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# **Raising a musical child: Predictors of children's musicality**

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**RAISING A MUSICAL CHILD: PREDICTORS OF CHILDREN'S  
MUSICALITY**

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## **Resumo**

A noção de musicalidade na literatura está a transformar-se. Primeiramente, a mesma era considerada unidimensional e medida através de tarefas percetivas de discriminação de tons, ritmos e melodias. Atualmente, o construto é reconhecido como multifacetado e definido por dimensões percetivas, emocionais e comportamentais. A musicalidade tem sido estudada em função de variados fatores individuais e socioculturais. O presente estudo investiga preditores de musicalidade infantil, analisando a influência de fatores demográficos (idade e sexo), socioculturais (educação parental, rendimento mensal, musicalidade materna), cognitivos e musicais (performance em tarefas percetivas de ritmo, melodia e memória). Usando uma amostra de 79 crianças entre os 6 e os 11 anos, o estudo recorre ao Musical Child Questionnaire (MCQ) como medida de musicalidade reportada pelos professores. Os resultados indicaram que o sexo das crianças e a educação parental são preditores de musicalidade infantil: as raparigas foram avaliadas como mais musicais e maior educação parental está associada a valores mais elevados de musicalidade das crianças. As tarefas de perceção rítmica relacionaram-se também com a musicalidade reportada. Não se evidenciou uma associação entre a musicalidade da mãe e musicalidade das crianças. Foram identificadas associações entre a musicalidade e as habilidades cognitivas da criança, bem como com o rendimento familiar mensal, mas estes fatores não se demonstraram preditores no modelo final de musicalidade infantil. Os resultados denotam a influência de fatores em vários domínios sobre a musicalidade infantil e a importância da exploração da musicalidade como um conceito mais abrangente do que o das abordagens unidimensionais.

*Palavras-chave:* musicalidade, infância, fatores socioculturais, perceção musical, questionário professores

## **Abstract**

The construct of musicality as viewed in the scientific literature is being reshaped. Firstly, musicality was considered unidimensional and measured through aural tasks of tone, rhythm and melody discrimination. Currently, the construct is seen as multifaceted and defined by perceptual, emotional and behavioural dimensions, and being studied as a function of several individual and sociocultural factors. The present study investigates predictors of children's musicality, examining the influence of different types of variables: demographical (age and sex), sociocultural, viz. parental education, monthly income and maternal musicality), as well as cognitive and musical (performance in perceptual tasks of rhythm, melody and memory). Using a sample with 79 children with ages between 6 and 11 years, we used the Musical Child Questionnaire (MCQ) as a measure of musicality reported by children's teachers. Results show that sex and parental education are significant predictors of musicality: girls were rated as more musical than boys and children with more highly educated parents were rated with higher musicality than those with parents with less schooling. Perceptual rhythmic tasks were associated with higher reported musicality. There was no evidence of an association between mother's and child's musicality. Cognitive abilities and household income, though initially correlated, were not significant predictors in the final regression model. These findings suggest that children's musicality is influenced by factors from diverse domains and emphasise the importance of considering musicality within a broader scope than musical abilities proper.

*Keywords:* musicality, childhood, sociocultural factors, music perception, teacher questionnaire

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## **Introduction**

As with most constructs in psychological assessment and research, musicality has been interpreted in numerous manners. Hallam (2010) parallels the approach to musicality with the one to intelligence: earlier conceptions considered a single factor, mostly of genetic nature, while recent work focuses more on musicality as a developmental multifaceted phenomenon.

The assessment of musicality started with Stumpf's study (1883, as cited in Hallam, 2010) of "individual judgement of sound", that relied on aural tasks such as identifying higher pitched notes or reproducing chords that had been played. These measures were proven successful in discriminating between experienced musicians and non-musical individuals.

The following decades, musicality assessment was similarly focused on aural tasks. As noted by Hallam (2010), although, in 1953, Revesz described part of musicality as the "ability to enjoy music aesthetically", suggesting a broader notion of the construct, he later developed tests that focused on subjects' performance tasks like rhythm copying or melody completion.

Later, Seashore (1960, as cited by Buren, 2021a) provided a factorial approach with standardised auditory measures. Task results were presented in a profile that included pitch, loudness, rhythm, tempo, timbre, and tonal memory. Wing was similar in his psychometric perspective but proposed that musicality's perceptual factors should be combined into a musical general score (Wing, 1960 as cited by Gembris, 1997). Gordon then presented the most comprehensive set of musical ability measures, from childhood to adulthood (1965; 1989, as cited by Gembris, 1997). Even though the approach of musicality became more complex with time, these objective conceptions were still limited, as they did not encompass the cultural and aesthetic aspects of the construct (Gembris, 1997).

Recent approaches consider that individual musicality is shaped by the sociocultural context, which determines what constitutes a musically relevant behaviour. Hallam (2010) and Prince (Hallam and Prince, 2003) have conducted research on current conceptions of musicality and found that, among musicians and non-musicians,

musicality was perceived in terms of rhythmic and instrumental abilities, but also in terms of valuing and appreciating music as well as motivational and communicational factors.

Buren and colleagues (2021a; 2021b) continued Hallam's work (Hallam & Prince, 2003; Hallam, 2010) by studying the conceptions of musicality in infancy and preschool ages. For that purpose, the researchers developed the Musical Child Questionnaire (MCQ) and its adaptation for younger children, called Musical Child Questionnaire for Infants and Toddlers. Their results were somewhat similar to those of Hallam's (2010). Using principal component analysis, the authors found four facets of childhood musicality. These were *musical communication* (emotional approach to music), *enthusiasm and motivation* (to engage and make music), *analytical understanding* (or capacity to evaluate different musical aspects) and *musical abilities* (as pitch, rhythm, pulse, timing and melody). Some categories identified by Buren and Hallam overlapped: for example, Buren's et al. (2021a) "enthusiasm and motivation" correspond to two of Hallam's (2010) categories: "valuing, appreciating and responding to music" and "commitment, motivation, personal discipline and organisation". However, some facets identified in the previous research on adults were not observed in children, likely due to the influence of age, as certain dimensions (i.e., "playing an instrument") are more relevant to older individuals. The fact that the questionnaire was designed for children aged 3 to 6 might explain these differences. Another interesting finding was that, while analytical understanding of music was considered the most important dimension by children's parents, educators seemed to value it less, emphasising the importance of motivation and enthusiasm (Buren et al., 2021a).

Concurrently, Müllensiefen and colleagues (2014) took Hallam's (2010) definition into account and developed a questionnaire with five dimensions of musical sophistication, the Goldsmiths Musical Sophistication Index (Gold-MSI), which has been validated in different cultures (Li et al., 2023; Lima et al., 2020; Sadataka et al., 2023; Santangelo et al., 2023; Schaal et al., 2014). The Gold-MSI seems to be a comprehensive instrument for assessing musicality in adulthood, comprising dimensions such as active engagement, perceptual abilities, musical training, singing abilities and emotional response to music.

