Does awareness of musical structure relate to general cognitive and literacy profile in children with learning disabilities?

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Background in clinical neurology/neuropsychology. In the past few years, increasing interest has been expressed in the aetiology and neurobiological factors of language and literacy difficulties experienced by children and a great research effort has been devoted to establish explicit classification criteria and effective identification procedures for individuals with learning disabilities (LD). Besides IQ measures, identification procedures usually focus on problems with oral language, writing, arithmetic, verbal memory, subtle motor dysfunction, hemispheric specialization, attention deficits and other emotional and personality disorders.

Background in music psychology. Recent research has provided growing evidence that specific problem areas for children with various types of learning disabilities, especially dyslexia, may also affect perceptual, cognitive and motor mechanisms that underlie the processing of aspects of melodic and rhythmic structure in music-related behaviour.

Aims. The aim of the present work is to investigate the relation between standardized nationally-normed measures of IQ / literacy skills and sub-skills underlying basic musical tasks in primary school children diagnosed as LD. Our concern in selecting the particular assessed types of music behaviour and designing the response methodology was to outline children's awareness of musical structure, both through listening and performance tasks, given their limited musical experience.

Method. A sample of 21 children with learning disabilities aged between 7- 12 years was recruited sequentially from the Lab of Developmental Pediatrics (Hippocrates Hospital of Thessaloniki, Greece). All participating children were assessed individually with the use of two standardized and nationally-normed test batteries that screen verbal and non-verbal intelligence, Greek vocabulary and cognitive ability. Besides, a recently revised short version of the Musical Aptitude Tests (Overy et al., 2003) was also given.

Results. Calculated significance of differences and effect size between the assessed sample of children and control data revealed the prominence of musical timing skills as an area of particular difficulty for children with learning disabilities. Interestingly, rhythm copying acuity showed relatively strong correlations with the WISC III-total IQ, the WISC III-verbal IQ, the WISC III-similarities and the WISC III-vocabulary, while melody discrimination sensitivity showed only a moderate correlation with the *AthenaTest*-memory for shapes.

Conclusions. Despite the fact that observed variability of children's performance among various subtests was relatively large, these significant correlations we observed, are in support of previous findings and imply a potential link between language processing and processing of structural aspects of music, mainly rhythm-related ones.

Learning Disabilities (LD) is a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities. These disorders are intrinsic to the individual, presumed to be due to central nervous system dysfunction, and may occur at any time along the life span. Problems in self-regulatory behaviours, social perception, and social interaction may co-exist with learning disabilities but do not constitute a learning disability per se. Although learning disabilities may occur concomitantly with other handicapping conditions (for example, sensory impairment, mental retardation, serious emotional disturbance), or with extrinsic influences (such as cultural differences, insufficient or inappropriate instruction), they are not the result of those conditions or influences (Definition of the National Joint Committee on Learning Disabilities as reported in Hammill et al., 1981). A distinct disorder is the *Attention Deficit Hyperactivity Disorder (ADHD)* which although is not a learning disability in itself, it is very common among people with learning disabilities and usually leads to school failure. Therefore, it is studied together with the other disorders that belong to the previously mentioned group. The syndrome is characterized by serious and persistent difficulties in at least two of the following specific areas: attention span, impulse control and hyperactive behaviour (Rack, 2005).

In the general group of learning disabilities we can find several major types of disorders that underlie language and literacy difficulties experienced by children. Namely: *dyscalculia* is a specific disorder that involves profound difficulties with mathematics, usually accompanied by problems in understanding basic concepts like place value, difficulties in handling money and problems with sequencing. *Dysgraphia* is a writing or fine motor skills deficit. Children with dysgraphia may have illegible writing with inconsistent spacing and capitalization, despite giving appropriate time and attention to the task. They may have great difficulty thinking and writing at the same time. Finally, *dyslexia*, also referred to as specific reading disability, is a developmental disorder of reading that is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unrelated to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede the growth of vocabulary and background knowledge (International Dyslexia Association, as reported in Beitchman & Young, 1997). From the previously mentioned types of learning disorders, dyslexia, is the most common one (Protopapas & Skaloumbakas, 2007). Estimates of its incidence range from 5% to 8% of Greek-speaking school-age children (Theofanidis & Fitsioris, 2007).

