidelines on score administration (one score per repetition) and added them up. The maximum score for the 3 WM tests together (digit forward, digit backward, non-words) was 42, that is 14 points per subtest.

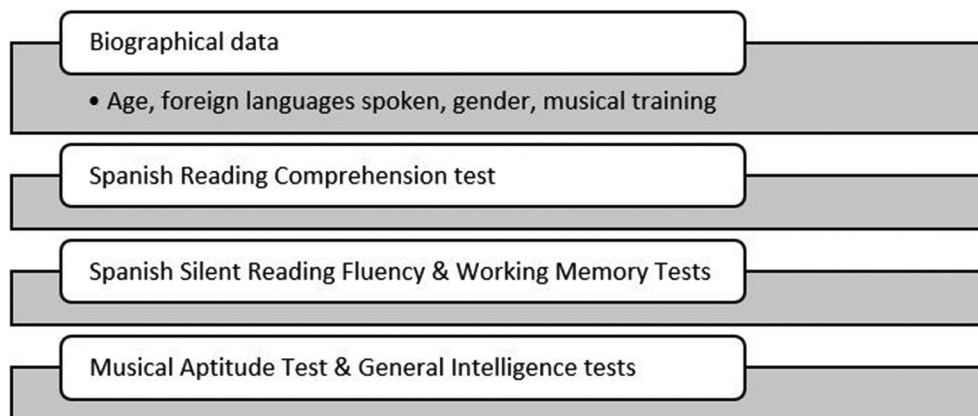
#### *2.3.6. General intelligence*

The Raven’s Standard Progressive Matrices (Raven, 1998) test is widely used as a measure of abstract reasoning and problem-solving skills that shape general intelligence. Further, this test is described as “culture-reduced” (Jensen, 1980, p. 638), what means that participants with different educational and cultural levels could use it equally. The test consists of 48 questions divided into five sets of geometrical patterns, where the participant was asked to identify a missing part to complete the puzzle using the options given. The patterns were characterized by increasing difficulty. On average, it took 40 minutes to complete the test.

### **2.4. Preparatory work and testing procedure**

The testing sessions were arranged individually via email correspondence. The time needed per person to complete all the tests was approximately 125–135 minutes. The testing sessions were divided into three phases. Prior to conducting the tests, the participants gave their consent and

**Figure 1. Data collection protocol flowchart.**



filled out a short biographical questionnaire. Firstly, their reading comprehension level in Spanish as a foreign language was assessed. Then, the silent reading and working memory tests were administered and finally, the musical aptitude and general intelligence tests. During the testing procedure it was ensured that the participants understood the tasks clearly and any follow-up questions were answered. Concerning the special equipment needed for testing, the participants were requested to use earphones during the musical aptitude test for better sound recognition. [Figure 1](#) shows the different steps followed.

### 2.5. Data analysis

SPSS Statistics Software 26 (IBM Corp, 2019) was used to analyse the results of the tests. First, the reading comprehension test was used to determine whether participants had the expected CEFR level (A2/B1). Next, a test of normality, Shapiro—Wilks test, was applied that showed that the data was not normally distributed. This test was carried out due the limited sample size. It fits better to the data than the skewness and kurtosis studies when the sample is less than 300 subjects (Kim, 2013).

Therefore, a Spearman two-tailed correlation analysis was performed to determine the relationship between reading comprehension, FL silent reading fluency, IQ, WM, number of known foreign languages and musical aptitude. Next, a linear regression model was carried out with the Stepwise method, introducing the variables of our study as Independent Variables in order to establish a predictive linear model of the dependent FL SRF. Additionally, Chi Square and U Mann-Whitney tests were performed to isolate whether musical training and reading comprehension levels to contrast our study variables. Lastly, a second linear regression was made where the lower reading proficiency level (A2) was used as a controlling variable. This helped to retest results obtained, now with a homogeneous population.

### 3. Results

[Table 1](#) presents the descriptive statistics of the studied variables. For categorical variables, the frequency is presented with the corresponding percentage in parentheses. For the quantitative variables, the mean  $\pm$  standard deviation is presented, with the median in square brackets, as well as the result of the Shapiro-Wilks normality test. Segmented descriptive statistics according to the subjects' musical experience are also presented. Based on self-assessment, the participants, all aged between 18–20 ( $M_d = 19$ ,  $R_g = 2$ ), were categorized into two subgroups, namely non-musically and musically-trained students. Eighteen participants (47.4%) out of thirty-eight reported an absence of musical training. Chi square and Mann-Whitney's U signification was made to test the dependent relations and differences between non-musically and musically trained groups. Indeed, these self-reported musical training groups are almost identical (in all but 3 cases) to the musical aptitude groups as tested by the PROMS and divided by a median split