More specifically for the assessment of musicality during childhood, there are recent scales for measuring perceptual abilities (Overy, 2003; Peretz, 2013), but there are no validated instruments that consider other facets of the construct through reports. While Buren's et al. (2021a; 2021b) questionnaires comprise all the factors perceived as

important when defining childhood musicality (musical communication, enthusiasm and motivation, analytical understanding and musical abilities), none has yet been standardised to be used as an instrument for musicality assessment.

Thus, there is a lack of scales that view children's musicality as a social construct built upon different components. This might be one of the reasons for which there is still work to be done in order to understand which factors are associated with or that predict musicality in earlier years. The following paragraphs present an overview of the current research on the associations between children's musicality and several individual and environmental factors. Firstly, we report found associations with the demographic variables of age and sex, followed by the relationship between cognitive abilities and musicality. Next, sociocultural factors, including parental musical influence, are tackled. Finally, the link between reported measures of musicality and perceptual musical abilities is mentioned.

Age differences in musicality were demonstrated in adult samples. Müllensiefen and colleagues (2014) observed that younger participants reported higher musicality, and similar results were found when the instrument was adapted for the Portuguese population (Lima et al., 2018). However, there is still a lack of research to explore if age trends are observable in earlier periods of life. Efforts have been made to identify critical periods of musical development (Trainor, 2005) and it is known that certain musicality aspects emerge fairly early in the lifespan, with infants as young as 3 months old being capable of timing and pitch perception, for example (Lau et al., 2017; Trehub, 2023; Trehub & Degè, 2016). These perceptual abilities further develop in pre-school and school years (Palheiros, 2014; Welch, 2006), in parallel with other musicality aspects such as emotional perception in music and aesthetic appreciation (Hargreaves & North, 1999). However, developmental trajectories have not yet been identified when broader multidimensional concepts of musicality are considered.

Similarly, research on the relationship between sex and musicality remains relatively underexplored (Miles et al., 2016). Most studies focus on perceptual musical ability (Shutter-Dyson & Gabriel, 1981) and, while some indicate boys score better in this type of tasks (Hassler, 1992), others show women outperforming men (Miles et al., 2016), and some do not report sex differences (Koelsch et al., 2003; Wehrum et al., 2011). In sum, there is no consistent conclusion for sex differences in perceptual musical ability. In studies based on Gold-MSI, Lima et al. (2018) showed that adult women report better

singing abilities and higher emotional responses to music than men. However, when it came to younger ages, teachers did not report sex differences in children's musicality (Hallam 2004). Since results in the field are scarce and mixed, the association of sex with childhood musicality seems to be worth studying.

Another relevant association is that of musicality with cognitive abilities. Numerous studies and meta-analysis have tackled this relationship aiming to find an IQ increase through musical practice (Román-Caballero et al., 2022; Schellenberg, 2004; 2006). However, such causality has been dismissed by several authors, as the correlation might be interpreted in the opposite direction: individuals with higher cognitive abilities being more likely to be involved in musical activities (Sala & Gobet, 2017a; 2017b; 2020; Schellenberg & Lima, 2020). Besides musical behaviour, the link of cognitive abilities with perceptual musical abilities has also been reported (Degé et al., 2011; Schellenberg, 2006; Swaminathan & Schellenberg, 2020). In sum, despite the direction of the relationship one considers, the correlation between cognitive abilities and some aspects of musicality seems well established. Further research is needed to fully understand its nuances.

As for socioeconomic status (SES), although numerous studies on children's musicality focus on middle-class families (Ilari et al., 2011), there have been reported associations between the two factors. For example, Holster (2023) evidenced that adolescents were more likely to engage in musical activities when coming from higher SES backgrounds. Concerning reported measures of musicality, studies in different populations showed adults with higher SES reported higher musical sophistication (Lima et al., 2018; Müllensiefen et al., 2014).

When considering the link between socioeconomic factors and a multifaceted definition of musicality, it might be relevant to equally regard SES as multidimensional. Similarly to the definition of musicality, recent studies have been replacing traditional definitions with more comprehensive measures of SES (Harwell, 2018). In fact, diverse contextual factors might influence the outcome variable differently. It is possible that, according to Oakes and Rossi's (2003) perspective, both material capital (income) and human capital (parental education) affect children's musicality. For example, monthly income would impact owning musical instruments or attending certain musical events and parental education could shape the importance parents give to children's enrolment in musical activities. Thus, the term sociocultural is preferred.

Conversely, familiar socioeconomic and educational characteristics are not the only way parents can influence their children's musicality. Parents can affect their children's relationship with music, for example, by their own attitudes towards music, expectations and familiar participation in musical activities (Zdinski, 2014). In fact, musically experienced parents are more likely to musically engage with their infants and provide more opportunities for musical play and practice than parents with no musical background (Custodero & Johnson-Green, 2003). Holster (2023) researched how parental involvement influenced children's musical engagement and found that SES and a musical home environment played different roles as predictors. The author showed that, while SES seemed to directly impact children's engagement in music, parental influence through a musical home environment impacted it by mediation. In other words, more musically involved parents had children with a higher sense of competence and autonomy, who seemed to value music to a greater extent, ultimately explaining children's enrolment in musical activities. Differences in parenting seem to show that parents' own musicality notably influences their children's musicality, even more so when broader definitions that comprise musical behaviours are taken into account.

Finally, there is evidence that self-report musical sophistication measures are correlated with objective tests of musicality. Müllensiefen and colleagues (2014) found evidence of the relationship between self-assessed musical abilities with tasks of melodic memory and beat perception. Correia and Lima (2023) found similar results. These correlations further highlight the different perspectives and dimensions of musicality and how they might relate to each other.

Given the current state of musical assessment and especially the lack of standardised multifaceted scales for children, our research goal here is using the MCQ as a tentative index of reported child musicality, exploring the factors that might influence the scores obtained. The present study aims to explore which demographic (sex, age), sociocultural (parental education, monthly income, maternal musicality), cognitive and music perception (rhythm, melody, memory) variables predict reported children's musicality.

## Method

### Participants

This study is part of a larger project where data collection is still ongoing. The current analysis focuses on a subsample ( $N = 116$ ) and variables that were of interest to our research for which sufficient data was already available.

