Multidimensional measurement of exposure to music in childhood:
Beyond the musician/non-musician dichotomy
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Abstract: Much research in music psychology characterizes the music background of its participants in a dichotomous manner, labeling participants as 'musicians' and 'non-musicians' or professionals and non-professionals. However, this terminology is inconsistent from study to study, and even more sophisticated measures fail to accurately represent music experiences; Moreover, there is no standardized measures suitable for use with younger participants. This paper presents a new measure, the Exposure to Music in Childhood Inventory, for capturing the amount and type of exposure to music activities suitable for use with children. Children from public and private school, aged 5-to-13 years old (*n* = 1006; mean 8.36 years old, standard deviation 1.5 years) completed the inventory, and through a combination of exploratory and confirmatory factor analysis a two-factor solution was obtained. The first factor includes personal music listening activities, home musical environment and the influence of television and the internet; the second reflects more social, active and public elements of music-making, playing an instrument and performing. This scale is suitable for use in a wide range of future research to more accurately assess the kinds of music activities children have access to in a dimensional way which can have a bearing on their understanding of music.

The process of quantifying a person's exposure to music may involve different facets of experience, represented by a multidimensional construct comprised of domains such as listening, instrumental practice, and composing. Consequently, measuring exposure to music appropriately is a complex task. In studies with both adult and child participants, musical experience is typically reduced to two groups: *musicians* and *non-musicians*. Researchers match participants (or groups of participants) on age and other socio-demographic variables and investigate group differences on cognitive tasks (Moradzadeh, Blumenthal & Wiseheart, 2015), neurophysiological measures (Musacchia, Strait & Kraus, 2008; Jantzen, Howe & Jantzen, 2014), or brain imaging modalities.

The first challenge in this approach is how to measure musical experience. Many studies measure years of formal training (Hanna-Pladdy & Gajewski, 2012). While the resultant continuous measurement has the potential to be correlated with behavioral or biological data, typically it is used more simply to create two dichotomous groups of musicians and non-musicians. Furthermore, the way this variable is classified is somewhat arbitrary. For instance, Hanna-Pladdy and MacKay (2011) created two groups of musicians: those with low (1-9) or high (>10 years) experience with music, while Smayda et al. (2015) defined their non-musician group as having fewer than 3 years of group or private music lessons. Other authors define musician participants as those currently studying at a conservatoire and engaging in a certain amount of practice (Burggraaf et al., 2013).

Another issue to be considered is how training is defined, especially during childhood where music might be experienced in many different contexts, such as musical activities as part of the school syllabus, formal training in conservatoires or music schools, and informal musical experiences at home. In many parts of the world, including Brazil where this research was

conducted, music is included as a compulsory subject in the curriculum for children for at least some of their school years. Going beyond the classical tradition also poses problems in terms of definition: 'professional' is typically used in studies of adult jazz musicians (Donnay et al., 2014; Limb & Braun, 2008) and freestyle rap musicians (Liu et al., 2012), although with different definitions. For example, both Donnay et al. (2014) and Limb and Braun (2008) defined their population *as proficient/highly skilled in jazz piano* with no description of amount of exposure across the life span, while Liu et al. (2012) considered professional experience to be performing in front of an audience or recording projects for public consumption and receiving payment for this work.

Irrespective of the challenges of ways of measuring, categorizing participants into two dichotomous groups provides a limited perspective on the concept of musicianship (see Rickard & Chin, 2017), is not good practice statistically, and leads to a loss of data (Royston, Altman & Sauerbrei, 2006; Maxwell & Delaney, 1993). Some tools have been developed to assess adults' musical background in a more multidimensional manner. For example, Müllensiefen et al. (2011; 2014) developed a multidimensional measurement instrument to assess self-reported musical skills, testing a general population from a large Internet sample ($n = 147,636$). Müllensiefen's Goldsmiths Musical Sophistication Index (Gold-MSI) consists of 38 items grouped into five subdomains as well as an overall general factor of musical sophistication, as indicated by high inter-factor correlations. The subdomains are: activity engagement (9 items), perceptual abilities (9 items), musical training (7 items), emotion (6 items) and singing abilities (7 items). In a similar manner, the MUSEBAQ, a comprehensive and modular instrument for assessing musical engagement in adults, consists of three modules evaluating musicianship (formal and informal music knowledge, music capacity, and music preferences; Chin & Rickard, 2012; Rickard et al., 2015).