The precise aetiology of dyslexia remains the focus of considerable research and debate, but it is clear that both genetic and environmental factors play a role in its clinical manifestations. The most common form of dyslexia is associated with deficits in verbal memory, language and phonological coding (ability to explicitly recognize individual phonemes in words), suggesting the involvement of the left hemisphere (Rumsey, 1992). A particular difficulty with temporal processing of rapidly presented stimuli has also been identified in verbal and non-verbal tasks (Miller-Shaul, 2005; Boets et al., 2006). Besides, a subgroup of dyslexics exhibit visual perceptual deficits, but therapies aimed to improve perception are unsubstantiated. Additionally, a multiple sensory system involvement as well as differences in reading deficits between adults and children has been reported (Hairston et al., 2005; Osmon et al., 2005). Dyslexic patients may also have impaired balancing skills, low-level sensory and motor learning deficits, and cerebellar dysfunction. In sum, there is a strong consensus among investigators in the field that deficiency within a specific component of the language-processing system -the phonologic module-underlies dyslexia, but considerable debate still goes on among researchers on the question whether rapid temporal processing deficits seen in dyslexics is sufficient for explaining poor phonological representation in the brain, which in turn produces the reading disorder (Galaburda, 2001). In Greece, the procedures that are followed in order to diagnose children with learning disabilities usually involve state-accredited service providers (child mental health agencies or Centres for Diagnosis, Assessment, and Support). Besides general IQ tests such as the Greek edition of the WISC-III, only a few nationally-normed test batteries that assess domain specific factors (such as for example phonological processing) are yet available in the field. However, most diagnosticians use qualitative means of assessment based on their personal experience (Protopapas & Skaloumbakas, 2007).

The term *awareness* is frequently used in primary speech and language development research literature to denote an emerging knowledge or perception of fundamental aspects of spoken language (e.g. phonological awareness, rhyme awareness) that have been recognized to be crucial in the achievement of alphabetic reading ability. In the same sense, *awareness of musical structure* is used in this study to denote a state of having knowledge or perception of critical aspects of melodic and rhythmic structure in music. In typically developing preschool and primary school children without any formal musical training that ability is mainly seen as the product of enculturation into the surrounding culture, which takes place without any self-conscious effort or direction and reflects their semiconscious understanding of pitch/temporal organization in music.

Over the last two decades, a rapidly growing body of interdisciplinary research, especially neuroimaging studies, has provided further support on the idea that music and language processing in humans shares a considerable amount of neural resources (Zatorre et al., 2002). Interestingly, it also appears that the human brain, at least at an early age, "does not treat language and music as strictly separate domains, but rather treats language as a special case of music" (Koelsch & Siebel, 2005). More recent research has focused on the question of whether rapid temporal processing difficulty seen in dyslexics is associated with difficulties they experience with music-related skills, especially with musical timing skills. As an extension of that hypothesis, specific forms of musical activities have also been tested and suggested as tools for preventing or remediating language-learning impairments.

A small number of previous studies that investigated the performance of children with learning disabilities as compared to typically developing ones have demonstrated a potential link between language/literacy-related subskills and music-related ones. In a series of studies, Overy and co-workers (Overy, 2000; Overy et al., 2003) used a battery of musical aptitude tests (MATs), which were designed specifically for use with dyslexic children, to assess a great variety of skills amongst dyslexic children and age-matched controls including measurements of rhythm skills, meter skills, rapid skills and pitch skills. Results indicated that perception and especially performance of musical rhythm is an area of particular difficulty for dyslexic children or children with a strong risk for reading difficulties, while pitch skills seem relatively strong. Other, more focused studies on timing and sequencing behavior in children with various types of learning disabilities and unaffected ones revealed that both groups perform equally well in simple rhythm pattern reproduction tasks, but the former display poorer performance with increasing rhythm pattern complexity (see: Tiffin-Richards et al., 2004 for an extended review).

A few studies also looked at the influence of musical training on language and literacy skills in typically developing children using pre-post-training designs suggesting potential links between music-related skills, musical training, auditory processing, language and literacy skills (Anvari et al., 2002; Moritz, 2007), or examining the use of music as a remediation technique for children with learning disabilities (Overy, 2003; see also: Tallal & Gaab, 2006 for a review).