One hundred and sixteen children participated in this study. One subject with atypically low cognitive ability was excluded from the sample (Ravens' score more than two standard deviations below the mean, IQ below 70). Furthermore, a cut-off point was established for the Montreal Battery of Evaluation of Musical Abilities (MBEMA) tasks, where any subject with an accuracy rate equal or below 50% (chance level) was excluded from the sample; this cut-off was established to ensure that scores reflected task engagement rather than random guessing. Based on this criterion, 36 children were excluded from the sample. Analyses were conducted on the remaining 79 children, of which 45 were girls. Data was collected from children of two public primary education schools in Porto's metropolitan area (59 children belonged to one of them). Children's average age was 8.91 years ( $SD = 1.05$ ) and mean cognitive ability was  $IQ = 110.02$  ( $SD = 10.66$ ).

Regarding sociocultural environment, the mean of mother's and father's years of schooling was 11.84 years ( $SD = 2.98$ ), with 4 years as the lowest level of education and 17.5 years the highest. In terms of monthly income, 48.6% of the parents reported earning an income within the second level<sup>1</sup> ("606€ a 1 815€ mês" [*from 606€ to 1815€ per month*]), while 41.3% reported having a monthly income of 1 816€ to 3 025€ per month (level 3: "1 816€ a 3 025€ /mês"). Three families were on the lower income level ("até 605€/mês" [*up to 605 € per month*]) and no family selected the higher income option ("superior a 4 235€/mês" [*superior to 4 235€*]). Descriptives are summarised in Table 1 and distribution for each variable is presented in Figure 1.

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<sup>1</sup> Monthly income was assessed with a 5-point Likert scale (see next section, Materials)

**Table 1**

*Participants characterization in demographic, sociocultural, cognitive and music perception variables*

| Sample descriptive statistics          |                       |               |                |
|----------------------------------------|-----------------------|---------------|----------------|
| <b>Sex</b>                             |                       |               |                |
|                                        | <b>Female</b>         | <i>N</i> = 45 |                |
|                                        | <b>Male</b>           | <i>N</i> = 34 |                |
| <b>Age</b>                             |                       | 8.91 ± 1.05   | (6.58-11.31)   |
| <b>Cognitive abilities</b>             |                       | 110.2 ± 10.66 | (84.87-126.91) |
| <b>Parental education</b>              |                       | 11.84 ± 2.99  | (4.00-17.50)   |
| <b>Monthly income</b>                  |                       |               |                |
|                                        | Lowest level 1.       | <i>N</i> = 4  |                |
|                                        | 2.                    | <i>N</i> = 35 |                |
|                                        | 3.                    | <i>N</i> = 30 |                |
|                                        | 4.                    | <i>N</i> = 3  |                |
|                                        | Highest level 5.      | <i>N</i> = 0  |                |
| <b>Maternal musical sophistication</b> | <i>N</i> = 66         | 3.67 ± 0.74   | (2.17-6.28)    |
| <b>Musical perception tasks</b>        |                       |               |                |
|                                        | Melody discrimination | 1.45 ± 0.75   | (0.25-3.29)    |
|                                        | Rhythm discrimination | 1.77 ± 0.75   | (0.25-3.29)    |
|                                        | Memory task           | 1.77 ± 0.62   | (0.36-3.29)    |

*Note.* Sex and monthly income statistics represent the frequency of each category and values for the remaining variables are mean, standard deviation ( $M \pm SD$ ), minimum and maximum (min-max). Sample size for maternal musicality is presented, since it differs from other variables.

## Materials

### *Sociodemographic Questionnaire*

A custom-developed sociodemographic questionnaire was used (Attachment 1). It includes items related to demographic details, such as the child's age and sex. The questionnaire also addressed the child's health, including the use of medication and the presence of any neurological or psychiatric conditions.

To assess sociocultural variables, two different measures were considered: parents' educational background and household income. The highest level of maternal and paternal education was assessed through completed years of study. Monthly income was operationalized in a five-point Likert scale from “até 605€/mês” (*up to 605€ per month*) to “superior a 4 235€/mês” (*superior to 4 235€ per month*).

### ***Musical Child Questionnaire***

The Musical Child Questionnaire (MCQ) recently developed by Buren et al. (2021) was used to assess children's musicality from the perspectives of their parents and teachers. The MCQ was designed specifically for children aged 3 to 6 years and comprises 49 items related to different aspects of musical behaviour. The questionnaire was developed on the basis of Hallam's (2003) questionnaire on adult musical abilities, which was reformulated and rephrased to better align with the context of early childhood musical development. The original version of the MCQ (Buren et al., 2021a) comprises four dimensions of musicality, assessed by principal component analysis: (1) musical communication, (2) enthusiasm and motivation, (3) analytical understanding, and (4) musical abilities.

In this study, the 49 items were adapted to Portuguese such that the respondent should rate each of them on a Likert scale ranging from 1 (*totally disagree*) to 5 (*totally agree*), which can be found in Attachment 2. We considered MCQ total score as the dependent variable - children's reported musicality - from now on referred to as “children's musicality”.

### ***Goldsmiths Musical Sophistication Index***

The Portuguese version of the Goldsmiths Musical Sophistication Index (Gold-MSI-P) (Lima et al., 2018; Müllensiefen et al., 2014) was used to evaluate the musicality of the children's mothers. The Gold-MSI-P is a comprehensive self-report questionnaire consisting of 38 items. Of these, 31 items about musical behaviours and skills are rated on a 7-point Likert scale ranging from 1 (*completely disagree*) to 7 (*completely agree*). The remaining 7 items use ordinal scales to assess specific musical behaviours, such as the number of instruments played or how often they go to live musical shows.

The Gold-MSI-P offers a multidimensional assessment of musicality through five subscales: (1) active engagement, which gauges the extent of an individual's involvement in musical activities; (2) perceptual abilities, which measures the ability to perceive and distinguish musical elements; (3) musical training, which captures formal and informal musical education; (4) singing abilities, which involves self-assessed singing skills; and (5) emotions, which examines the emotional responses elicited by music.

### ***Montreal Battery of Evaluation of Musical Abilities***

The abbreviated Montreal Battery of Evaluation of Musical Abilities (MBEMA; Peretz et al., 2013) was employed to assess the musical abilities of children. The MBEMA is a validated tool designed specifically for evaluating musical skills in children aged 6 to 8 years. The battery relies on a set of perceptual musical tests, such that children are presented with 60 musical sequences, divided into three tasks: melodic discrimination, rhythmic discrimination, and recognition of melodies by memory. The melodic discrimination task assesses the ability to detect changes in pitch, and the rhythmic discrimination task the sensitivity to changes in duration and timing. The memory task evaluates the child's capacity to recall previously heard melodies. In other words, for melody and rhythm, children are asked to identify if two musical excerpts are the "same" or "different". Each task comprises 10 equal stimulus and 10 discrepant musical excerpts. For the memory task, after listening to an excerpt, children are asked to decide if they heard it during the previous tasks. 10 of the stimuli are present in the previous tasks of melody and rhythm discrimination, while the other 10 are not.