In terms of factor structure, in both these approaches the use of confirmatory factor analysis is mentioned but no fit indices are presented for the model solution. Moreover, while the analytic approaches of principal components analysis and classical testing theory are applied in the validation process, neither of these are statistical models and therefore prohibit testing of falsifiable assertions about the properties of a scale (Raykov & Marcoulides, 2011; Steyer & Eid, 2012; Zimmerman, 1975). Neither the MUSEBAQ nor the Ollen Musical Sophistication Index (Ollen, 2006) present construct validity (obtained via confirmatory factor analysis and other techniques derived from a structural equation approach) and as a consequence the underlying structure of the items cannot yet be evaluated. Moreover, coefficient alpha is commonly reported across these studies, yet this index of internal consistency is only meaningful and accurate following two assumptions which are commonly not met. These are: a) alpha is only reliable for unidimensional tests, questionnaires or scales: if the measurement model is theoretically developed to evaluate different dimensions (as described above in all cited tests and inventories), the use of alpha is inadequate; and b) each item must be correlated uniformly and highly with its relevant dimension (Raykov, 1997).

Childhood is a very important stage in neurodevelopment where the neural bases of emotional regulation are established, and during middle childhood (from six to twelve years old) the brain is actively undergoing synaptic pruning (Mah & Ford-Jones, 2012). In such a fluid life stage, a dichotomous categorization of musician/non-musician is unlikely to be very informative, although this is typically used in many studies of children's musical understanding. Formal training and informal experiences seem to have different effects at different stages in

development, and teasing out their relative contributions is far from simple (Lamont, 1998). Furthermore, a more continuous measure such as amount of training is also potentially limiting, given that infants and children can show rapid change after short amounts of training. For instance, six months of music engagement results in differences in neuropsychological outcomes for infants (e.g., Gerry, Unrau & Trainor, 2012), and similarly short periods of musical training can have significant consequences on the functional organization of the developing brain, enhancing pitch discrimination abilities in speech (Moreno et al., 2009; Santos et al., 2007).

Hence, for children and young people, rather than categorizing groups based on whether the participant plays an instrument or counting amount of musical exposure, it is important to create tools to capture exposure to a broad range of musical activities and exposure to music in everyday life, especially going beyond traditional formal music education and the classical tradition. Given the potential consequences of early exposure to music on a range of cognitive and behavioral domains, tools with good psychometric properties are needed to evaluate the impact of musical activity on neurodevelopmental trajectories within a younger population. Therefore, one might hypothesize that musical exposure is a dimensional rather than a categorical phenomenon, wherein the extremes are normally marked as musician vs. non-musician.

Where might such exposure originate? Exposure to music begins before birth, with evidence for infants 'learning' familiar music based on prenatal exposure that can set down long-lasting musical memories, as demonstrated through the phenomenon of transnatal memory (e.g., Partanen, Kujala, Tervaniemi & Houtilainen, 2013). The home provides the first most influential context for music exposure, with parents (particularly mothers) using music in caregiving routines around the world (Tafuri, 2008; Trehub et al., 1997). Young children are also exposed to a great deal of music: Lamont (2008) found 81% of 3.5-year-olds' waking hours were accompanied by music in some form, with television, film and multimedia providing most of this. Early years education settings also include many different forms of musical activity, both active and passive. Informal exposure to music takes place in the family and amongst friends throughout childhood, with children's music listening being shaped by other family members in different ways and music-making often combining the activities of listening and recreating music (Green, 2008; Marsh & Young, 2016). At school, most children around the world experience music in a formal manner with music chosen by teachers and typically engage in more structured and separate musical activities such as listening, singing, performing, improvising and composing (O'Flynn, 2010; Green, 2008). School often provides other opportunities for engaging with music such as choirs, dramatic productions, and so on. As indicated earlier these more formal types of music training during sensitive periods in development can have significant effects. For instance, Steele et al. (2013) found formal music training before the age of seven may have measurable effects on brain structure.

