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The purpose of this study was to examine the relationships among children's aural perception of tonal patterns and children's symbol use in drawing and selection tasks based on tonal information. Children's performances on perception, drawing, and selection tasks were investigated for developmental trends within and across tasks. Sixty-four children, ranging in age from 4 years, 7 months, to 12 years, 8 months, were tested for their performance on aural perception of tonal patterns (PMMA/IMMA), selection, and drawing tasks. A principal components analysis showed perception, selection, and drawing to load on one factor. When factor scores were examined for differences by age with a one-way ANOVA, age was shown to be a significant effect, $F(3, 60) = 7.58$, $p < .001$. *Post-hoc comparisons showed that children at the youngest level differed significantly* ($p < .01$) *from those at the two older levels on the literacy factor, with scores on all tasks and factor score means revealing a linear trend in children's musical development of symbol use.*

Joyce Eastlund Gromko and Allison Smith Poorman
Bowling Green State University

Developmental Trends and Relationships in Children's Aural Perception and Symbol Use

A growing body of research in music has shown that invented notations are measures of children's musical understanding (Bamberger, 1980, 1982, 1991; Davidson & Colley, 1987; Davidson & Scripp, 1988; Gromko, 1994; Smith, Cuddy, & Upitis, 1994; Upitis, 1987a, 1987b, 1990). Studies have shown that, as children develop, their perceptions of musical sound and the invented notations that embody their perceptions of musical sound grow richer in musical detail. Rhythmically, children's invented notations reflect a developmental progression from the perception of steady beat or melodic rhythm of a song, to perception of "figural" musical groupings within a song, to perception of accurate relationships among the temporal durations of musical tones (Bamberger, 1980, 1982, 1991; Davidson & Scripp, 1988; Upitis, 1987a, 1987b, 1990). Tonally, children's invented notations reveal a progression from perception of the high-low contour of a melody, to discrimination of directional leaps and steps within a melody, to perception of functional pitch relationships within a melody (Davidson, McKernon, & Gardner, 1981; Domer & Gromko, 1996; Dowling & Harwood, 1986; Gromko, 1995, 1996a, 1996b). Gromko (1994) found relationships among children's aural perception, singing and playing ability, age, and the sophistication of invented notations. These research findings suggest that a direct relationship exists between children's perception of musical sound and the visual image that they create to represent their perceptions of musical sound.

Although some investigators have examined the relationship between children's perception of musical sound and the visual representations they create, there are comparatively few studies in which they have examined the relationships that exist among children's perception of sound and the efficacy of young children's symbol use in musical writing and reading tasks. In a recent study designed to examine whether children's symbolic representations of rhythm patterns would be different on drawing (writing) and selection (reading) tasks, Adachi and Bradshaw (1995) compared children ($N = 80$) at four different grade levels: kindergarten ($n = 22$), lower elementary ($n = 18$), middle elementary ($n = 21$), and upper elementary ($n = 19$). In the drawing task, children heard a rhythm pattern, produced the rhythm pattern, and then created a visual representation of the pattern. In the selection task, children heard a rhythm pattern and selected one of two graphic representations displayed on a computer screen (e.g., either a figural or a durational representation). The results showed (a) a significant effect ($p < .001$) for grade level by category on the drawing task; that is, significantly more younger children produced drawings in the enactive [the scribbles (marks or loops) that result from the child's "dancing" across the page—they embody the child's action] and iconic categories, and significantly more older children produced drawings classified as symbolic; (b) a significant effect ($p < .001$) for grade level on the selection task, with a significant linear trend ($p < .001$) for grade level from the lowest category to the highest; and (c) a significant difference ($p < .01$) in selection task performance across drawing category, with a significant linear trend ($p < .01$) for drawing category. The authors concluded that the higher the grade level, the more musically sophisticated the children's representations, regardless of task, and that children's abilities to represent rhythms in a selection task outpaced their abilities to draw or create visual representations of rhythm patterns. They suggested, on the basis of their findings, that different cognitive abilities may underlie the tasks of writing and reading musical symbols.

The purpose of this study was to examine the relationships among children's aural perception of tonal patterns and children's symbol use in drawing and selection tasks based on tonal information. This study extends the investigation of Adachi and Bradshaw (1995) into the tonal area; however, the tests in the present study are not modeled directly

Joyce Eastlund Gromko is associate dean in the Graduate College and an associate professor of music education in the College of Musical Arts, Bowling Green State University, Bowling Green, OH 43403. Allison Smith Poorman is assistant to the director of creative arts in the College of Musical Arts at the same school.

on that study's testing procedures. Children's performances on perception, drawing, and selection tasks were investigated for developmental trends within and across tasks.

METHOD

Subjects

Sixty-four children, ranging in age from 55 months (4 years and 7 months) to 152 months (12 years and 8 months), participated in the study. All children were enrolled at a private school that serves as a field and research site for a midwestern state university. The school population reflected the ethnic and socioeconomic demographics of the city that houses the school.