The MBEMA is particularly well-suited for cross-cultural and developmental studies, offering a comprehensive assessment of core musical abilities with high internal consistency (Cronbach's  $\alpha = .94$ ). The tasks are presented in a game-like format, seeking high engagement and accurate measurement of the children's musical abilities without requiring prior musical training. This tool has been shown to effectively differentiate children with and without musical training. In this study, the MBEMA was used to obtain a detailed profile of the children's musical perceptual abilities, providing critical data to understand its potential relationship with reported musicality.

### ***Raven's Coloured Progressive Matrices***

The Raven's Coloured Progressive Matrices (RCPM; Raven et al., 2009) is a test of non-verbal intelligence that assesses the ability to identify relationships between shapes and patterns. The coloured version adapted for Portuguese children from 6 to 11 years-old by Simões (1994) was used in this study.

The test includes 36 items equally divided in three sets (A, Ab and B). For each item, a coloured pattern with a missing portion is presented, as well as six options to fill in the missing part; the child is asked to point to the correct option to complete the pattern. The patterns are presented individually and have increasing difficulty. In this study, scores obtained through Raven's test are considered and further described as "cognitive abilities" measures.

### **Procedure**

The sociodemographic and Gold-MSI questionnaires were completed by the children's mothers at home, and the MCQ questionnaire was filled in by the children's teachers.

MBEMA and Raven's tasks were completed by the students at their respective school. Raven's test was administered first, and data collection lasted approximately 30 minutes. The MBEMA tasks were performed in random order, such that some participants randomly started with the rhythmic task, while others first completed the melodic task.

### **Data Analysis**

Statistical analysis was performed with JASP 0.18.3, taking into account significance levels of  $p < .05$  and Bayes Factors as evidence for the alternative hypothesis over the null hypothesis. The interpretation of  $BF_{10}$  values followed Jeffreys' (1961) criteria, such that values above 1 indicate evidence for the alternative hypothesis (1-3 corresponds to weak evidence; 3-10 to substantial evidence; 10-30 to strong evidence; 30-100 very strong evidence; and values above 100 decisive evidence).  $BF_{10}$  factors below 1 favour the null hypothesis (values below .01 indicate decisive evidence for the null hypothesis; .01-.03 indicates very strong evidence; .03-.10 substantial evidence; and .33-1 weak evidence).

In this study, Likert scale variables (Gold-MSI and MCQ) were treated as continuous variables, as the intervals between response options were considered equal. Parental education was calculated as the mean of years of schooling completed by children's parents.

Additionally, *d*-prime (*d'*) scores were calculated for the MBEMA tasks, in accordance with signal detection theory, to assess sensitivity to the target stimuli. Proportions of hits and false alarms were corrected, so that high values (i.e., 1) were replaced with  $0.5/n$  and low values (i.e., 0) were replaced with  $(n-0.5)/n$  (*n* being the number of distractor or target trials). *d'* scores were then calculated with the formula  $d' = z(\text{hit rate}) - z(\text{false alarm rate})$ .

Independent sample *t*-tests, one-way ANOVA and bi-variate Pearson correlations were conducted to examine the associations between demographic, sociocultural, cognitive and music perception variables and children's musicality, as measured by MCQ. Then, a multiple regression analysis was implemented in order to ascertain how much variability in children's musicality was explained by the associated factors, and which proved to be independent contributors of children's musicality.

Skewness (*S*) and kurtosis (*K*) were examined to verify the normality of the distribution. Values of *S* between -3 and 3 and values of *K* ranging from -10 to 10 were considered indicative of normality (Kline, 2016). Data distribution was further inspected through violin boxplots.

## Results

Values of *S* and *K* fulfilled Kline's (2016) criteria for normality of distributions, since *S* varied from -0.56 to 0.66 and *K* ranged from -0.81 to 1.25. Violin boxplots with individual results for each variable are presented in Figure 1.

**Figure 1**

*Distribution of (A) children's ages, (B) children's cognitive ability, (C) children's reported musicality, (D) parental education, (E) monthly income, (F) maternal musical sophistication and d prime scores of MBEMA tasks of (G) rhythm discrimination, (H) melody discrimination and (I) memory.*