Research has begun to capture the type of music exposure that children may experience, but each study tends to do so in its own terms, leading to a serious lack of comparability. A more systematic approach as advocated above has been attempted for parents' observations of younger children's musical experience (aged 5 years and below) by Valerio, Reynolds, Morgan & McNair (2012), finding that a single factor provided the best fit to the kinds of music-related behaviors the children experienced. However, there are no existing measures suitable for children's own reports of their music behavior and experiences through middle childhood and adolescence. The aim of the current paper is thus to create an inventory for children's exposure to music experience in everyday life as a measure to capture the amount and type of exposure they have to music. The

principle behind developing this inventory is to generate a multidimensional assessment in order to control and model these effects in future studies, providing a validated questionnaire, which allows us to go beyond the musician/non-musician dichotomy.

Method

The Exposure to Music in Childhood Inventory (EMCI)

Fourteen categorical items (dichotomous and ordinal items) with different categories of response are presented in Table 1. They were developed to include the informal listening activities which take place at home (including engagement with technology and media) and the formal music activities (at school/social project where music is taught). Music has been part of the compulsory curriculum in Brazil since 2008 (Mas & Narita, 2011), and most music education is Western classical in orientation, whether in a formal or non-formal setting (Arroyo, 2001).The first six items cover access and availability to different forms of music including more conventional playback equipment (record player, radio) and newer forms of technology (iPods, internet downloads), interest and exposure to popular music television programs such as The Voice, and the importance of listening in children's lives. Two further items addressed extent of attendance at music events as an audience member, at school and at public events. Two items asked about family influence: whether parents sing to the child and whether anyone plays a musical instrument at home. The final section of four items asked about the child's own involvement in practical music-making (singing, playing, having formal lessons, and involvement in performance opportunities). As observed in Table 1 (column three), the more exposure to music-making environments, the higher the scores.

The items were developed by the authors in English and then translated into Portuguese by two Brazilian musicians and one psychologist with experience of music interventions in childhood.

Sample size calculation

This study's sample came from a wider project designed to assess and validate a battery of music perception (MP) skills among children and young people (Barros et al., 2017). Because the battery consists of 80 items evaluating seven compositional features (contour, timbre, meter, pitch, scale, duration, and loudness), in order to adequately estimate the parameters of the music perception items we considered at least 10 participants per observed indicator variable (i.e., the 80 items) as a rule of thumb for an adequate lower-bound sample size calculation (Nunnally, 1967), resulting in at least 800 children.

Table 1 – Exploratory factor analysis results (* = statistically significant p values for the factor loadings (adopted level of significance was 0.05)