**Table 1. Descriptive statistics of the studied variables**

		Global	S-W (p)	Non-musically	Musically	p
				[18 (47,4%)]	[20 (52,6%)]	
Gender (Female)		20 (52,6%)		7 (18,4%)	13 (34,2%)	.107
Age	18	10 (26,3%)		7 (18,4%)	3 (7,9%)	.088
	19	13 (34,2%)		7 (18,4%)	6 (15,8%)	
	20	15 (39,5%)		4 (10,5%)	11 (28,9%)	
R. COMP. <sup>a</sup>	A2	26 (68,4%)		17 (44,7%)	9 (23,7%)	.001
	B1	12 (31,6%)		1 (2,6%)	11 (28,9%)	
FL SRF <sup>b</sup>		84.74 ± 20,92 [82]	0,969 (0,364)	71.28 ± 18,23 [60]	96.85 ± 15,14 [96]	.000
WM <sup>c</sup>		23.34 ± 2,47 [24]	0,851 (0,000)	21.67 ± 2,09 [21]	24.85 ± 1,73[25]	.000
Raven IQ <sup>d</sup>		116 ± 12.46 [119.5]	0,915 (0,007)	108.06 ± 11,39 [112]	123.15 ± 8.53 [121]	.000
Nº FL <sup>e</sup>		1.71 ± 0,65 [2]	0,775 (0,000)	1.33 ± 0,49 [1]	2.05 ± 0,60 [2]	.002
MA <sup>f</sup>		22.75 ± 3,70 [23.25]	0,923 (0,012)	19.89 ± 3,24 [21]	25.33 ± 1,59 [25.25]	.000

The frequencies are presented, together with the percentages in parentheses, for the categorical variables, and the means ± standard deviation, together with the median in brackets.

a. Reading comprehension (CERF); b. Foreign Language Silent Reading Fluency; c. Working Memory; d. Raven Intelligence Quotient; e. Number of Foreign Languages Spoken; f. Musical Aptitude.

into high and low aptitude groups. Thus, we saw that self-reports of music training reliably reflected the results of the objective musical aptitude test in the population of this study.

As regards the undergraduates' reading comprehension level, most learners had an A2 (n = 26, 68.4%), while only the 31.6% (n = 12) of them exhibited a B1 level of Spanish. Differences between musically and non-musically trained students are observed (p = .001). The non-musically trained students (n = 18, 47,4%) were less fluent while reading silently in Spanish (71.28 ± 18,23 [60]), exhibited lower scores in musical aptitude (19.89 ± 3,24 [21]), working memory (21.67 ± 2,09 [21]) and IQ (108 ± 11,39 [112]) and knew a smaller number of foreign languages (p < .05).

Strong correlations with adults' FL silent reading fluency are observed between general intelligence (p = .546), working memory (p = .549), musical aptitude (p = .711) and the number of foreign languages known (p = .580) (see Table 2).

When participants were grouped according to their foreign language reading comprehension levels, significant differences between working memory, musical aptitude and number of foreign languages were found, but no differences were observed for general intelligence (see Table 3) with a high size

**Table 2. Rho spearman correlations between the variables: Foreign language silent reading fluency, musical aptitude, number of foreign languages spoken, working memory and raven intelligence quotient**

		FL SRF	MA	Nº FL	WM	IQ Raven
FL Silent Reading Fluency	ρ	1	,711**	,580**	,549**	,546**
Musical Aptitude	ρ		1	,563**	,777**	,825**
Nº Foreign Languages	ρ			1	,482**	,362*
WM	ρ				1	,629**
IQ Raven	ρ					1

\*\* Correlation is significant at the 0.01 level (bilateral).

**Table 3. Mann-whitney U test for contrasting groups (sig. group difference) according to left panel: the CERF (Common European Reference Frame) levels: A2 versus B1 group and right panel: musically trained versus non-trained group**

	CERF Levels			Musical Trained		
	U <sub>MW</sub>	p	r	U <sub>MW</sub>	p	r
Musical Aptitude	43	.000	.578	6	.000	.828
Raven IQ	99	.070	.293	43.5	.000	.654
Working Memory	56.5	.001	.516	52	.000	.618
Nº Foreign Languages	44	.000	.633	75	.001	.552
FL SRF	38.5	.000	.599	32	.000	.703

\*\* group difference is significant at the 0.05 level (bilateral).