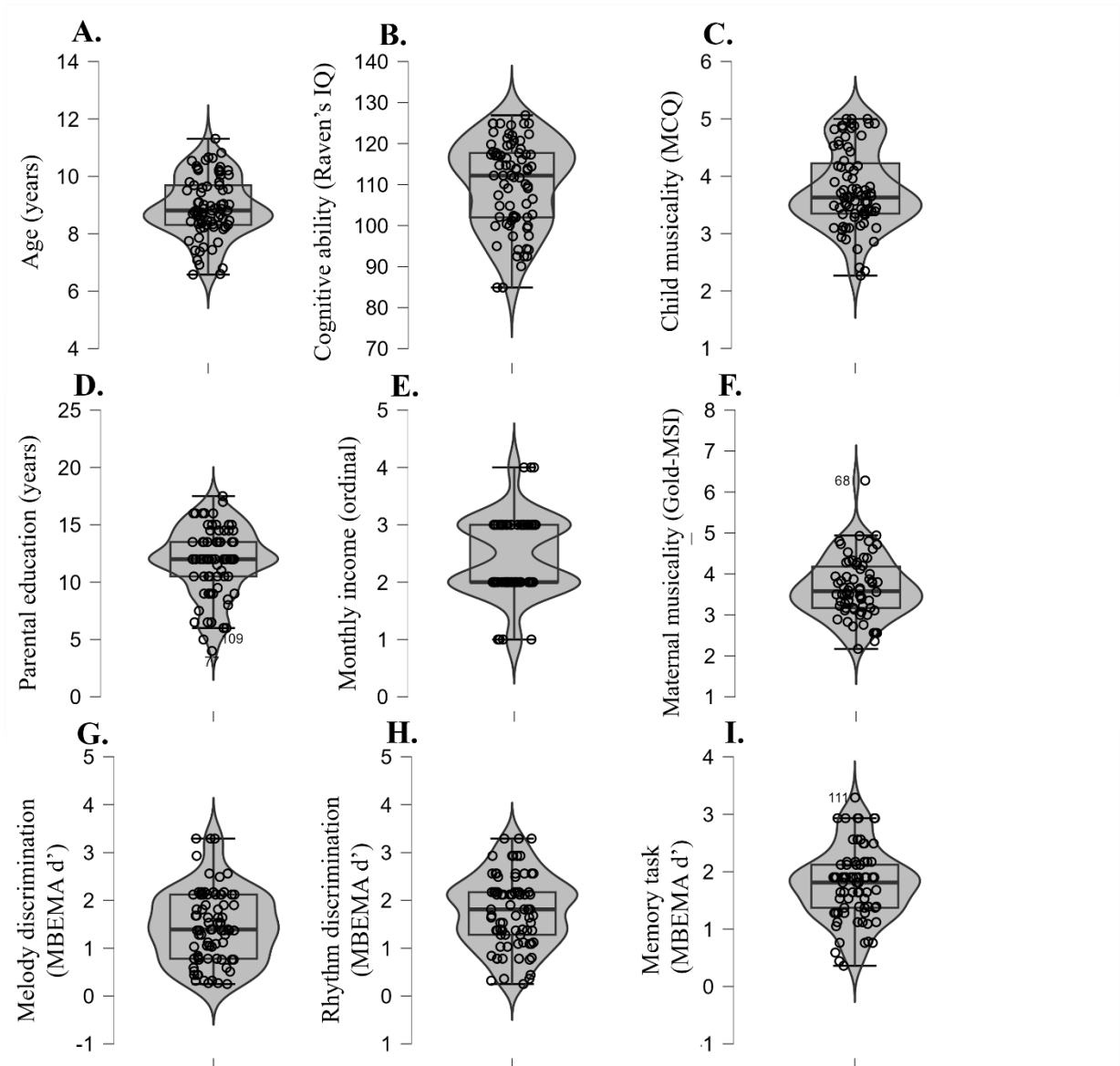


Table 3 shows the associations between children's musicality and demographic (age), sociocultural (parental education, monthly income, maternal musicality), cognitive and music perception (rhythm, melody, memory) variables.

**Table 3**

*Associations of children's reported musicality with demographic, sociocultural, cognitive and musical perception variables*

|                                            | Child musicality (MCQ) |                 |                           |
|--------------------------------------------|------------------------|-----------------|---------------------------|
|                                            | Test                   | <i>p</i> -value | BF <sub>10</sub>          |
| Sex                                        | $t(76.29) = 2.97$      | $p = .004^a$    | BF <sub>10</sub> = 7.91   |
| Age                                        | $r(75) = -.09$         | $p = .422$      | BF <sub>10</sub> = 0.20   |
| Parental education                         | $r(77) = .40$          | $p < .001$      | BF <sub>10</sub> = 106.37 |
| Monthly income                             | $F(3,68) = 5.32$       | $p = .002$      | BF <sub>10</sub> = 48.90  |
| Cognitive ability                          | $r(75) = .29$          | $p = .010$      | BF <sub>10</sub> = 3.84   |
| Maternal musical sophistication (Gold-MSI) | $r(64) = -.08$         | $p = .505$      | BF <sub>10</sub> = 0.19   |
| Musical perception tasks (MBEMA)           |                        |                 |                           |
| Melody discrimination                      | $r(77) = -.02$         | $p = .850$      | BF <sub>10</sub> = 0.14   |
| Rhythm discrimination                      | $r(77) = .30$          | $p = .008$      | BF <sub>10</sub> = 4.67   |
| Memory task                                | $r(77) = .20$          | $p = .077$      | BF <sub>10</sub> = 0.65   |

**Note.** <sup>a</sup> Indicates that the Levene's test for equality of variances was significant ( $p < 0.05$ ), and the respective analyses were adjusted to account for unequal variances.

An association between children's musicality and sex was found,  $p = .004$ , such that girls are perceived as more musical than boys ( $M_{girls} = 3.97$ ,  $SD = 0.71$ ;  $M_{boys} = 3.53$ ,  $SD = 0.59$ ) by their teachers, and substantial evidence supports this association, BF<sub>10</sub> = 7.91. There is no relationship between age and MCQ scores,  $p = .422$ , and this absent link is supported by substantial evidence, BF<sub>10</sub> = 0.20.

Higher parental education is correlated to higher levels of musicality in children,  $p < .001$ , with decisive evidence supporting this relationship, BF<sub>10</sub> = 106.37. We found very strong evidence supporting the link between monthly income and children's musicality,  $p = .002$ , BF<sub>10</sub> = 48.90. Post-hoc comparisons were performed to further analyse this association and the only significant mean difference in children's musicality arose between the third and second level of monthly income,  $p < .001$ . Children that belonged to families in the second

income level (606€ to 1 815€ per month) showed lower musicality scores than those on the third income level (1 816€ to 3 025€ per month), with decisive evidence supporting the association,  $BF_{10,U} = 102.56$ . For the remaining comparisons, no association was found with children's musicality: level 1 vs. level 2,  $p = .984$ ,  $BF_{10,U} = 0.44$ ; level 1 vs. level 3,  $p = .070$ ,  $BF_{10,U} = 1.15$ ; level 1 vs. level 4,  $p = .520$ ,  $BF_{10,U} = 0.26$ ; level 2 vs. level 4,  $p = .424$ ,  $BF_{10,U} = 0.60$ ; level 3 vs. level 4,  $p = .426$ ,  $BF_{10,U} = 0.58$ .

The correlation between cognitive abilities and children's musicality was positive and significant,  $p = .010$ , with substantial evidence supporting the association,  $BF_{10} = 3.84$ . Substantial evidence supports the absence of a link between maternal and child musicality,  $p = .505$ ,  $BF_{10} = 0.19$ .

For the perceptual musical tasks, rhythm scores positively correlated to children's musicality,  $p = .008$ , and substantial evidence supports the association,  $BF_{10} = 4.67$ . Substantial evidence supports that melody task scores are not related to MCQ results,  $p = .850$ ,  $BF_{10} = 0.14$ , while weak evidence ( $BF_{10} = 0.65$ ) suggests no association of memory task scores with children's musicality,  $p = .077$ .

To further examine the relationship between the teacher's report of children's musicality (MCQ general score) and predictor variables (sex, parental education, cognitive abilities and children's scores on the rhythmic perception task), a multiple linear regression analysis was conducted (model 1). Decisive evidence supports this model,  $R = .58$ ,  $F(5,64) = 6.34$ ,  $p < 0.001$ ,  $BF_{10} = 306.44$ , that explains 27.9% of the variance in children's musicality (for details see Table 4). Independent contributions were found for sex,  $\beta = -0.28$ ,  $p = .009$ ,  $BF_{10} = 11.85$ , and parental education,  $\beta = .31$ ,  $p = .020$ ,  $BF_{10} = 15.67$ , but not for monthly income,  $p = .479$ ,  $BF_{10} = 1.27$ , or cognitive ability,  $p = .277$ ,  $BF_{10} = 1.56$ . For rhythm perception scores no significant relationship was found,  $p = .097$ , but substantial evidence supported the association,  $BF_{10} = 3.05$ .