Items	Questions	Type of Answer/Scores	One factor	Two factor			Three factor		
Item 1	Do you have technology at home (radio, CD, record player, television) to listen to music?	Yes=1/No=0							
Item 2	Do you have any personal device which allows you to listen to music? (MP3, cellphone, iPod)	Yes=1/No=0	0.387*	**0.449***	0.031		**0.506***	-0.040	-0.025
Item 3	Do you download music from the internet?	Yes=1/No=0	0.578*	**0.706***	-0.112		**0.752***	-0.222	0.005
Item 4	How much time do you spend listening to music?	None=0, A little=1, Sometimes=2, Often=3, 4=All the time	0.518*	**0.487***	0.178		**0.341***	0.013	**0.346***
Item 5	Do you watch The Voice?	Never =0/ Rarely=1/ Sometimes=2/ Always=3	0.436*	**0.540***	-0.015		**0.572***	-0.101	0.017
Item 6	Do you watch Esquenta? [a TV show which includes music from the suburbs (favelas). Both The Voice and Esquenta are aired at prime time on TV by Globo - the largest broadcasting TV station in Brazil.]	Never =0/ Rarely=1/ Sometimes=2/ Always=3	0.301*	**0.421***	-0.151		**0.443***	-0.219	0.012
Item 7	In the last year, did you attend any musical event offered by your school?	Yes=1/No=0	0.415*	-0.040	**0.598***		-0.011	**0.628***	-0.064
Item 8	In the last year, did you pay to see any live music event? (funk, concerts, any international band)	Yes=1/No=0	0.377*	0.330*	0.144		**0.376**	0.103	-0.040
Item 9	Do your parents sing to you?	Never=0/ Rarely=1/ Sometimes=2/ Frequently=3/ Always=4	0.480*	**0.404***	0.206*		**0.312***	0.097	**0.198***
Item 10	Does anybody at home play a musical instrument?	Yes=1/No=0	0.415*	0.354*	0.155		**0.495***	0.177	-0.147
Item 11	Do you play an instrument?	Never=0/ I used to=1/ currently=2	0.695*	0.334*	**0.666***		0.342	**0.642***	0.005
Item 12	Have you ever taken music classes (at school, any social project, private schools)?	Never=0/ I used to=1/ currently=2	0.709*	-0.006	**0.920***		-0.027	**0.960***	0.020
Item 13	Do you sing?	Not at all=0/ a little=1/ sometimes=2/ often=3/ all the time=4	0.531*	0.395*	0.288*		-0.012	-0.007	**1.052***
Item 14	Have you ever sung in any presentation at school, in your community or any event?	Never=0/ I used to=1/ currently=2	0.662*	0.193*	**0.619***		0.030	**0.535***	**0.290***

School selection

A stratified random sample of 14 elementary schools was chosen from a pool of São Paulo State's districts and cities where the first author had prior agreement with the Department of Education to collect and conduct research. The cities included were São Paulo, Jacarei, Marilia, and Mogi das Cruzes. Thirty-five per cent of private schools were invited to participate, and this number was over-sampled in order to provide invariance. The number of private schools was oversampled almost twice as much compared to the official student enrollment reports from 2014 from São Paulo State where 18.6% of the schools in those districts were private. Based on the list of schools from the Department of Education of the four cities, a stratified random sample of schools was selected; if school principals were unwilling to participate, another school was selected.

Selection of children

Fourteen schools were invited to participate. In each school, one teacher was instructed on how to randomly select 14 students per grade, from first to fifth, using www.random.org, returning on average 70 children per school. Teachers, nominated by the school principals, evaluated the children on the MP test. Based on the school's enrolment list for each grade, five working days were allowed for the students' parents to return informed consent about their selected child's participation in the research. If there was no interest in participating or no return of informed consent, another child was selected using the same process to replace them. This method of random selection without any inclusion/exclusion criteria was used to maximize generalizability and representative sampling of the MP spectrum and in terms of music exposure. Table 2 shows the distribution of the population in terms of demographic features, by gender and type of school (private and public).

Table 2 – Sex distribution across grades and type of school

School type	Grade	Sex Female	Male	Total
Private	First Grade	32	31	63
	Second Grade	28	31	59
	Third Grade	33	30	63
	Fourth Grade	36	16	52
	Fifth Grade	32	29	61
	Total	161	134	295
Public	First Grade	77	62	139
	Second Grade	72	69	141
	Third Grade	67	63	130
	Fourth Grade	90	71	161
	Fifth Grade	86	54	140
	Total	392	319	711

Statistical analysis

Exploratory and confirmatory factor analysis (EFA and CFA, respectively) were employed to elucidate the underlying dimensional structure of the EMCI. A random sample of 458 children was selected for the EFA procedure and the remaining sample used for CFA. Because the items are ordinal, Mplus's default estimator known as weighted least squares mean- and variance-adjusted (WLSMV; Muthén & Muthén, 2012) was used; the magnitude of factor loadings has been shown to be more precisely estimated under this kind of estimator (Beauducel & Herzberg, 2006). Due to cluster structure (i.e., children nested in schools), the standard errors and chi-square test of the model fit took into account this non-independence using the implementation method proposed by Asparouhov (2005, 2006).

