This study examined first-, third-, and fifth-graders' (n = 73) ability to hear two simultaneous melodies. Two familiar melodies and one unfamiliar melody were used as the stimuli. The pairs of simultaneous melodies were presented in different register and timbre combinations. The children were asked to press specially labeled keys on a computer keyboard to indicate which song(s) they heard. Responses were recorded by a computer. The older children identified two simultaneous melodies faster and more accurately than the younger ones did. While 70% of the first graders reported hearing two melodies and identified them with 75% accuracy, more than 95% of the fifth graders reported hearing two melodies and identified them with 97% accuracy. Children who were able to correctly identify two simultaneous melodies identified the melody in the upper register first significantly more often than the one in the lower register. However, when the melodies were played with contrasting timbres (trumpet and piano), they tended to identify the trumpet melody before they identified the piano melody regardless of register. Children who were only able to identify one melody tended to focus on the upper melody when the timbre was the same in both registers, but when the melodies were played with contrasting timbres, they attended to the trumpet melody regardless of register.

Helga R. Gudmundsdottir

Children's Auditory Discrimination of Simultaneous Melodies

Although music listening and performance involves perceiving simultaneous events, little is known about children's perception of simultaneous melodies. Discriminative abilities in identifying simultaneous events in music, such as melodies and timbres, are not tested in most common standardized musical tests (see Boyle & Radocy, 1987). However, some tests measure the discrimination of simultaneous sounds (Bentley, 1966; Wing, 1961).

Zenatti (1969) found for four-part music that children were more likely to hear the theme in the soprano and alto lines than in the bass line. Other studies show that young children attend more to the upper melodic line than the lower one when presented with two-part music (Imberty, 1969; Zimmerman, 1971). Nevertheless, Costa-Giomi and Pennycook (1994) did not find that young children necessarily attend to the upper melody in two-part music.

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Research has shown that children have difficulty discriminating simultaneous events in music (Bertrand, 1997; Serafine, 1981, 1988). In fact, young children have difficulty focusing on more than one aspect of a musical stimulus at once (Costa-Giomi, 1994a, 1994b; Sims, 1991). Older children can perform complex tasks, such as focusing on relevant information while filtering out irrelevant information, but young children do not display the ability to do so (Doyle, 1973; Maccoby & Konrad, 1966; Sergeant & Roche, 1973).

Serafine (1988) tested children's and adults' ability to recognize two newly learned tone sequences. The subjects responded verbally to the question "Would the melodies sound like this together (or not)?" This proved to be a difficult task even for the adults (73% success) and the 5- to 8-year-olds performed at or below chance level (50% or less). Gudmundsdottir (1995) conducted a similar study with 5-, 7-, and 9-year-olds using longer melodies that were both newly learned and familiar. The children scored significantly higher with the familiar melodies than with the newly learned melodies. In fact, responses to the newly learned melodies were highly inconsistent. While the 9-year-olds were able to identify simultaneous familiar melodies quite accurately, the 5-year-olds tended to identify only the upper melody.

Listening to two melodies may be qualitatively different than listening for one. Research in perceptual grouping and stream segregation has demonstrated that an auditory stimulus is not perceived as merely the sum of its parts. Auditory stimuli are perceived as "streams" that depend on variables such as frequency, pitch, timbre, and loudness (see, e.g., Bregman, 1990; Hartman & Johnson, 1991). For example, in a rapid sequence of tones that are of alternating high or low frequencies, the sounds are organized into two perceptual streams. This "perceptual fusion," however, will not occur if the sequence is played at very slow speed (Bregman & Campbell, 1971). Bregman and Pinker (1978) further found that onset/offset synchrony is an important determinant to simultaneous effects and that tones that seem likely to have come from the same source—such as tones of the same timbre—are most often grouped into the same stream.

The purpose of the present study was to investigate children's ability to hear two simultaneously sounding melodies. The goal was to use complete, tonal melodies of the same length that would sound musical in any paired combination. Comparing differences in performance, such as accuracy, speed, and attention to upper or lower melody, by different age-groups was of particular interest to the researcher.