Variables tested: Musical Aptitude, Raven’s Intelligence Quotient, Working Memory, Number of Foreign Languages spoken, Foreign Language Silent Reading Fluency (FL SRF).

effect. When contrasting results of musically-trained and non-musically trained language students, significant differences as regards all variables, IQ, WM, musical aptitude, number of foreign languages known and students’ silent reading fluency in Spanish are obtained (see Table 3).

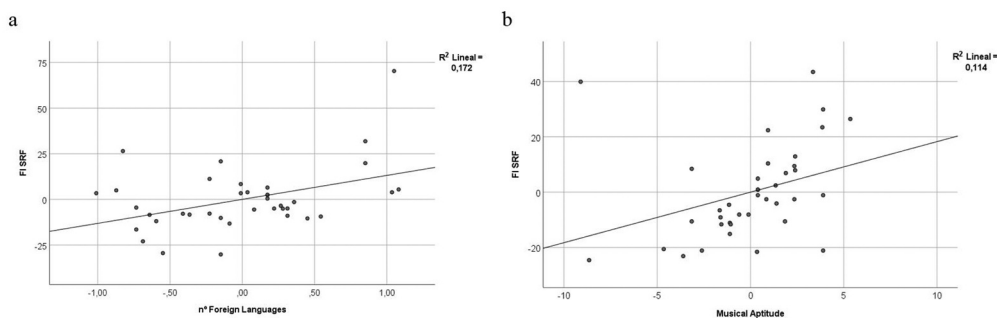
Although we hypothesized that undergraduates with higher scores in IQ, Working Memory, Musical Aptitude and number of Foreign Languages known would be more fluent while reading silently, our regression analysis pointed only to musical aptitude and plurilingualism as predictors of their silent reading fluency in Spanish.

The model with these two predictors adjusts correctly with medium to high effect size ( $F_2 = 12.22$ ,  $p < .01$ ,  $f_{Cohen}^2 = .203$ ) and explains a 41.1% of its variance ( $R^2 = .411$ ). Tolerance values are higher than .01, so no multicollinearity is observed. Coefficients of both variables are significant, and the linear regression equation with standardized values remains as follows (see Figure 2):

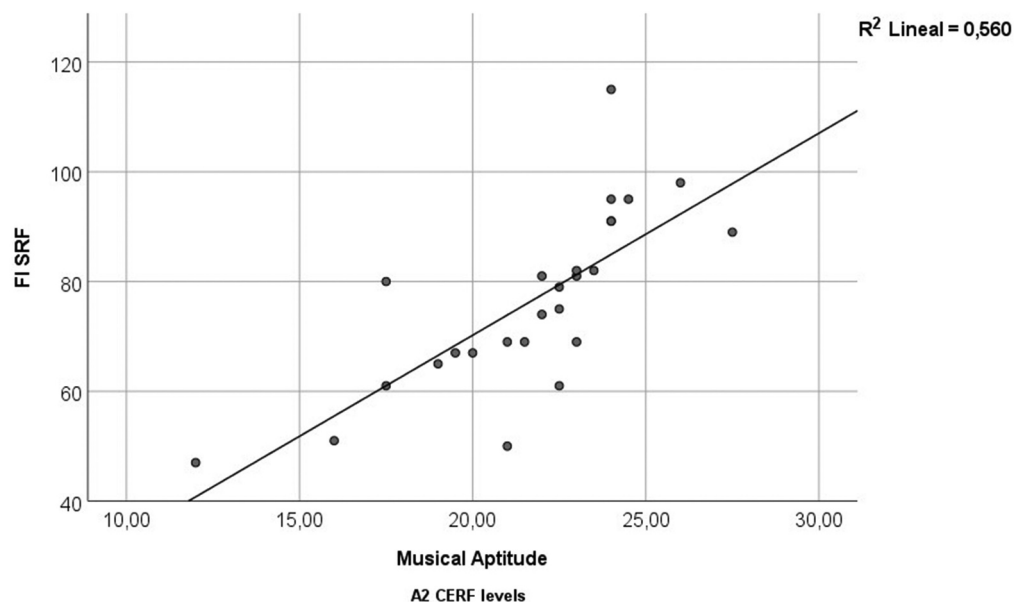
$$FL\ SRF' = .410 \cdot n^\circ\ Foreign\ languages + .323 \cdot Musical\ Aptitude + e$$

But when controlling participants according to their A2 reading comprehension level, the linear regression of SRF reveals that only musical aptitude is significant ( $F = 30.574$ ,  $p < .01$ ), explaining the 56% of variance ( $R^2 = 0.56$ ). The other independent variables: nº of foreign languages, IQ and WM became excluded (see Figure 3).