For EFA, items with factor loadings (represented by λ) lower than 0.4 related to all the explored factors were considered to be poorly correlated with those factors, thus indicating a poor content/correlation with such factors. It is important to note that we adopted a more conservative approach than the circulated guidelines, which consider a loading larger than 0.3 to be relevantly correlated to the factor (Raykov & Marcoulides, 2012), so here we adopted a more restricted cutoff of 0.4 to create a very short scale with highly relevant items to capture dimensions of music exposure. Oblique rotation (GEOMIN) was used. EFA is a useful multivariate statistical technique used to determine the number of continuous latent variables (domains) necessary to explain the correlations between a set of items. Some statistical rules of thumb are commonly used to help decide on the number of factors to be extracted: a number of eigenvalues greater than one and a ratio between the first eigenvalue and the second eigenvalue higher than 3 would indicate unidimensionality (Embretson & Reise, 2000). In addition to these statistical indicators, interpretation of how the items of the questionnaire group together to form the factors will depend on reasonable theoretical interpretation. Although some statistical solutions may indicate a good solution, they might be untrustworthy due to the absence of a fair underlying proposed theory. Therefore it is fundamental to consider theoretical issues while deciding on the best underlying factorial solution. Because the EMCI items were developed based on two hypothetical domains – informal listening activities at home and formal music activities at school/social projects where music is taught – we would expect these domains to emerge in the factor structure. However, via EFA it will be possible to concatenate how the items are grouping and to link solutions to different theories. For example, North and Hargreaves' (2008) globe model of music opportunities identifies a formal/informal dimension and a statutory (school)/elective (home) dimension, with a further distinction between specialist and generalist activities. Hargreaves, Marshall and North (2003) identified outcomes of music education (which could equally be applied to music exposure) as falling into the three domains of musical-artistic, personal, and social-cultural. These kinds of typologies might be reflected in our analysis.

For CFA, conducted on the remaining sample of 548 children, as the name suggested, we attempted to confirm the best solution from the EFA analysis.

The following fit indices were used to evaluate the model fit for both EFA and CFA: chi-square, comparative fit index (CFI), Tucker-Lewis Index (TLI), root mean square error of approximation (RMSEA), and weighted root mean square residual (WRMR). For both the CFI and TLI, values near or below .90 were considered inadequate. For the RMSEA, values less than .08 and .06 were considered, respectively, as indexes of reasonable and optimal fit to the data. For WRMR values near or below .90 was considered adequate (Marsh, Hau & Wen, 2004). The adopted statistical significance level was 0.05.

Results

EFA

From the sample of 458 children, the first pass revealed that Item 1 "Do you have technology at home [radio, CD player, television] to listen to music?" had a perfect correlation with other two items, Item 9 "Do your parents sing to you?" and Item 13 "Do you sing?" due to bivariate empty cells. Therefore, Item 1 needed to be excluded. Table 1 shows the solutions from one to three factors. Five eigenvalues were greater than 1, but a solution with five dimensions is not theoretically parsimonious nor even justifiable because only two items loaded onto a factor is a very weak assumption. Indeed, there is no strong evidence for unidimensionality, as the ratio between the first eigenvalue and the second eigenvalue is lower than 3 (ratios higher than 3 are indicative of unidimensionality). The two-factor solution was promising. The fit indices for this solution were: $\chi^2_{(53)} = 80.034$, $p = 0.0096$; RMSEA = 0.033 (90% confidence interval [CI] = 0.017 to 0.048), Cfit = 0.974; CFI = 0.920; TLI = 0.882. Interpreting the factor structure, the majority of items in the first factor were related to personal, at-home music listening and technology/equipment (items 2-6) and whether parents sing or not, while the second factor comprises more external and social music playing and performing activities (items 7, 11, 12, and 14). Items 8, 10, and 13 did not exhibit factor loadings according to our cut-offs (i.e., higher than 0.4) in either of the two factors. Thus these were excluded. After this exclusion and rerunning of the model, all the fit indices improved markedly as expected because the model became more parsimonious as follows: $\chi^2_{(26)} = 33.031$, $p = 0.1612$; RMSEA = 0.024 (90% CI = 0.000 to 0.047), Cfit = 0.974; CFI = 0.975; TLI = 0.957; SRMR = 0.044. The correlation between personal and social music activities was weak and not statistically significant ($\rho = 0.210$, $p = 0.1627$).