The aim of the present work is to investigate the potential link between standardized nationally-normed measures of IQ/literacy skills and sub-skills underlying basic musical tasks in primary school children diagnosed as LDs. Our concern in selecting the particular assessed types of music behavior and designing the response methodology was to outline children's awareness of musical structure, both through listening and performance tasks, given their limited musical experience. It must be stressed that the current stage of this study has a rather exploratory character, since no related research has been performed yet in Greek-speaking populations of primary school children with learning disabilities. Obviously, this study may be considered as a double perspective work; quantitative exploration of relationships between indices of IQ/literacy and musical skills possesses an autonomous value for the detection of potentially causal mutual effects, while at the same time, it steps towards an identification of major "underlying" structures of variables that may be used in applications of parsimonious description of the intelligence-capabilities space, efficient classification, screening, e.t.c.

Method

Participants

During that phase of our work, a sample of 21 children (14 boys, 7 girls) aged between 7-12 years, was recruited sequentially from the outpatient clinic of the Lab of Developmental Pediatrics Hippocrates Hospital of Thessaloniki, Greece. The selection criteria for the sample were based on a clinical investigation by a qualified child psychiatrist or a developmental pediatrician. When applying the DSM-IV criteria (American Psychiatric Association, 1994), 11 of the children were diagnosed as having the core symptoms of dyslexia and 10 as facing a learning disorder other than dyslexia. A summary of children's distribution per diagnosis, grade and sex is shown in Table 1.

		other learning disabilities		dyslexia		Total	
Grade	Mean age (years)	boys	girls	boys	girls	boys	girls
2	7,5		1		1		2
3	8,5	2		2	2	4	2
4	9,6	1		2	1	3	1
5	10,5	3	1	3		6	1
6	11,7	1	1			1	1
	Total	7	3	7	4	14	7

Table 1. Diagnostic data per grade and sex for the assessed sample of children.

Moreover, all parents were interviewed so as a detailed developmental and medical history was completed for each child. It is important to note the difficulty of obtaining fewer cases of children at the lower grades of elementary school, due to the absence of systematic screening procedures for literacy and learning-related deficits in the first elementary levels in the Greek educational system.

Control groups. In the absence of any standardized procedure that measures music aptitude in children populations in Greece, data that were collected from an earlier study through the use of the same music tests (Papadelis et al., 2006) were used as an indication of the mean performance in the assessed music tasks by typically developing children. Thus, two control groups consisted of children in the age range from 6 to 9 years were used: 35 from a music school (MS group) that provides intensive music training (mean age: 7.8 years) and 53 from a state primary school (SPS group) that provides one 35-minute music lesson per week (mean age: 7.5 years).

Materials

Two standardized and nationally normed test batteries were used to screen children's verbal and non-verbal intelligence, Greek vocabulary and cognitive ability:

The adapted and standardized Greek edition of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III)

The WISC, developed by David Weschler, is a battery of tests for 6 to 16 year olds that evaluates intellectual abilities. The Greek edition that was adapted from the WISC-III version (Georgas et al., 1997), consists of two scales, the *Verbal Scale* and the *Performance Scale* which generate a Full Scale IQ score (FSIQ). The Verbal Scale is comprised of six (6) subscales:

1. *Information*. General knowledge questions; evaluates general factual knowledge and long term memory.
2. *Similarities*. Asking how two concepts are alike; assesses abstract reasoning, knowledge of categories and relationships.

3. *Arithmetic*. Arithmetic questions; assesses attention, concentration and numerical reasoning.
4. *Vocabulary*. Questions over the meaning of words; evaluates word knowledge and verbal fluency.
5. *Comprehension*. Questions about common concepts; assesses common sense reasoning.
6. *Digit span*. Sequences of numbers are presented orally and the test-taker is required to repeat them, either as heard or in reverse order; assesses short term auditory memory and concentration.