METHOD

Subjects

Subjects were English-speaking first (n = 29), third (n = 22), and fifth graders (n = 22). These children attended a public school in Montreal and received weekly music lessons by a music specialist.

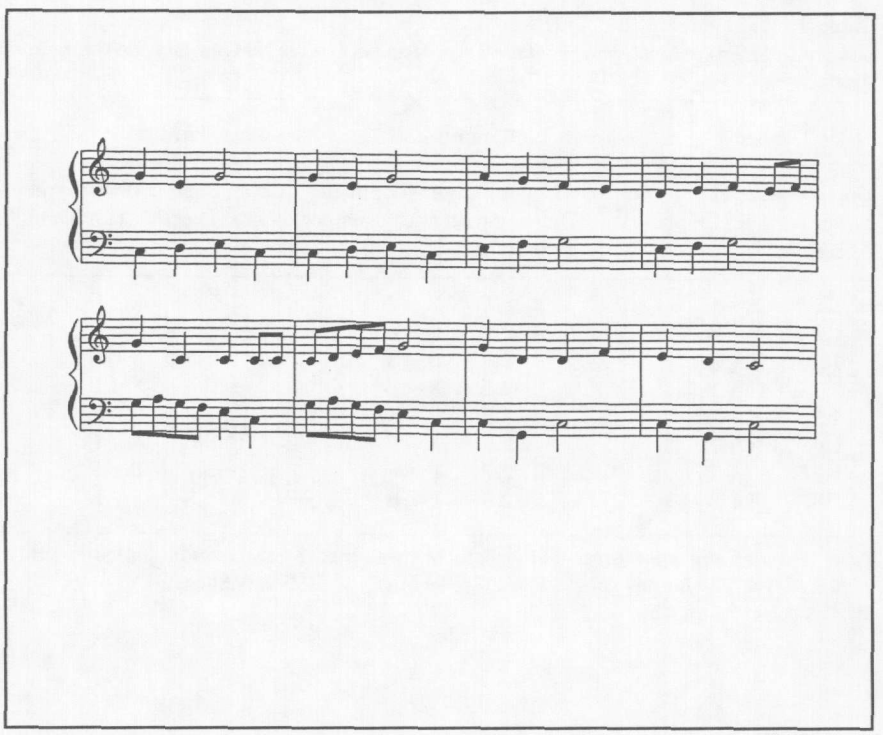

Figure 1. An example of a melody pair in the stimuli. Here the "Barney Song" (B) is in the upper register, and "Frère Jacques" (F) is in the lower register (B + F).

Preparation of the Stimuli

Subjects learned three melodies, two familiar and one unfamiliar. The familiar melodies were "The Barney Song" (B) and "Frère Jacques" (F). The unfamiliar melody (X) was composed for the purpose of this study. All three melodies were of the same length. Two melodies played simultaneously in various combinations made up each test item (Figure 1). The three melodies were combined into six different melody pairs. The melody pairs were played in three timbre combinations: (1) piano/piano, (2) piano/trumpet, (3) trumpet/piano. Each pair was played once in every timbre combination except for pairs (B + F) and (F + B), which were played twice in each timbre combination. Thus, there were eight pairs in each combination and a total of 24 items in the test (Table 1). The timbre combinations were presented in randomized order, and so were the items within each combination. The length of each item was 16 seconds. There were 2 seconds of silence between items. The total duration of the test was 7.2 minutes.