CFA

A sample of 548 children was used to fit the CFA model, returning good fit indices for the ten remaining items: $\chi^2_{(34)} = 45.160$, $p = 0.0955$; RMSEA = 0.024 (90% CI = 0.000 to 0.042), Cfit = 0.994; CFI = 0.940; TLI = 0.920. Then, the EFA two-factor solution was confirmed. Compared to CFA, the correlation between the two factors was higher ($\rho = 0.463$, $p < 0.001$). Figure 1 shows the confirmatory model with the two dimensions of personal and social music activities. Factor loadings (represented by λ) and their respective standard errors (in parentheses) were estimated. Figure 2 shows the distribution of raw scores, where the y-axis is the frequency of the participants and the x-axis shows raw scores ranging from 0 to 21, where 0 represents very low music exposure to musical activities and 21 represents someone with a great deal of exposure selecting the highest response categories for each of the ten items. This is a simple sum of the 10 remaining items in the confirmatory model. The exposure factor has a minimum observable value of 0, a maximum of 21, mean = 8.66 (95% CI = 8.41 to 8.92), standard deviation = 4.07, skewness = 0.257, and kurtosis = -0.365.
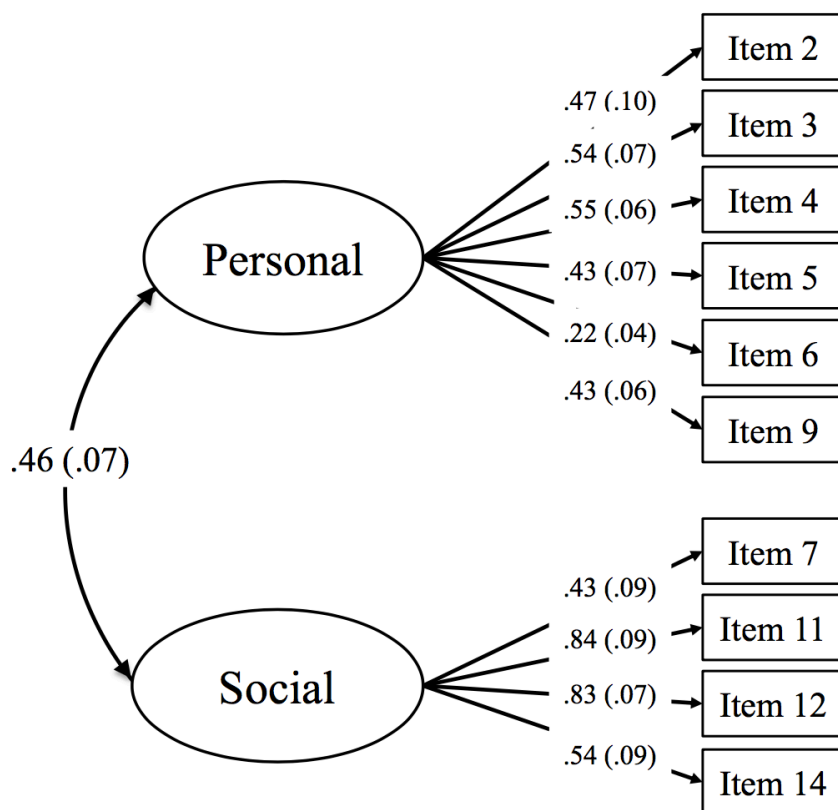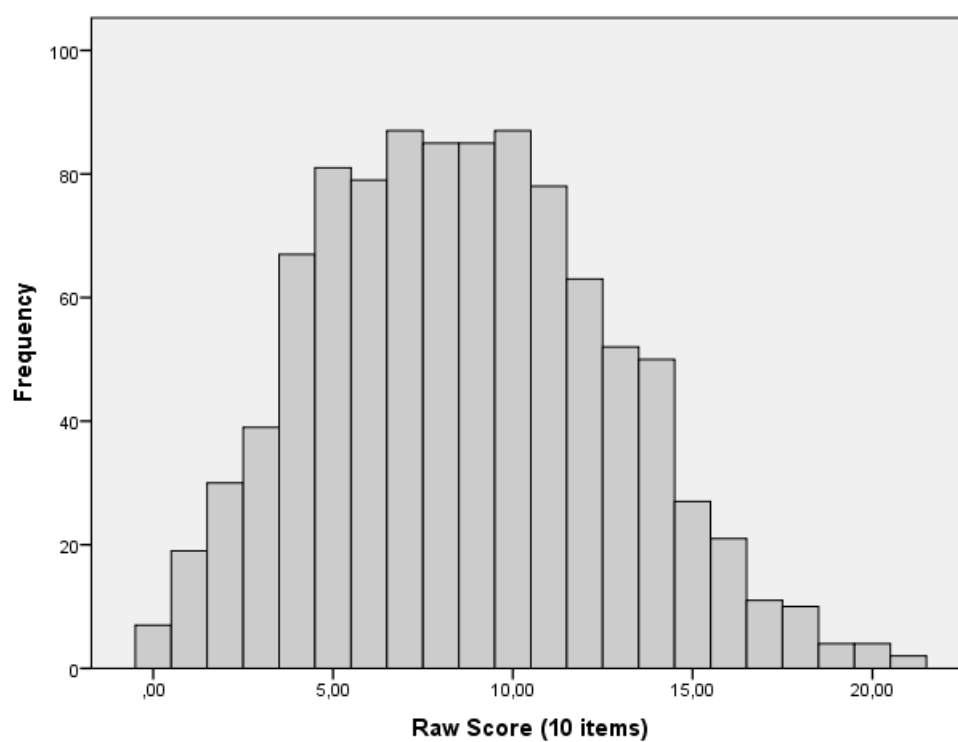
Figure 1: Confirmatory factor analysis of EMCI model.

