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Pitch error analysis of young piano students' music reading performances

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Abstract

This study analyzed the music reading performances of 6–13-year-old piano students ($N = 35$) in their second year of piano study. The stimuli consisted of three piano pieces, systematically constructed to vary in terms of left-hand complexity and input simultaneity. The music reading performances were recorded digitally and a code of error analysis was constructed from the data. The effect of age on the types of errors made was investigated. The age differences found were in terms of error frequency, performance continuity, contour preservation, and stimulus complexity. The study sheds light on what may be typical music reading errors of piano students in their second year of study and suggests some trends of age-related development in music reading among piano students.

Keywords

error analysis, music literacy, music reading, music reading development, piano students

Learning to read traditional staff notation is an integral part of most music education programs within the western musical tradition (Campbell & Scott-Kassner, 1995; Mark, 1996). 'Reading and notating music' constitutes one of the voluntary 'National Standards for Music Education' in the United States (1994). Music reading skills are also emphasized in the UK Associated Board of the Royal Schools of Music curricula and various other curricular documents that refer to western musical traditions. Although music reading skills are not prerequisites for engagement in music or playing an instrument (Green, 2002), and may be irrelevant in the context of many musical styles, this has not changed the fact that success in acquiring staff reading skills continues to serve as one major criterion by which western instrumental music students are evaluated (Mills, 2005).

While some music education programs have reduced the emphasis on music reading skills characteristic of traditional programs, written music continues to frequently serve as a starting point in instrumental music instruction (Mills, 2005; Swanwick, 1994). A notable exception is the popular Suzuki method under which children are taught to read music only at later stages of instrumental study (Suzuki, 1969). The musical material for all mainstream western music education methods,

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including the Suzuki method, uses conventional staff notation. Hence, music reading facility is considered an important skill for a musician to have and even 'necessary for full membership of the musical community' (Sloboda, 1978, p. 4). Although shortcomings in the ability to read staff notation do not exclude an individual from full participation in some musical genres and cultures, music reading skills are obviously valuable for musicians.

Methodological differences in instruction have reflected different opinions on how reading skills should be introduced to music students. However, various methods seem to be mostly based on conventions. A method based on research findings has yet to be proposed, likely as a result of insufficient research on the acquisition of music reading skills. As has been pointed out before, there is a considerable lack of basic theories regarding music reading (Hodges, 1992).

Introduction to music reading traditionally occurs early in life. Recent studies suggest that expert music reading skills must be mastered before the age of 15 (Kopiez, Weihs, Ligges, & Lee, 2006), consequently stressing the importance of understanding how children's natural cognitive development interacts with their mastering of music reading. Studies show that elementary pitch reading skills can be taught to children as young as three or four years old (Capodilupo, 1992; Tommis & Fazey, 1999). As in other studies in music perception, age effects are found in studies on pitch reading. Brotz (1992) found a significant difference in the speed and accuracy between seven and nine year olds in a finger-tapping and pitch-reading task on a piano, and according to Capodilupo (1992), children's ability to retain more complex aspects of pitch reading increased linearly from age four to 10. Apparently, when children have reached an understanding of the correspondence between a notated pitch and a note on an instrument they may still not be able to visually comprehend a notated melody. In one study, first and second graders (six to seven year olds) were more confident reading and playing one pitch at a time than reading pitches in a melodic context (Pick, Unze, Metz, & Richardson, 1982). These results demonstrate how children's cognitive development plays an important role and should be consciously included in the endeavor of understanding the early acquisition of compound skills such as music reading.

Music reading is a complex process involving both reading skills and mechanical skills (Wolf, 1976). Studies find that music reading achievement at a high level is determined by the speed of information processing and psychomotor speed (Kopiez et al., 2006). The reading process requires a decoding of two distinct types of codes entailing the pitch information and the timing information. Behavioral and neurological studies suggest that pitch and temporal information are perceived separately both in a listening situation (Palmer & Krumhansl, 1987) and in a music reading situation (Schön & Besson, 2002; Waters & Underwood, 1999). Because music reading is a construct of processes in music perception (Sloboda, 1976, 1978, 1984), research on music reading depends on investigating the underlying processes of perception. Although pitch and timing cannot be truly separated in a musical event or in a music reading situation, the independence of pitch and timing in terms of perception is useful for the purpose of analysing pitch reading independent of the reading of timing information.

The pitches in a score that appear in a sequence usually represent a melody. According to studies on melodic perception, melodies can be perceived in terms of contour or sequence of intervals (Dowling, 1978, 1982). During the development of melodic perception, the global features of a melodic contour tend to precede the local or analytic perception of specific intervals (Bartlett & Dowling, 1980; Pick et al., 1988; Trainor & Trehub, 1993). And with musical training, global strategies of perceiving melodic contour are replaced by more specific strategies of identifying interval structures (Fujioka, Trainor, Ross, Kakigi & Pantrev, 2004). In the context of pitch reading, the visual perception of pitches and of a melodic line is likely to affect the pitch accuracy in music reading. That is, in a music reading situation, the accuracy of a melody produced is likely to reflect the strategies used to visually comprehend the notation. It is likely that the development of contextual comprehension may affect children's reading of melodies (Pick et al., 1982).

Researchers have suggested that proficient music reading involves a heightened sensitivity to musical structures and understanding of relationships between groups of notes (Sloboda, 1984). Studies indicate that successful sight-reading depends on the recognition of familiar structures such as chords (Salis, 1980; Waters, Townsend, & Underwood, 1998), musical phrases (Sloboda, 1977), and tonality (MacKenzie, Vaneerd, Graham, Huron, & Wills, 1986). The absence of familiar structures results in poorer music reading performances than when these structures are present. Furthermore, Sloboda (1976) demonstrated a parallel between language reading and music reading when he reported the effect of the so-called proofreader's error in adult pianists' sight-reading performances. The best sight-readers in the study played fewer of the errors implanted in the score than did the poorer sight-readers indicating that the experts were reading the score for meaning within the context of the musical piece and thus disregarded erroneous information that did not fit the context.