**Figure 2. Partial regression plots. Dependent variable: FL SRF (foreign language silent reading fluency) for a) number of foreign languages known and b) musical aptitude.**



**Figure 3. A2 group's musical aptitude linear regression plot. Independent variable: Musical aptitude of A2 group (CERF level) only. Dependent variable: FL SRF (foreign language silent reading fluency).**



#### 4. Discussion

This study seeks to determine whether musical aptitude as well as factors such as working memory, general intelligence and plurilingualism could contribute to the understanding of adults' foreign silent reading fluency. We focused only on silent reading fluency as this reading subskill has been considered the hallmark of skilled readers (Lyon et al., 2003). Our results reveal that IQ, WM, musical aptitude and number of foreign languages are significantly correlated, and rather highly, with silent reading fluency. Despite the high correlations, WM and IQ are excluded as predictors of adults' silent reading fluency by a regression because they failed to predict significantly. Our B1 learners of Spanish with knowledge of other foreign languages and higher musical aptitude compared to our A2 students seemed to be more fluent readers relying on automaticity and less on memory demand. These results obtained are similar to the reported by Adams and Shahnazari-Dorcheh (2014), where working memory was only found to be a fine predictor in explaining FL reading ability at the beginning level where language processing requires more control and effort.

When reading comprehension proficiency levels were not controlled, our multiple linear regression shows that SRF is influenced by plurilingualism and musical aptitude. But when the lower level of reading proficiency (A2 level) was controlled due to homogeneous sampling, only musical aptitude was significant in the linear regression model.

Our results are largely in agreement with previous research that studied the relation between music and reading. In line with our approach to test for beginner to intermediate levels of L2 proficiency in Spanish in terms of CERF levels (tested by the reading comprehension test), we expectedly found all subjects distributed either over A2 (N =26) or B1 (N =12) levels. B1 level participants had significantly higher musical aptitude (mdn =25.75) than A2 level students (mdn =22.5) tested by the musical aptitude test (UMW = 43, Z = -3.5, p < .01). This may show that already within these subtly different levels related to FL reading and overall proficiency, musical aptitude plays a role.

Regardless of the aetiology of musical aptitude and expertise, we see correlations between the domain of music and silent fluency reading skill and can try to explain why they are related. One suggestion to link these domains is long known and is to be found in the field of phonetics/phonology: prosody. The strong link between music processes and especially the reading processes involved while reading fluently in silence (e.g., phonemic awareness, subvocalization, stress pattern recognition, word decoding) might be well-described and explained by prosodic bootstrapping theories and studies investigating this concept by showing transfer effects from the music domain on the linguistic domain (M. Besson et al., 2017; Gross et al., 2014; Gutiérrez-Palma & Palma Reyes, 2007; Kadota, 1987; Wermke & Mende, 2009).

Co-improved general linguistic and phonological perception skills, as precursors of linguistic functions like reading ability, have repeatedly been shown after intense music training, especially after training in childhood. Therefore, language improvements after exposure to music training has substantially been reported so far (Dittinger et al., 2018; Francois et al., 2013; Mireille Besson et al., 2011; Moreno et al., 2009; Politimou et al., 2019). Our study was concerned with musical aptitude. As suggested by Degé et al. (2015) and Strait et al. (2011), a strong link between musicality and reading ability might co-occur due to initial correlations between musical aptitude and speech abilities (Christiner & Reiterer, 2015; Couvignou et al., 2019; Turker et al., 2019), or components of reading proficiency, namely silent word-decoding skills, working memory and general intelligence, due to common subcortical brain processing mechanisms, or co-evolved pre-existing auditory abilities (Mankel & Bidelman, 2018; Strait et al., 2011). It is difficult to disentangle the precise proportions of pre-existing, early developed or genetic components of musical aptitude per se and, as rightly suggested, more population-level screening research is still needed (Gingras et al., 2015). Thus, both nature and nurture might have their share in the interplay in the development of musical aptitude (Law & Zentner, 2012; Oikkonen et al., 2015; Schneider et al., 2009; Seither-Preisler et al., 2014) and have their far-reaching effects on FL reading abilities.