Figure 2 – Histogram of the EMCI scores

Discussion

This paper has presented a multidimensional representation of exposure to music in childhood. By dimensional representation we mean that there is evidence underlying these items that exposure to music is a continuum, and approaching this as a dichotomy obscures the whole spectrum of exposure between the extremes of complete lack of exposure to music on the one hand and immersion in musical activity on the other. The two dimensions in our proposed EMCI model reflect two different underlying kinds of music experience: the personal and the social. It is important to note that, as a model, this is a representation of a type of phenomenon. There is no true model/correct model. The fit indices, as the name suggests, provide an indication of how our model fits the data. With a different theoretical orientation and with different data where items may group statistically in other ways, other models and representations of music exposure in childhood may be necessary.

Moreover, in other contexts and populations, such as with adults or in different parts of the world, the current model might not fit so well and items might need adapting or adding. As noted earlier, in Brazil music was introduced as a compulsory curriculum subject at school in 2008 when Law 11.769 was signed, and prior to this there had been inequalities of access to music education (Mas & Narita, 2011). Nine years after the implementation of the law, our results show a positive skew (skewness = 0.257) in the score of exposure to music in childhood, indicating that this inequality in terms of music exposure still exists. Such an imbalance might be observed due to a concentration of children scoring below the mean, and furthermore the distribution of exposure is not normally distributed. Given the representative and random sample this suggests that regardless of the law, there are still students experiencing low levels of musical exposure. Items in the EMCI such as "Do you have any personal device which allows you to listen to music? (MP3, cellphone, ipod)" and "Do you download music from the internet?" could be intrinsically related to family socio-economic status. However, only 15.1% of the explained variance in EMCI scores is due to the type of school (public vs. private), an indicator of socio-economic status of the children's family. Therefore, the skewness on EMCI scores might be a sign of a continuing inequality of music exposure which has nothing to do with socio-economic status.