The Performance Scale is comprised of five (5) subscales:

1. *Picture completion*. Common objects with a missing part are presented and test-takers are asked to identify it; assesses alertness to essential detail.
2. *Coding*. Children copy symbols that are paired with other symbols. Assesses visual motor co-ordination, speed and concentration.
3. *Picture arrangement*. Children must place a series of pictures in logical sequence. Assesses sequential, logical thinking.
4. *Block design*. Children are shown two dimensional red and white pictures of abstract designs and then must assemble a design that is identical to each picture, using three dimensional red and white blocks. Assesses spatial, abstract visual problem solving.
5. *Object assembly*. Children put jigsaw pieces together to form common objects. Assesses abilities of visual analysis and construction of objects.

The "AthenaTest"

The "AthenaTest" is a standardized Greek vocabulary and cognitive ability screening test that is administered individually to children between 5-9 years. In cases of children with LDs it could also be given to older ones (Paraskevopoulos et al., 1999). This psycho educational scale is one of the most widely used standardized batteries for the screening/diagnosis of learning disabilities in Greek children populations and consists of fourteen (14) subscales:

1. *Verbal analogies*. Incomplete pairs of sentences; measures relationships of categories and cognitive ability.
2. *Figure copying*. Copying of 6 geometrical figures; measures visuospatial coordination.
3. *Vocabulary*. Similar to the WISC III – Vocabulary.
4. *Digit span*. Similar to the WISC III – Digit span.
5. *Memory for pictures*. Pictures of common objects are presented in a sequence for 5 seconds and the test-taker is required to put them in order by heart; assesses short term visual memory.
6. *Memory for shapes*. Similar to *memory for pictures*.
7. *Sentence completion*. Children must complete the missing word in a series of 32 sentences; measures word knowledge and verbal fluency.
8. *Word completion*. 32 words are presented with one phoneme missing and the child is required to pronounce the whole word correctly; assesses semantic knowledge.
9. *Grapheme discrimination*. Pairs of pseudo words are presented on a sheet and the child is required to erase the different letters between them; assesses grapho-phonological discrimination.
10. *Phoneme discrimination*. Pairs of pseudo words are presented orally and the child is required to tell whether they are same or different; assesses grapho-phonological discrimination.
11. *Phoneme blending*. Examiner pronounces a sequence of separately spoken phonemes and the child is called to tell the word those phonemes make; assesses grapho-phonological discrimination.
12. *Visual motor synchronization.* The child is required to follow a maze with his pencil without deviations; measures visual motor coordination.

13. *Right – left orientation.* The child must discriminate between the right and left side of his body and other's body; assesses perception of right and left and visuospatial perception.

14. *Lateralization.* The child must accomplish 14 simple tasks by using parts of his body; assesses preference of body side and lateralization.

Measures of musical aptitude. Fundamental rhythm and pitch skills that children typically possess by the age of six or seven (Hargreaves, 1986) were measured and evaluated on the basis of musical aptitude testing, as an indication of children's awareness of musical structure, which in turn is considered to be crucial for emergent full-scale musical perception and performance. Because the majority of currently available test batteries of musical aptitude are reported as being unsuitable for children with learning disabilities (see Overy, 2003 for further discussion), a new test instrument, adapted from the MATs described in Overy et al. (2003), was used. That instrument consists of simplified tests of the MATs adapted by Dr. Overy together with Dr. Papadelis, which were piloted and decided as being appropriate for children with learning disabilities, who may have difficulties concentrating for long periods at a time.

A short description of each test is given below:

1. *Tempo copying (4 test items)*. Four isochronous taps (short bongo drum taps) were presented over computer speakers, and the child copied the pattern by tapping on the computer keyboard space bar. Presentation rates were at 60, 80, 100 & 136 bpm.
2. *Rhythm copying (14 test items)*. Simple rhythm patterns consisted of 3 to 7 taps (short bongo drum taps) were presented at increasing levels of difficulty. After listening to a pattern, the child was asked to copy it exactly by tapping on the computer keyboard space bar.
3. *Rhythm discrimination (14 test items)*. Pairs of simple rhythm patterns were presented, and the child reported whether they were the same or different. This was repeated at increasing levels of difficulty.
4. *Melody discrimination (14 test items)*. Pairs of simple isochronous melodies consisted of 4 notes (piano sounds), limited to pitches within the octave beginning with middle-C, were presented, and the child reported whether they were the same or different. This was repeated at increasing levels of difficulty.