Although studies directly investigating the link between musical skills and foreign language reading skills in adults are scarce, a general picture emerges, that musical aptitude usually tested in children's L1 reading skills (Degé et al., 2015; Gordon et al., 2015; Strait et al., 2011) also impacts on children's (Gómez-Dominguez et al., 2019) and on adults' foreign reading fluency skills (Foncubierta et al., 2020) even when the foreign language does not belong to the same Indo European stock, as it is the case of this study. Data obtained from the musical aptitude test corroborate and cross-validate learners' self-reported musical training data. Our data shows that B1 learners are better in all respects with significantly higher scores in WM, musical aptitude and number of foreign languages, just not in IQ, where they have comparable scores. This reflects that in this sample, musical training and musical aptitude are overlapping concepts which is not always the case. Some non-musically-trained learners may enjoy a high musical aptitude just through direct exposure to the musical data, without explicit formal training (Bigand & Poulin-Charronnat, 2006; Law & Zentner, 2012). Whether the one is a result of the other component cannot be disentangled by the design of the present study.

When the control variable "levels of reading comprehension" are not introduced in the linear regression model, musical aptitude and plurilingualism influence adults' foreign language silent reading fluency. In line with Peyer et al. (2010) who stated a positive correlation between French students' "overall foreign language reading competence" and their reading performance in German as a foreign language (FL), we also found that plurilingualism affects adults' foreign reading fluency.

We hypothesize that this result bears two possible explanations. On the one hand, it could mean that increased metalinguistic (Jessner, 2014) awareness accumulated through multiple foreign language learning also fosters the reading skill acquisition in the currently learned language Spanish (mostly their L3 or L4). A kind of foreign language learning "expertise effect", which was not attributable to bilingualism or a bilingual benefit effect per se, because the study participants were all "late bilinguals" or rather classical language learners, with ages of onset of first L2 around

8–10 years of age. Thus, we would not call that a “bilingual” benefit in the strict sense of the word, namely early bilingualism, (Kovacs & Mehler, 2009), but perhaps a multilingual expertise effect, which could lead to structural neural changes in the basal ganglia system, language processing or so-called “polyglot/multilingualism language control areas” (Hervais-Adelman et al., 2018). On the other hand, it could also be the case that those students who study foreign languages at the tertiary level—out of free will—are also those whose levels of language aptitude are already enhanced before enrolment to the language courses and that they strive to study languages out of a heightened pre-existing ability and intrinsic motivation to do so (Reiterer, 2019; Turker et al., 2019). In other words, if the knowledge of other foreign languages predicts the LX reading performance, it could be a hidden indication for higher language aptitude due to finding intrinsic pleasure with foreign language learning (Fernández-García & Fonseca-Mora, 2019)—However, mixed-form co-evolution of both “ways leading to Rome”, namely experience-expertise and pre-existing language aptitude developing and cross-enhancing each other hand in hand is maybe the most likely scenario, as it is the case with musical experience leading to higher musicality and vice-versa. On a final note, number of foreign languages, multiple language expertise or plurilingualism, can also coincide with higher musical abilities, as recently found in a cohort of mixed plurilingual students who self-reported on their singing skills which correlated with their number of foreign languages (Reiterer et al., 2020).

## 5. Conclusions

Our results reveal that IQ, WM, musical aptitude and number of foreign languages are significantly correlated, and rather highly, with silent reading fluency. When reading comprehension proficiency levels were not controlled, our multiple linear regression shows that SRF is influenced by plurilingualism and musical aptitude. But when the lower level of reading proficiency (A2 level) was controlled due to homogeneous sampling, only musical aptitude was significant in the linear regression model.

The findings of this study strongly support the assumption that there is a close relationship between musical aptitude and adults’ foreign silent reading fluency. This link could be explained due to the common (co-evolved or trained) cognitive processes crucial to music and language learning. In fact, the results of this study show that the individuals with a higher musical aptitude achieve significantly better results in the FL silent reading tasks.

In light of the above-mentioned arguments, an important role of musical aptitude in developing improved reading ability skills, as SRF, was observed. Taking this positive association between musical aptitude and SRF into account, it could be suggested to incorporate more music-related activities into an FL curriculum.

Since little previous research on the role of the musical aptitude on FL silent reading fluency has been conducted, the outcomes of this study should be treated with caution. However, it confirms the effect of musical aptitude on silent reading fluency that was already found between two romance languages, Italian and Spanish (Foncubierta et al., 2020).

The results of this study are encouraging and should be further investigated with a larger sample size and with non-alphabetic languages.

According to our data, learners’ musical aptitude and their plurilingualism predicts their silent reading fluency in a foreign language. Both domains, the musical and the linguistic ones, depend on the development of humans’ auditory sensitivity. Therefore, our results are also complementary to the interpretation that early music training can facilitate later foreign language learning (Dittinger et al., 2016).

It seems that working with different musical and language melodies and rhythms helps to become a good reader that in any language feels the pleasure of reading fluently.

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