**Table 4***Summary of multiple regression analysis for variables predicting children's musicality*

| Variable                             | <i>B</i>                    | <i>SE B</i>     | $\beta$          | <i>p</i> -value | BF <sub>10</sub>          |
|--------------------------------------|-----------------------------|-----------------|------------------|-----------------|---------------------------|
| Sex                                  | <i>B</i> = -.40             | <i>SE</i> = .15 | $\beta$ = -0.28  | <i>p</i> = .009 | BF <sub>10</sub> = 11.85  |
| Parental education                   | <i>B</i> = .07              | <i>SE</i> = .03 | $\beta$ = .31    | <i>p</i> = .020 | BF <sub>10</sub> = 15.67  |
| Monthly income                       | <i>B</i> = .10              | <i>SE</i> = .14 | $\beta$ = .09    | <i>p</i> = .479 | BF <sub>10</sub> = 1.27   |
| Cognitive ability                    | <i>B</i> = .01              | <i>SE</i> = .01 | $\beta$ = .12    | <i>p</i> = .277 | BF <sub>10</sub> = 1.56   |
| Rhythmic skills                      | <i>B</i> = .17              | <i>SE</i> = .10 | $\beta$ = .18    | <i>p</i> = .097 | BF <sub>10</sub> = 3.05   |
| <b><i>R</i></b>                      | <i>R</i> = .58              |                 |                  |                 |                           |
| <b>Adjusted <i>R</i><sup>2</sup></b> | <i>R</i> <sup>2</sup> = .28 |                 |                  |                 |                           |
| <b><i>F</i></b>                      | <i>F</i> (5, 64) = 6.34     |                 | <i>p</i> < 0.001 |                 | BF <sub>10</sub> = 306.44 |

## Discussion

This study explored predictors of children's musicality. For this purpose, we investigated demographic (sex, age) and sociocultural characteristics (parental education, monthly income, parental musicality), cognitive abilities and music perception (rhythm, melody, memory) as potential factors determining children's musicality. Through *t*-tests, one-way ANOVA and bivariate Pearson correlations, we assessed which associations were significant and supported by evidence. Then, we conducted a multiple regression analysis of children's musicality as a function of these predictors: sex, parental education, monthly income, cognitive abilities and rhythm perception were included in the model. We found that, within the model, monthly income and cognitive abilities were not significant predictors of children's musicality, with evidence supporting this lack of association. The rhythmic task was not a significant predictor for children's musicality, but evidence in support of this association was substantial. To clarify this mixed result, we performed a data-driven multiple regression analysis, i.e., one that only included sex, parental

education and rhythm perception variables, and compared this data-driven model to the previous model. Our evidence supported that these models are similar,  $BF_{10} = 0.23$ ; furthermore, they explained a similar amount of variability in children's musicality, adjusted  $R^2 = .27$ .

It is possible that choosing to use two measures of SES might have introduced unnecessary variability to the original model. The aim of taking parental education and income into account was to follow recent suggestions of considering SES as a multifaceted phenomenon (Harwell, 2018). However, one-way ANOVA indicated that SES measures of monthly income and parental education are strongly associated,  $F(3, 68) = 11.05, p < 0.001, BF_{10} = 1622.07$ , with a large effect size of  $\eta^2 = .34$ . Removing monthly income from the model does not necessarily imply that familial income is not associated with children's musicality, but it might mean that its impact is not fundamentally different from those of other SES measures - in this study, parental education.

Parental education seemed to appropriately explain children's musicality, as expected based on current literature (Holster, 2023; Lima et al., 2018; Müllensiefen et al., 2014). It seems that sociocultural factors are relevant predictors of children's musicality, as children with more educated parents have higher musicality scores.

As for parental musicality, there were no found associations with children's musicality. This might mean that parental influence on child musicality is not differentiable from other parental measures of SES, contradicting Holster's findings (2023). Conversely, it might mean that parent's musicality does not necessarily directly impact their musical influence on children. As Ilari et al. (2011) suggested, "musical parenting" is a construct in itself and has more to do with what parents value and decide to implement when educating their children, and less to do with their own musicality or SES.

The fact that cognitive abilities were not a significant predictor might be explained by the cognitive test we used. When compared to other general IQ measures, with various subscales, such as WISC, Raven's assesses a somewhat different construct, given its non-verbal nature. This might explain why our findings were different from previous research that showed correlations between IQ and musicality (Degé et al., 2014; Schellenberg, 2004), even if some authors (Thompson, 2004; Trimmer & Cuddy, 2008) have found that Raven's scores associated with musical training. Instead, our results seem to reflect more recent research that showed that the relationship between musicality and cognitive

abilities is weak or non-existent, especially when taking into account potentially confounding variables like SES (Boal-Palheiros et al., 2022; Schellenberg & Lima, 2024).

The present study revealed a significant and substantially supported association between children's musicality and their sex. Girls were perceived by their teachers as more musical than boys, which seems to mirror the male-female differences found in adults' self-reported musicality (Lima et al., 2018; Müllensiefen et al., 2014) but does not coincide with Hallam's (2004) previous findings on the teachers' report of their students' musicality.

Looking specifically at perceptual musical abilities could help interpret these results. *t*-tests were performed to identify sex differences for the musical abilities dimension of the MCQ subscale, as well as for each MBEMA measure. Similarly to the general factor of musicality, teachers rated girls' musical ability as higher than boys' ( $M_{girls} = 4.14$ ,  $SD = 0.77$ ;  $M_{boys} = 3.71$ ,  $SD = 0.67$ ). The significant association was supported by substantial evidence,  $p = .012$ ,  $BF_{10} = 3.89$ . Instead, boys outperformed girls in MBEMA's melodic task ( $M_{girls} = 1.23$ ,  $SD = 0.70$ ;  $M_{boys} = 1.75$ ,  $SD = 0.74$ ), with strong evidence supporting the found association,  $p = .002$ ,  $BF_{10} = 15.48$ . There were no significant differences for the rhythm,  $p = .140$ , and memory tasks,  $p = .389$ , although evidence to support the absence of a link is weak: respectively,  $BF_{10} = 0.61$ ;  $BF_{10} = 0.33$ .

Therefore, teachers' perceptions do not necessarily reflect true variation in perceptual abilities. This could mean there is some level of bias in their rating of children's general musicality as well. In fact, current work shows that bias in terms of students' sex remains a prevalent factor, even in Western countries that have higher levels of equality between sexes. Teachers tend to expect girls to succeed more in areas such as language, while boys are expected to be better in fields like mathematics (Olczyk et al., 2023). It is possible that teachers expect girls to prefer and engage in musical activities (i.e., singing or dancing) more than boys. Furthermore, Hanley (1998) suggested that teacher stereotypes can be generalised to the "musical classroom". The author found that, even though girls had higher musical achievement, music teachers considered boys to be more musically creative and interested. However, in our sample, bias seems to be opposite of Hanley's findings, with teachers rating girls as more musical. This might be because, in this study, teachers were not music teachers or the fact that teachers were female might play a role (Dee, 2006). Findings can also be relevant in terms of self-fulfilling prophecies, since

teachers' expectations in terms of sex differences can influence students' performance and behaviours, further increasing the gap between sexes (Olczyk et al., 2023).