Procedure

The study took place at the Lab of Developmental Pediatrics, Hippocrates Hospital of Thessaloniki, Greece. All tests were administered during two sessions on different days. Each session lasted between 60 and 90 minutes. In the beginning of the first session parents were informed in detail about the whole study and the specific procedure by the first and third authors. Then, children remained in the test room and parents were completed a detailed developmental and medical history of their child as long as they waited outside the room. The first test given in each child individually by a board qualified psychologist (the third author), was the extended form of the Greek version of WISC-III. During the last 10 minutes of this session the child was also assessed in reading, writing and orthography/spelling. In the second session, every child was assessed with the AthenaTest, by the same psychologist (the third author) and a doctor (the first author). During the second session the music tests were also administered on a one-to-one basis by a musician, who had considerable experience with children of that age range. Music testing was performed using a computer-based environment specifically designed by the second author and co-workers for the assessment of fundamental music-related subskills in kindergarten children and primary school children.

Data scoring

Subtest scaled and summary scores were obtained from all the WISC-III and AthenaTest scales according to the procedures reported by the authors. Performance accuracy on rhythm and tempo copying for each test item was derived as follows: The magnitude of deviation of each performed time interval from the original was expressed as an absolute percentage (%) of the original duration. The geometric mean of all individual deviations within each test item was calculated as an index of average inaccuracy of child's performance. Finally, geometric means for all individual items were averaged to produce two overall inaccuracy indices in tempo and rhythm copying tasks respectively. Before statistical analysis, raw scores on rhythm and melody discrimination tests were converted to d' (d prime) scores. This scoring technique provides a bias-free estimate of sensitivity in 2 AFC designs (Macmillan & Creelman, 1991).

Results

In order to compare the performance on the assessed music-related tasks of the LD group against the music school (MS group) and state primary school controls (SPS group) in detail, graphs for rhythm copying, rhythm discrimination and melody discrimination were plotted (Figures 2-4). These graphs present summary statistics for the two control groups (25^{th} and 75^{th} percentiles) combined with a scatterplot that shows the distribution of individual scores for the LD group. Performance in tempo copying is presented in terms of average scores at all different tempi for the three groups of participants (Figure 1), so that data can be directly comparable to related findings from previous studies. Possible significant differences in music performance between the LD group, the State Primary School and Music School controls were also investigated. Due to severe divergence from normality for most of the musical performance variables (within various groups of subjects), we resort to non-parametric tests for the LD vs. SPS group and the LD vs. MS group comparisons.

Indicators of differences in music performance between the LD group and typical controls

Children's performance on tempo copying task was quite variable across different tempi, except for the MS group controls (Figure 1). A pronounced difference occurred only between the Music School controls and each of the other two groups. The Mann-Whitney test showed a significant difference and a moderate effect between MS controls and the LD group ($Median_{LD}$=39.05, $Median_{MS}$=22.64, U=149, p=0, r=-.48). Overall, the LD group scored slightly better compared to the State Primary School controls, but this may have been, in part, due to the relatively large mean difference in age (2.1 years) between those two groups. There was a clear tendency for both LD and SPS groups to perform worse at slow tempi. These results are in accordance with findings reported by Overy and co-workers (2003), as well as, by other studies that have shown the basic timing reactions to be intact in LD groups (Tiffin-Richards et al., 2004).

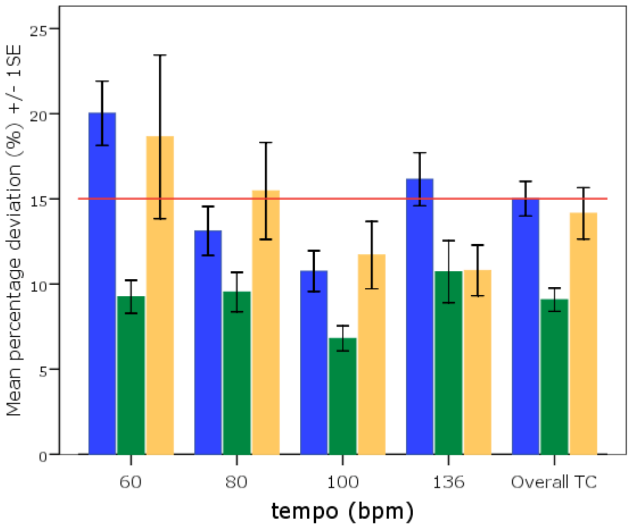

Figure 1. Mean percentage deviations (%) from accurate performance (+/- 1SE) on the tempo copying tests as a function of tempo for the three groups of children. Reference line at 15% indicates a maximum acceptable level of inaccuracy proposed by experienced music educators.
Blue bars: State primary school controls (n = 53)
Green bars: Music school controls (n = 35)
Orange bars: LD group (n = 21)