Table 1
Timbre and Register Combinations of the Three Melodies Used in the Auditory Discrimination Test

Timbre 1		Timbre 2		Timbre 3	
Upper register (U): piano Lower register (L): piano		Upper register (U): piano Lower register (L): trumpet		Upper register (U): trumpet Lower register (L): piano	
Item	U L	Item	U L	Item	U L
1.1	B + F	2.1	B + F	3.1	B + F
1.2	F + B	2.2	F + B	3.2	F + B
1.3	B + X	2.3	B + X	3.3	B + X
1.4	X + B	2.4	X + B	3.4	X + B
1.5	F + X	2.5	F + X	3.5	F + X
1.6	X + F	2.6	X + F	3.6	X + F
1.7	B + F	2.7	B + F	3.7	B + F
1.8	F + B	2.8	F + B	3.8	F + B

Note. The melodies were presented in pairs in three timbre combinations and alternating registers. B = "The Barney Song"; F = "Frère Jacques"; X = "Mystery Song."

Apparatus

The stimuli were created using Opcode's *Max* computer software. Two synthesized sounds were used: piano and trumpet. The stimuli were generated by a portable Macintosh computer, connected to a Roland Sound Canvas via MIDI and projected using a Boss speaker with the volume set at a comfortable level.

Procedure

Subjects were tested individually. Each was seated facing the computer with the loud-speaker at one side. Three keys on the computer keyboard were specially marked with stickers, symbolizing the three songs of the stimuli. After a short pretest and training, the subjects were instructed to listen to the stimuli and to press the corresponding key as soon as they recognized a melody. Responses of each subject were automatically stored in a computer file. The computer was programmed with the Max software to record which keys were pressed for each of the items and the time it took for each response by counting the number of beats from the beginning of the melody until each response occurred. When the same key was pressed more than once during an item, only the first response was counted. Pressing of other than the designated keys was not recorded. The children could identify from 0 to 3 melodies, but each test item consisted of only two melodies.

RESULTS

Three randomly selected children from each grade level took the test two times on two different occasions in order to establish the reliability of the measurement. A paired *t*-test performed on first scores versus second scores indicated that the two were not significantly different ($M = -1.44$; $SD = 3.21$; *t*-value (–1.35); $df = 8$; $p = .21$). To further establish this test's reliability, responses to identical pairs were compared. The proportion of identical responses was 81% for Pairs 1 and 7, and 82% for Pairs 2 and 8. The probability of observing these proportions by chance is negligible ($z = 8.3$; $p < .01$).

The number of melodies identified and the proportion of correct responses were counted for each test item. Most children identified two melodies. Very few gave no or three responses. Eighty-three percent of all the items elicited two-melody responses, and 15% of them elicited one-melody responses. The frequency of two-melody responses was highest in Grade 5 and lowest in Grade 1. In the instances of two-melody responses, the proportion of correct responses was high in Grade 5 (97%), lower in Grade 3 (86%), and lowest in Grade 1 (75%). The number of correct one-melody responses was lowest for first graders (95%), higher for third graders, and highest for the fifth graders, whose responses were all correct.

Statistical methods were used to examine the effects of age, gender, and contrasting timbres on the children's success in identifying two simultaneous melodies. The accuracy of responses and the response speed were examined through analysis of variance (ANOVA). The effect of placement in register on the children's identification of melodies was examined using chi-square analyses.

Scores were assigned to each response according to accuracy. The scores increased significantly from Grades 1 to 3 and from Grades 3 to 5 [F (2, 58) = 13.10, $p < .01$] (see Table 2). Scores for items with two familiar melodies were higher than the scores for items with one familiar and one unfamiliar melody [F (7, 406) = 2.69, $p < .01$]. Timbre affected general scores significantly [F (2, 116) = 2.90, $p = .05$] (see Table 3). Two melodies were correctly identified significantly more often with the trumpet sound on the lower melody and the piano sound on the upper melody than with the trumpet sound on the upper melody and the piano sound on the lower melody. While the combination with trumpet on the lower melody elicited more correct responses than the piano/piano combination, this difference was not found to be statistically significant.

Correct two-melody responses and the correct one-melody responses were examined separately. Analysis of the correct two-melody responses showed that the older children (third and fifth graders) responded significantly faster than the younger children (first graders) in terms of the number of beats counted until both melodies were identified [F (2, 772) = 12.803, $p < .01$] (see Table 4). However, there was not a significant difference between grades regarding speed in identifying one melody.