No significant relationship was observed between children's age and their musicality score, with substantial evidence supporting the missing association. This suggests that within the age range studied (6.58-11.31), musicality as perceived by teachers remains stable. This might be because all students were attending the same level of studies. For example, in Portugal, musical education guidelines for primary school are not divided by years of schooling, like other school subjects (Direção-Geral da Educação, 2018a, 2018b, n.d.). Such could shape teachers' expectations in terms of their students' musicality.

Finally, only the rhythmic perceptual tasks were associated with reported musicality measures, while melody and memory did not. Previous research similarly found differences in melodic and rhythmic task's association with musicality (Correia & Lima's, 2023; Kragness, 2021). Authors suggested the mechanisms through which rhythmic and melodic abilities relate to broader musicality are fundamentally different (Schellenberg & Lima, 2024), although no clear conclusions can be drawn from our study in that regard.

Despite the study's significant results, several limitations should be taken into account. Although the Musical Child Questionnaire, MCQ (Buren et al., 2021) provides valuable insights into childhood musicality as a multifaceted construct, it is not a standardised measure; it was developed for children 3 to 6 years old and teachers' reports seemed to show bias particularly based on students' sex. In the future, it is important to standardise scales for children with a broader definition of musicality and it might be relevant to consider multiple sources of reports (i.e., parents, teachers and music teachers). Additionally, the implemented test of cognitive abilities could be reconsidered, as it focuses on a non-verbal dimension of intelligence. Raven's test does not entail the multifaceted approach regarded for other variables and does not provide insight into other dimensions of cognition that were associated with musicality in the literature, such as executive functions or working memory (Degé et al., 2009). Lastly, our conventional sample of 79 participants might limit the generalisation of results and the correlational design does not allow for any inference on the direction of found associations. Future research should consider larger and more diverse populations, as well as longitudinal and cross-sectional studies to better understand the relationship between children's musicality and demographic, sociocultural, cognitive and music perception variables.

In conclusion, this study contributes to the body of research that considers childhood musicality as a multifaceted construct, influenced by individual and environmental factors. Results suggest that sex, parental education and performance in rhythmic tasks are predictors of children's musicality. Conversely, cognitive abilities, familial income, parental musicality and other perceptual musical tasks (melody and memory) seem to play a more limited role than previously thought. Overall, our results emphasise the need for broader notions of musicality in childhood, particularly in a sociocultural perspective. Advancing the understanding of predictors of childhood musicality, this study lays the groundwork for future investigations to further explore the diverse nuances of this comprehensive construct.

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## Attachments

### Attachment 1

*Sociodemographic questionnaire (both sides)*

**Questionário sociodemográfico**  
(Data de preenchimento do questionário: \_\_\_\_ / \_\_\_\_ / \_\_\_\_)

| <b>INFORMAÇÕES RELATIVAS À CRIANÇA</b>                                                                             |  |
|--------------------------------------------------------------------------------------------------------------------|--|
| Escola: _____ Turma: _____                                                                                         |  |
| Nome: _____ Sexo: <input type="checkbox"/> Feminino <input type="checkbox"/> Masculino                             |  |
| Data de nascimento ____ / ____ / ____                                                                              |  |
| Está a tomar medicação? <input type="checkbox"/> Sim <input type="checkbox"/> Não Qual (ais)? _____                |  |
| Doença(s) neurológica/psiquiátrica(s)? <input type="checkbox"/> Sim <input type="checkbox"/> Não Qual (ais)? _____ |  |
| Atividade(s) extracurricular(es) (fora da Escola): <input type="checkbox"/> Sim <input type="checkbox"/> Não       |  |
| Qual (ais)? _____                                                                                                  |  |
| Há quanto tempo participa na (s) atividade(s)? _____                                                               |  |
| Carga horária semanal na atividade _____                                                                           |  |

| <b>INFORMAÇÕES RELATIVAS À FAMÍLIA</b>                                        |                                                          |
|-------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>A. Escolaridade e atividade profissional dos pais ou responsável legal</b> |                                                          |
| Escolaridade concluída pela mãe: _____                                        | Escolaridade concluída pelo pai: _____                   |
| N.º de anos que frequentou a escola: _____ anos                               | N.º de anos que frequentou a escola: _____ anos          |
| Profissão da mãe: _____                                                       | Profissão do pai: _____                                  |
| Situação profissional da mãe:                                                 | Situação profissional do pai:                            |
| <input type="checkbox"/> Desempregada                                         | <input type="checkbox"/> Desempregado                    |
| <input type="checkbox"/> Trabalhadora por conta de outrem                     | <input type="checkbox"/> Trabalhador por conta de outrem |
| <input type="checkbox"/> Trabalhadora por conta própria                       | <input type="checkbox"/> Trabalhador por conta própria   |
| <input type="checkbox"/> Reformada                                            | <input type="checkbox"/> Reformado                       |
| <input type="checkbox"/> Outra situação. Qual? _____                          | <input type="checkbox"/> Outra situação. Qual? _____     |

**B. Rendimento**

Para cada um dos aspetos indique com uma cruz (X) a situação que melhor caracteriza a família.

**B1. Rendimento disponível por mês** (consideramos rendimento disponível o somatório do rendimento de cada um dos elementos do agregado familiar depois dos descontos para a segurança social e IRS):

- ☐ Até 605€ / mês  
☐ 606€ a 1815€ / mês  
☐ 1816€ a 3025€ / mês  
☐ 3026€ a 4235€ / mês  
☐ Superior a 4235€ / mês

**B2. O rendimento disponível indicado é suficiente para...**

|                                                                                   | Nenhum<br>mês | Poucos<br>meses | Alguns<br>meses | Muitos<br>meses | Todos os<br>meses |
|-----------------------------------------------------------------------------------|---------------|-----------------|-----------------|-----------------|-------------------|
|                                                                                   | 0             | 1               | 2               | 3               | 4                 |
| ... a família viver confortavelmente                                              |               |                 |                 |                 |                   |
| ... pagar água, eletricidade e/ou gás                                             |               |                 |                 |                 |                   |
| ... comprar bens essenciais (por exemplo, carne, peixe, legumes, papel higiénico) |               |                 |                 |                 |                   |
| ... comprar roupas e calçado                                                      |               |                 |                 |                 |                   |
| ... comprar e/ou realizar atividades educativas e/ou culturais                    |               |                 |                 |                 |                   |