Performance on rhythm pattern copying showed more pronounced differences between the LD group and both control groups. The distribution of individual scores (Figure 2) presents a pronounced variability in overall performance for the LD group together with a concentration towards values above the 15% threshold. Nevertheless, a percentage of 30% scored equally well compared to the controls, but overall performance of the LD group was significantly worse, compared to both SPS controls

(Median$_{LD}$=45.19, Median$_{PS}$=34.45, U=395, p=.053, r=-.22, mild effect) and MS ones (Median$_{LD}$=41.24, Median$_{MS}$=21.86, U=121, p=0, r=-.56, moderate effect).

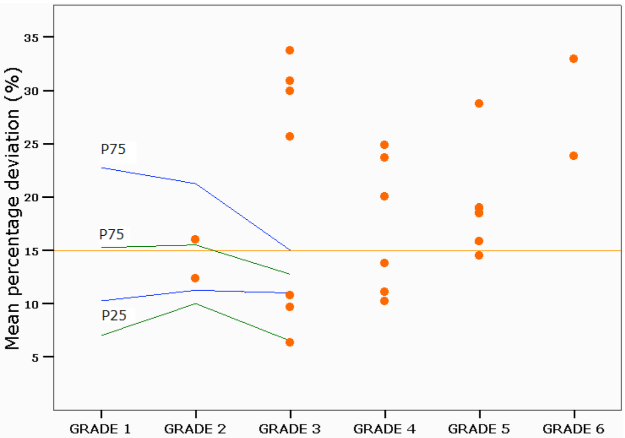

Figure 2. Mean percentage deviations (%) from accurate performance in rhythm copying task (higher values indicate more inaccurate performance). Lines indicate the 25th and 75th percentiles for Music School controls (green line) and State Primary School ones (blue line). Dots present individual scores for the LD group. Reference line at 15% indicates a maximum acceptable level of inaccuracy proposed by experienced music educators.

High variability in same/different discrimination sensitivity was also obtained in both rhythm and melody discrimination tests for the LD group (Figures 3 & 4): scores are widely distributed over almost the entire range of measurement and no apparent indication of improvement with age is obtained.

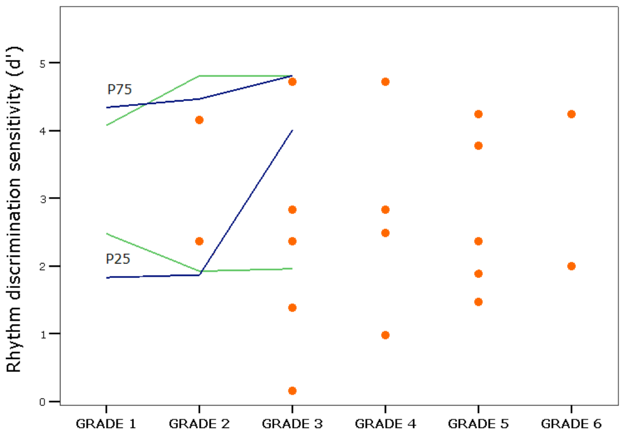

Figure 3. Same/different discrimination sensitivity (d') in rhythm discrimination task. Lines indicate the 25th and 75th percentiles for Music School controls (green line) and State Primary School ones (blue line).

The Mann-Whitney test showed a significant difference and a mild effect between the LD group and both MS controls (Median$_{LD}$=23.66, Median$_{MS}$=33.07, U=267.5, p=.039, r=-.27) and SPS ones (Median$_{LD}$=29.61, Median$_{PS}$=41.48, U=398.5, p=.031, r=-.25) in rhythm discrimination test, but non significant differences were found among groups in melody discrimination performance.