Table 2
Means (M) and Standard Deviations (SD) of All Auditory Discrimination Scores by Grade

Grade 1 (n = 546)		Grade 3 (n = 528)		Grade 5 (n = 504)	
M	*D*	*M*	*SD*	*M*	*SD*
1.48	.58	1.68	.52	1.91	.31

The children who correctly identified two melodies responded significantly faster to items that had two familiar melodies than to items with one familiar and one unfamiliar melody [$F(5, 772) = 5.514$, $p < .01$]. These children identified melodies in the upper register significantly faster than melodies in the lower register ($df = 825$; $t = 4.34$; $p < .01$). Both timbre and register affected the order of identification. The trumpet melody was identified first significantly more often than the piano melody ($df = 2$; $\chi^2 = 120.7$; $p < .01$). When the piano played in both registers, there was a tendency to identify the melody in the upper register first (see Figure 2).

Analysis of the correct one-melody responses showed that the identified melody was more than twice as often the upper melody than the lower melody (Table 5). However, comparison between the three timbre combinations revealed that the lower melody was chosen more often than expected when the trumpet played the lower melody ($df = 2$; $\chi^2 = 27.044$; $p < .01$).

DISCUSSION

This study measured children's ability to attend to two melodies simultaneously. The nonverbal measurement allowed for collecting data concerning the speed and order of identification. As confirmed by statistical reliability measures, the computerized test procedure proved to be appropriate for the age-groups involved.

Table 3
Score Means and Standard Deviations of All Auditory Discrimination Scores by Timbre

Timbre 1 piano/piano (n = 523)		Timbre 2 piano/trumpet (n = 529)		Timbre 3 trumpet/piano (n = 526)	
M	*SD*	*M*	*SD*	*M*	*SD*
1.66	.51	1.73	.49	1.67	.55

Table 4
Response Speed Means and Standard Deviations for Correct Two-Melody Responses by Grade

Grade 1 (n = 198)		Grade 3 (n = 273)		Grade 5 (n = 355)	
M	*SD*	*M*	*SD*	*M*	*SD*
18.30	6.33	16.59	5.70	15.65	5.97

Knowledge of children's ability to attend to numerous aspects of music at the same time is important for the music educator, especially when it comes to group performance. The educator needs to know, for example, at what ages it is meaningful to ask the young choristers to listen for the second soprano or young band players to pay attention to the clarinet line. This study suggests that first graders do not easily hear two melodies playing together, even when both are familiar. Many first graders apparently stop searching when they have identified one melody and insist that there is only one melody playing. By the third grade, the children seem to be more aware that they are hearing two melodies, but still for many third graders, it is hard to correctly identify both melodies. For fifth graders, it is easy to attend to two melodies when at least one of them is familiar. From