**C. Agregado familiar**

**C1.** Contando com a criança, quantas pessoas fazem parte do agregado familiar? \_\_\_\_\_

**C2.** Quem são as pessoas que fazem parte do agregado familiar (parentesco em relação à criança)?

- ☐ Mãe ☐ Irmã (Quantas? \_\_\_\_\_)  
☐ Pai ☐ Avós (Quantos? \_\_\_\_\_)  
☐ Irmão (Quantos? \_\_\_\_\_) ☐ Outro (Quem? \_\_\_\_\_)

**C3.** No total, quantas crianças fazem parte do agregado familiar? \_\_\_\_\_

Outras informações que considere importantes:

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## Attachment 2

### Portuguese version of the MCQ

#### QUESTIONÁRIO DE MUSICALIDADE PARA CRIANÇAS

| Em relação a esta criança, por favor indique com uma cruz (X) a categoria mais apropriada:                                        | Discordo<br>Totalmente<br>1 | Discordo<br>2 | Nem discordo<br>Nem concordo<br>3 | Concordo<br>4 | Concordo<br>Totalmente<br>5 |
|-----------------------------------------------------------------------------------------------------------------------------------|-----------------------------|---------------|-----------------------------------|---------------|-----------------------------|
| 1. Tem ouvido musical, i.e., reconhece melodias e progressões tonais                                                              |                             |               |                                   |               |                             |
| 2. Consegue reproduzir bem melodias                                                                                               |                             |               |                                   |               |                             |
| 3. É capaz de interiorizar sons, altura tonal e ritmo                                                                             |                             |               |                                   |               |                             |
| 4. Tem boas competências auditivas, por exemplo, para melodias e ritmos                                                           |                             |               |                                   |               |                             |
| 5. Tem uma boa memória para padrões                                                                                               |                             |               |                                   |               |                             |
| 6. Tem bom sentido de tempo e de ritmo                                                                                            |                             |               |                                   |               |                             |
| 7. Tem um bom sentido de pulsação                                                                                                 |                             |               |                                   |               |                             |
| 8. É capaz de detetar padrões quando dança ou faz música                                                                          |                             |               |                                   |               |                             |
| 9. Consegue seguir a estrutura da música que ouve e fala sobre isso                                                               |                             |               |                                   |               |                             |
| 10. Incorpora ativamente a música na sua vida                                                                                     |                             |               |                                   |               |                             |
| 11. É capaz de reagir ao <i>mood</i> de uma melodia                                                                               |                             |               |                                   |               |                             |
| 12. É capaz de se mover em sincronia com a música                                                                                 |                             |               |                                   |               |                             |
| 13. Consegue reagir de forma criativa, emocional e intelectual quando ouve uma peça musical                                       |                             |               |                                   |               |                             |
| 14. Gosta de ter música na sua vida, como executante ou como ouvinte                                                              |                             |               |                                   |               |                             |
| 15. Gosta de música e aprecia sons                                                                                                |                             |               |                                   |               |                             |
| 16. Mostra abertura quando aborda e experimenta as diferentes formas de música                                                    |                             |               |                                   |               |                             |
| 17. Aprecia diferentes estilos musicais                                                                                           |                             |               |                                   |               |                             |
| 18. Reconhece diferentes estilos musicais (e.g., música infantil, pop, música clássica)                                           |                             |               |                                   |               |                             |
| 19. Tem consciência sobre diferentes aspetos da música, sendo possível falar com ele/a sobre isso                                 |                             |               |                                   |               |                             |
| 20. Gosta de ouvir música e consegue descrevê-la com palavras e gestos                                                            |                             |               |                                   |               |                             |
| 21. Aplica critérios para avaliar música                                                                                          |                             |               |                                   |               |                             |
| 22. É capaz de ouvir, comparar e distinguir diferentes tipos de música                                                            |                             |               |                                   |               |                             |
| 23. Consegue cantar uma melodia ou ritmo simples ou tocá-los com um instrumento                                                   |                             |               |                                   |               |                             |
| 24. Tem boa coordenação motora                                                                                                    |                             |               |                                   |               |                             |
| 25. Toca música com sentimento                                                                                                    |                             |               |                                   |               |                             |
| 26. Percebe as emoções ou sentimentos transmitidos pela música que ouve                                                           |                             |               |                                   |               |                             |
| 27. Consegue comunicar com os outros através da música, produzindo sons, ouvindo, improvisando, dançando e compreendendo a música |                             |               |                                   |               |                             |
| 28. Consegue expressar emoções perceptíveis para o ouvinte quando canta ou toca música                                            |                             |               |                                   |               |                             |
| 29. Fazer música em grupo motiva-o/a, seja para cantar, tocar instrumentos em conjunto, ou mover-se ao som da música de outros    |                             |               |                                   |               |                             |
| 30. Consegue inventar melodias ou ritmos, seja com a voz ou com outro instrumento                                                 |                             |               |                                   |               |                             |
| 31. Gosta de espontaneamente produzir música ou sons musicais                                                                     |                             |               |                                   |               |                             |
| 32. É criativo quando faz música                                                                                                  |                             |               |                                   |               |                             |
| 33. Conjuga várias competências: tem ideias musicais e procura implementá-las                                                     |                             |               |                                   |               |                             |
| 34. É capaz de produzir ou reproduzir música                                                                                      |                             |               |                                   |               |                             |
| 35. É capaz de combinar audição e produção sonora                                                                                 |                             |               |                                   |               |                             |
| 36. Tem uma grande diversidade de competências musicais                                                                           |                             |               |                                   |               |                             |
| 37. Ouve enquanto faz música para verificar se o resultado é o pretendido                                                         |                             |               |                                   |               |                             |
| 38. Tem interesse por música                                                                                                      |                             |               |                                   |               |                             |
| 39. Quer fazer música frequentemente                                                                                              |                             |               |                                   |               |                             |
| 40. Tem motivação para fazer música, de forma a tornar-se progressivamente mais competente                                        |                             |               |                                   |               |                             |
| 41. Tem um grande entusiasmo pela música                                                                                          |                             |               |                                   |               |                             |
| 42. Tem vontade própria ao ouvir e fazer música                                                                                   |                             |               |                                   |               |                             |
| 43. Gosta de se ocupar com a música                                                                                               |                             |               |                                   |               |                             |
| 44. Prefere expressar-se através da música, do que de outras formas                                                               |                             |               |                                   |               |                             |
| 45. Tem uma grande afinidade por música                                                                                           |                             |               |                                   |               |                             |
| 46. A música tem um significado especial para ele/ela                                                                             |                             |               |                                   |               |                             |
| 47. Os sons absorvem-no/a completamente                                                                                           |                             |               |                                   |               |                             |
| 48. Consegue expressar-se através do som                                                                                          |                             |               |                                   |               |                             |
| 49. Consegue ouvir atentamente e reagir de forma apropriada à música                                                              |                             |               |                                   |               |                             |