Procedure

Children were tested in six groups, none larger than 15 students, on two separate days of testing. Age in months was calculated from children's birthdays on school records. Aural perception tests were given on the first day of testing, followed by the selection and drawing tasks on the second day of testing.

Aural perception of tonal patterns was measured with a tonal subtest of the Primary/Intermediate Measure of Musical Audiation (Gordon, 1979, 1982). All children working at kindergarten through second-year levels were given the Primary Measure of Musical Audiation (PMMA); children working at third-year through sixth-year levels took the Intermediate Measure of Musical Audiation (IMMA). Because the school places children in music groups according to their singing and playing abilities as well as their keyboard background, one child from the second-year age-group was grouped with third-year children in her math, language, and music learning. She took the IMMA version of the aural perception test with her music group. In all cases, raw scores, with a maximum of 40 possible points, were recorded.

Selection of tonal patterns was measured with a researcher-designed test derived from the PMMA/IMMA aural perception measure. Each pair of the 20 "different" patterns was abstracted directly from the aural perception tonal subtest and used as an item on the selection task. Thus, the selection task consisted of 20 items, with a possible maximum score of 20 points. Before a tonal pattern was played on the soprano recorder, the children were instructed to, "Look at the two patterns: Listen." The pattern was played. "Now, select the pattern that you heard: Circle." The same pattern was played a second time so children could check their answers. For 10 randomly selected items, the researcher played the first pattern from the pair; for the remaining 10 items, the researcher played the second pattern from the pair. The children practiced the task with two written examples. The selection task was a test of children's ability to select the notated pattern that exactly matched what they heard.

Table 1
Pearson Correlation Matrix for Age, Perception, Selection, and Drawing

	Age	Perception	Selection
Perception	.39*		
Selection	.41*	.59**	
Drawing	.50**	.41*	.57**

Note. * $p < .01$; ** $p < .001$.

Drawing of tonal patterns was measured with a researcher-designed test derived from the PMMA/IMMA aural perception measure. Each pair of "same" patterns was abstracted directly from the aural perception subtest and used as an item on the selection task. Because the PMMA and the IMMA differ by the number of pitches on the first six items, these six patterns were used as practice examples. The drawing task consisted of 14 items. Before a tonal pattern was played on a soprano recorder, the children were instructed to "Put your pencil on the black dot that represents the first tone. Listen to the pattern." The pattern was played. The next instruction was "Connect the dots so your lines show the way the tones go. Listen again." The pattern was played a second time. The children practiced the connect-the-dots task as a group using examples written on the blackboard in front of the class, then silently as individuals using the first six items. The second researcher moved about the room to assure that all children understood the task. Items 7 through 20 from the subtest were scored at 2 points each, 1 point for each line that accurately conveyed perception of melodic direction within the tonal pattern, with a maximum score of 28 (only the first three tones of the final four-tone ascending PMMA pattern were used). Only melodic direction was scored.

RESULTS

All data were analyzed with SYSTAT (Wilkinson, 1989). The population mean for aural perception (PMMA/IMMA) was 34.5, $SD = 3.97$. The selection task population mean was 14.45, $SD = 2.52$ (out of 20 possible points); the drawing task population mean was 23.22, $SD = 5.27$ (out of a possible score of 28). A Pearson correlation determined relationships among the variables of age, perception, selection, and drawing. Table 1 shows the matrix of correlations and probabilities. All variables were significantly correlated at or beyond the alpha level of .001.

For the purpose of investigating developmental trends across age-groups, the population was divided into four levels of age that spanned approximately 20 months. A one-way analysis of variance (ANOVA) was conducted for the effect of age on each variable.

Separate one-way ANOVAs showed a significant main effect for age

Table 2
Age-Group Means and Standard Deviations for Perception, Selection, and Drawing

Age in months	*n*	PMMA/IMMA	Selection	Drawing
55–76	17	33.12 (4.64)	13.41 (3.18)	17.82 (3.37)
77–94	16	32.88 (4.56)	13.75 (2.72)	24.19 (4.34)
95–120	15	35.53 (2.59)	14.87 (1.72)	26.07 (2.12)
124–152	16	36.63 (2.36)	15.88 (1.31)	25.31 (1.89)

on aural perception (PMMA/IMMA), $F(3, 60) = 3.91$, $p < .05$; selection, $F(3, 60) = 3.60$, $p < .05$; and drawing, $F(3, 60) = 13.40$, $p < .001$. Age-group means for perception, selection, and drawing are shown in Table 2. Post-hoc tests (Tukey HSD multiple comparisons) revealed the means for the two youngest levels of children on aural perception differed significantly from the mean for the oldest level of children ($p < .05$). Post-hoc tests for differences between selection means showed a significant difference between the youngest level and the oldest level of children ($p < .05$). On the drawing task, the youngest level of children differed significantly from the three older levels of children ($p < .001$).