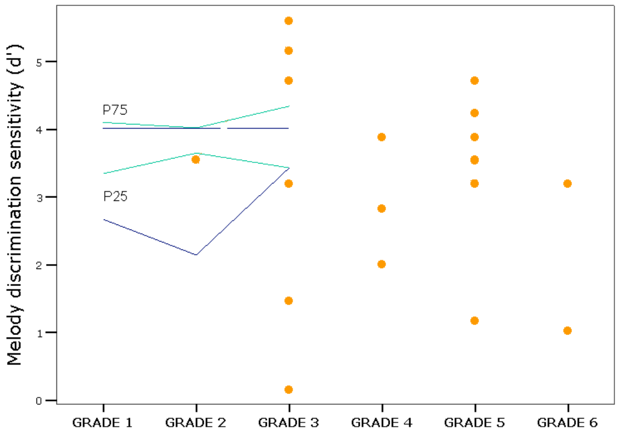

Figure 4. Same/different discrimination sensitivity (d') in melody discrimination task. Lines indicate the 25th and 75th percentiles for Music School Controls (green line) and State Primary School ones (blue line). Dots present individual scores for the LD group.

Indicators of relationship between music awareness and LD

Monotonic relationships between all studied variables were identified using Spearman's rank correlation coefficient. As stated before, special attention was paid to the relationships between the assessed descriptors of IQ/literacy and awareness of music structure. Among the variables describing musical performance within the Learning Disabilities (LD) group (namely Tempo copying, Rhythm copying, Rhythm Discrimination, and Melody Discrimination), Rhythm Copying was the one that mostly correlated with some of the studied IQ/literacy variables. More specifically, a moderate to high-significance relationship was detected between Rhythm Copying and WISC Total IQ (r_s=-.46, p=.032), WISC Verbal IQ (r_s=-.44, p=.015), WISC Similarities (r_s=-.60, p=.007) and WISC Vocabulary (r_s=-.5, p=.017). Melody discrimination also showed a moderate relationship with the AthenaTest Memory for shapes

(r_s=.48, p=.024), while Tempo Copying and Rhythm discrimination did not show any significant correlations. Negative signs in the correlations of Rhythm Copying are due to the nature of the used index (mean copying inaccuracy) for which more accurate performance corresponds to lower index values.

Discussion

Awareness of musical structure in school-children with learning disabilities, indicated by means of assessing fundamental music behaviors such as tempo/rhythm pattern copying and rhythm/melody pattern same vs. different discrimination, were compared to a series of descriptors of children's general cognitive and literacy profile provided by two standardized and nationally normed test batteries.

In sum, calculated significance of differences and effect sizes imply that musical timing skills, mainly those associated with rhythm pattern copying (reproduction), tempo copying at slow musical tempi, and rhythm pattern same/different discrimination may constitute areas of particular difficulty for children with learning disabilities, while melody perception skills seem to remain relatively intact. Also, given the considerable mean age difference between the LD group and both control groups, more pronounced differences might be expected to occur between the LD group and age-matched controls. Similar trends for a group of dyslexics between 7 and 11 years are also reported in Overy et. al (2003) and partly in Tiffin-Richards et al. (2004), who found no significant differences in time reproduction tasks between a sample of children with ADHD and/or dyslexia and age-matched controls, except for the case of increased complexity of the reproduced rhythm pattern. However, it should be stressed that the sample of children assessed by the later consisted of middle school children between 11 and 13 years, which also imply that an improvement in time reproduction skills with age may also had been occurred. Pronounced variability of performance on music related tasks, may lead to the hypothesis that performance, may be highly dependent of the specific subtype of learning disability.

Returning to the hypothesis of potential links between descriptors of awareness of musical structure, indices of general cognitive ability and literacy subskills, a particularly interesting finding was the correlation between rhythm copying and a) WISC-FSIQ, also reported in Overy et al. (2003), b) WISC-VerbalIQ and WISC-vocabulary, which in general, implies the advantage of musical rhythm copying tasks -compared to other types of musical behavior- to screen problem areas in children with learning disabilities.

Conclusion

Despite the growing body of evidence about the potential link between subskills that underlie awareness of musical structure and those that constitute descriptors of the general cognitive and literacy profile in children, the heterogeneity of impaired populations, taken together with methodological inconsistencies in the related research and the frequently-occurring conflicting findings suggest that any obtained causality assumptions should be interpreted cautiously.

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