The items with the highest factor loading (strongest correlations with the factor) on the social factor are items 11 ("Do you play a musical instrument?") and 12 ("Have you ever taken music classes?"; $\lambda = 0.84$ and $\lambda = 0.83$, respectively). While these could be read as similar to questions commonly posed to participants in other studies, being broad proxies of length of time learning, there is no explicit wording focused here on *formal* learning of music in terms of the kind of classical/traditional training provided by music schools and conservatories. Previous research has not provided any statistical evidence for these items being related to a single latent factor, but our data show that both items are the best indictors for this kind of social, external experience of music; they are the most reliable as they have the highest factor loading values. Therefore, we provide content validity and convergent validity for the most commonly used items to access this kind of exposure, which we call the social, external factor.

In addition to this more commonly used external source of information, our model also includes an inward, personal dimension. Although this has lower factor loadings than the external social factor, loadings on the personal dimension are statistically significant with a moderate effect size (around 0.4). For the internal factor, items 3 ("Do you download music from the internet?") and 4 ("how often do you listen to music?") were the highest.

Together these ten indicators offer a new opportunity to measure exposure to music beyond the categorical and dichotomous view of musician/non-musician. The explored and confirmed two-dimensional model presented here provides a way of measuring musical experiences and musical training in a continuous way generating a score by summing 10 items easily answerable by the children. This score might be used in future research to reliably test the dose-response effects of such musical exposure on different outcomes ranging from academic achievement to neuroimaging studies. With this dimensional perspective, we are going beyond classifications of participants on the extremes (musicians vs. non-musicians), positioning them on a likely spectrum (score) of amount of exposure. Moreover, each domain captures different content of music experience, one personal, the other social, thus providing finer-grained measurement of how and where musical activities might occur. As noted at the outset different models have been proposed to assess music exposure, particularly with adults; however, a lack of strong methodological and analytical details about the process of exploration/confirmation via robust structural equation modeling approach of the hypothesized domains is a typical limitation of existing work. The EMCI has shown good psychometric features in terms of construct validity, and the content of the items reflects existing theory (thus having high content validity). The fact that most factor loadings range from moderate to high indicates reliability of the items, suggesting they are capturing moderate to high levels of common variance (common information between the item and the latent factor). However, as discussed earlier, the model underlying our items will not necessarily fit other contexts and populations (e.g., adults), especially as some items might operate differentially in other cultural contexts.

Researchers interested in using EMCI scores simply need to sum the type of response (0, 1, 2, 3, or 4) for each item used in the final confirmatory model. Note that not all items in Table 1 were used in the confirmatory factor model (Figure 1), being scores ranging from 0 to 21. Although the model is multidimensional (two dimensions), a simple summed score is still recommended. Gustafsson and Åberg-Bengtsson (2010) recommend the use oftotal scale scores (simple summed or raw scores), and findings of multidimensionality do not guarantee that subscales (such as the personal/internal and social/external scales found here) provide meaningful and reliable information about subdomains beyond that contained in the general construct (exposure tomusic in childhood). As the literature in psychometrics has shown in over 50 scales measuring different psychological constructs (Rodriguez et al., 2016), using subscales is neither reliable neither viable.

Linking our results back to existing theory, the division between personal and social dimensions of music activities relates well to Hargreaves et al.'s (2003) model of outcomes of music education. What is missing from that model in our data is any influence of performance skills as a separate dimension, but our factors incorporate the personal elements that result from personal music listening and engagement (mood regulation, aesthetic sensitivity, and emotional expressiveness) and also the social elements from external activities (group performance and communication with audience, teamwork and co-operation).

Conclusion

The EMCI allows researchers to investigate exposure to music activities in childhood in a dimensional sense. This fills an important gap in the existing literature, which despite exhortations from statisticians (Maxwell & Delaney, 1993; Royston et al., 2006) still tends to rely on dichotomous classifications of 'musicians' and 'non-musicians' based on intuitive but arbitrary categorizations of varied measures such as years of training or types of formal education or professional practice. The current inventory thus provides a simple yet multidimensional way of measuring children's musical exposure which includes exposure to multimedia, the internet, and television alongside more conventional elements of family background and activities at school.

Funding

Ethical Approval

Ethical approval for this project was given by the Ethics Committee of the Federal University of São Paolo (CAEE: 00751812.3.0000.5505).

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