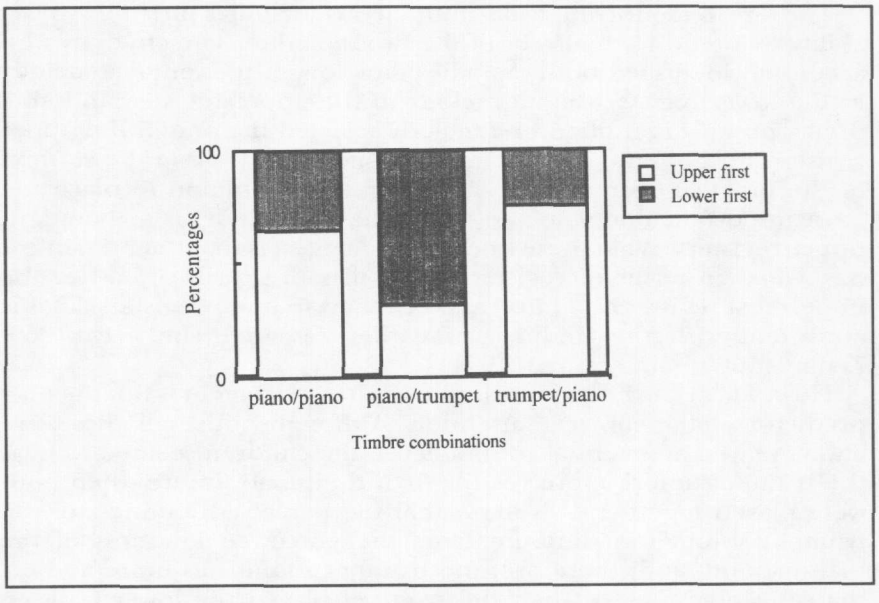

Figure 2. Analysis of correct two-melody responses: Proportion of upper and lower melody identified first by timbre.

Table 5
Analysis of Correct One-Melody Responses: Incidence of Upper and Lower Melody Identified, for the Three Timbre Combinations

	Timbre 1 piano/piano	Timbre 2 piano/trumpet	Timbre 3 trumpet/piano	Totals
Upper	128 (116.8)	65 (86.5)	107 (96.6)	300
Lower	34 (45.2)	55 (33.5)	27 (37.4)	116
Totals	162	120	134	416

Note. Values in parentheses represent expected values.

this study, we cannot tell how well they would have done with relatively unfamiliar melodies, although judging from the research literature in melodic perception (see, e.g., Dowling 1994), it is certain that the use of unfamiliar melodies would have made the task harder.

It is interesting to note that all the children identified one melody at the same speed. The age difference was apparent only in the time the children took to complete the identification of both melodies. This suggests that the presence of a second melody did not seriously distract the younger children's concentration and supports the notion that the young child hears one melody right away but seems to be unable to refocus and listen to the second melody.

The key to identifying two simultaneous melodies might lie in the ability to attend to the lower of the two melodies. The children who accurately identified both melodies took longer to identify a melody in the lower register than a melody in the upper register, and children who only identified one melody selected the one in the upper register most often. These findings are not surprising in the context of the practice of musical composition. It is common to place the most important things in the music, like a melody or a theme, in upper registers. What these findings do suggest is that the human ear has a bias in terms of registers and will more easily attend to the uppermost register of a musical piece than to lower registers. This is consistent with the findings of earlier research (Imberty, 1969; Zenatti, 1969; Zimmerman, 1971).

However, according to this study, register placement is not the only predictor of the subjects' attention. Although both melodies were always played at an equal volume level, the children seemed to hear the trumpet timbre more readily than the piano timbre when both were played together. It is likely that the perceived loudness of the trumpet sound was different from the perceived loudness of the piano sound, and, therefore, the trumpet sound was more audible than the piano, even when the trumpet played the lower register. These findings are important because they indicate strongly that the characteristics of timbre can override the ear's bias for the upper

register. The effect of timbre on children's perception deserves attention in future research.

The results of this study have direct implications for music educators. The results suggest that children in third grade and younger need help to direct their attention to other than the uppermost register of a musical composition. It is probably not enough to familiarize those children with a given theme if it is playing in lower registers. Especially the younger children will ignore even a familiar melody in a lower register when they can hear a melody playing above it. On the other hand, if the lower playing melody is played with a more dominating timbre, even first graders should be able to detect it. Until children are in the third grade, the tendency is to listen for only one melody at a time, which is consistent with findings that reveal young children's difficulty in directing their attention to more than one aspect of music (Bertrand, 1997; Sims, 1991).

The results of this study do not indicate that children who are in the third grade or younger are incapable of performing music with more than one layer in choirs, ensembles, and bands. They are at least able to direct their attention to one line in the music without being distracted by other musical events occurring at the same time, but they are likely to do better if they are performing in the uppermost register. However, it is not until after the third grade that children have acquired the skill to deliberately center their attention on different registers of music, which is the skill that enables musicians to control tuning and the quality of musical performances.

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