A principal-components analysis showed perception, selection, and drawing to load on one factor with an eigenvalue of 2.04. Component loadings were 0.88 for selection, 0.80 for perception, and 0.79 for drawing, with the factor explaining 68% of the total variance. When factor scores were examined for differences by age with a one-way ANOVA, age was shown to be a significant effect, $F(3, 60) = 7.58$, $p < .001$. The youngest level of children had a mean factor score of –0.71 ($SD = 1.21$); the second level had a mean of –0.21 ($SD = 0.99$); the third level's mean was 0.38 ($SD = 0.56$); the fourth and oldest level had a factor score mean of 0.61 ($SD = 0.46$). Post-hoc comparisons showed that students at the youngest level differed significantly ($p < .01$) from those at the older two levels on the factor.

DISCUSSION

The results of this investigation show that children's ability to use musical symbols in reading and writing tasks is related to their aural perception of musical sound, and these abilities follow a developmental progression within and across perception, selection, and drawing tasks. Previous research has revealed that invented notations reflect children's musical understandings and, as children's perceptions grow in musical detail, their notations grow in sophistication. The results of the present study support those findings. Furthermore, these results support earlier indications of a developmental link between aural perception and what the child chooses to express in writing about musical sound, and these results extend those findings to suggest a developmental link between the ability to discriminate between short tonal patterns and the ability to use musical symbols for pitch, that is, to select a written version of the perceived pattern and to draw a visual representation of the perceived pattern.

In evidence presented by Adachi and Bradshaw (1995), children's performance on their rhythmic drawing task lagged behind their performance on their rhythmic selection task, leading the authors to suggest that the cognitive abilities that underlie writing and reading rhythmic patterns may be different. However, the scores for the tonal drawing task in this study were better overall than the scores for the tonal selection task. We offer two explanations for the differences in our findings. First, the inherent structure of the drawing tasks in the two studies differed. Adachi and Bradshaw's drawing task, like those in the invented notation studies, was open-ended, offering children relatively less structure for their written expressions than did our task. The inherent structure of the tonal drawing task in this study, a connect-the-dots task, and the short length of tonal information—only three tones—resulted in a task that was feasible for even the youngest children. Secondly, Adachi and Bradshaw's drawing task asked children to invent symbols for rhythmic patterns, whereas in our study, children were asked to draw tonal patterns. Whether the reading and writing of tonal information develops earlier than does rhythmic information, or whether the cognitive abilities that underlie representation of tonal and rhythmic information differ, demands further investigation.

Significant differences were found between the mean for the youngest level and combinations of the upper levels, suggesting a qualitative leap in musical cognitive abilities for children between preschool and elementary school. Despite remarkable individual exceptions within each age-group, with, for instance, the youngest child performing near-perfectly on each task, these results reveal a linear trend in development of literacy. Further research may reveal the reasons for exceptional individual results within age-groups, as well as help investigators better understand the nature of the influences of other symbol systems on the expression and refinement of children's symbol use in music.

The results of this study suggest that common cognitive abilities may underlie aural perception of tonal patterns and children's symbol use. The relationships among the various forms of children's expression of the symbolic function in music (e.g., perception, reading, and writing) indicate that literacy is a complex process that involves the ability to transform detailed echoic images (internal musical images) of pitch into visual images in writing tasks and to recognize echoic images of pitch in the traditional symbols of music. Further research may provide clues as to genetic or environmental influences that prompt expression of children's symbol use.

Developmental psychologists have asserted the importance of multiple representations for thorough understanding (Bamberger, 1991; Eisner, 1994; Gromko, 1996a; Hargreaves & Zimmerman, 1992). Therefore, to draw one's perceptions of musical sound may aid in the ability to read musical symbols. Symbol use may reinforce echoic images encoded during perception of musical sound. The effect of one form of representation on the development of other forms or on the development of musical understanding remains to be shown in experimental research.

All the children in this study enjoyed performing the musical literacy tasks. With children's affects running high in anticipation of end-of-the-year activities, we worried that the students would not focus on the tasks involved in the present study. On the contrary, they seemed to approach the perception, selection, and drawing tasks as captivating mental puzzles to solve or as games. The practice session was critical in that regard; if any children remained confused after they listened to the tonal patterns and responded accordingly, they were encouraged to ask for further clarification or another practice example. Given the relatively small amount of tonal information and the structured nature of the tasks, no child was overwhelmed by the task. In only one case did a young child cry; she was grouped with third- and fourth-year children in math, language, and music learning, and, therefore, was included in their music-testing group. She failed to grasp how to connect the dots during the practice examples, remained silent when a chance was given to ask questions, and, on the first example, let out a gasp that signaled her confusion. A practice example was repeated while a researcher stood nearby and her confusion was cleared up.

We offer the view that a fuller picture of children's musical understanding can be gained by asking children to represent what they know in a variety of ways, including singing, playing, dancing, and composing. We support active musical learning in which every child is engaged. Our results suggest that the perception of musical sound may evoke internal musical images that can be made visual by drawing and that can be recognized in the traditional symbols of music.

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