From language reading literature it is apparent that the fundamentals for successful language reading are essentially the same as in music reading. That is, the ability to perceive context and search for meaningful structures in a symbolic representation is necessary for reader proficiency (Singleton, 2005). The differences between proficient language readers and beginning language readers are reflected in the types of errors they make reading a text (Goodman, 1969). The fluent reader analyses meaning at a deep level and uses this to make predictions about the text during the process of reading and is therefore more likely to make errors that are meaningful in the context of the text. The novice reader is more likely to make errors of decoding single word units, resulting in errors without meaning or non-contextual errors (Goodman, 1969; Laing, 2002). Errors are frequent in complex tasks such as language reading and music reading. The way in which errors are made can be revealing of the processes underlying such tasks. In language reading research, error analysis of the reading performances of novice readers has been an important tool for understanding the development of language reading proficiency (Goodman & Marek, 1996) and for improving language reading instruction (Singleton, 2005).

The existing knowledge on music reading is mostly drawn from studies on expert sight-readers (Edgington, 2006; Goolsby, 1994a, 1994b; Kopiez et al., 2006; MacKenzie et al., 1986; Schön & Besson, 2002; Sloboda, 1974, 1977; Thompson, 1987; Truitt, Clifton, Pollatsek, & Rayner, 1997; Waters et al., 1998) or adult novices (Kostka, 2000; Lowder, 1973). In music reading there is a lack of knowledge of the types of errors made by novices. In order to improve music reading instruction it is important, albeit not sufficient, to understand how experts read. It is of crucial importance to understand how novices read, how they make errors and why they make them. The primary purpose of the present study was to explore pitch reading errors of young piano students and the effect of age on the error making. A secondary objective was to propose error categories that could be useful as a basis for further studies on music reading.

Method

Composition of testing material

Three musical pieces were composed for this study. The pieces were in the same key (C major) and of the same length (eight measures long). The melodies moved by intervals of seconds and thirds and the rhythms contained only eighth notes and quarter notes (Figure 1). In Piece A, the melody alternated between right and left hand, a common style in beginners' piano method books (see e.g., Bastien, 1985; Palmer, Manus, & Lethco, 1995). In contrast to Piece A, Pieces B and C required simultaneous reading of the left-hand and the right-hand staff. The rhythm in Pieces B and C were identical and the melodies had the same number of seconds and thirds. Pieces B and C differed only in terms of left-hand complexity (Figure 1).

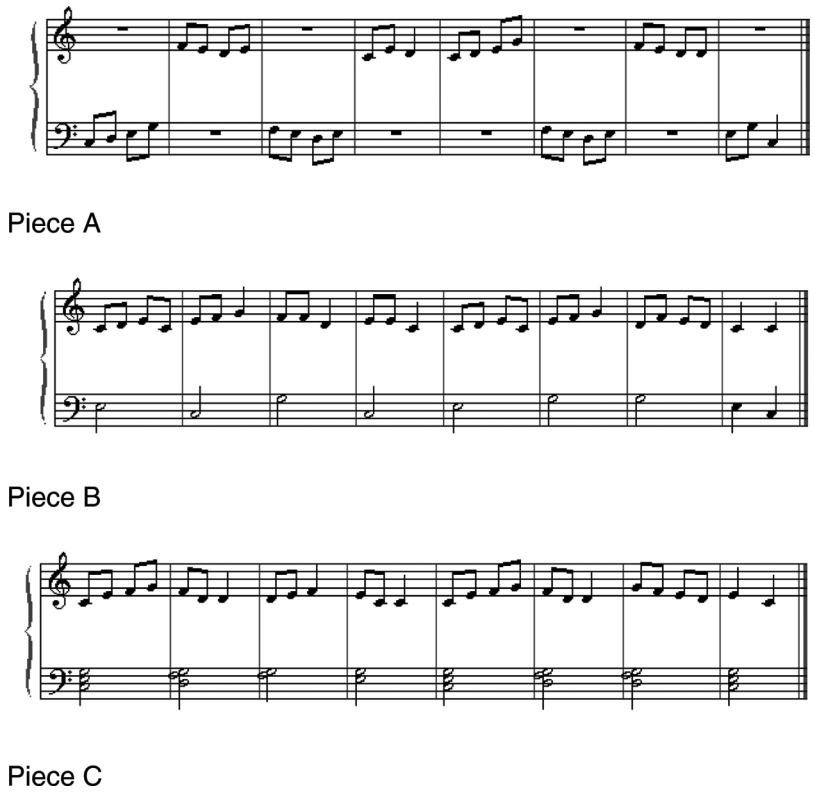

Figure 1. The three musical pieces composed for the study

Subjects

Subjects were recruited through seven piano teachers from two music schools in the Princeton, New Jersey area. The criterion asked for piano students in their second or third year of piano study excluding adults. Forty piano students were tested, but five were not included in the final analysis. Three subjects had studied piano for a longer or shorter period than required by the set criterion and two subjects had to be excluded from the final sample because of technical failures in recording. The final sample consisted of 35 subjects, with age normally distributed in the age range of six to thirteen years.

All of the subjects received a half-hour piano lesson, once a week. The average amount of formal piano training of the children was 23.22 months ($n = 18$, $M = 23.22$, SD = 7.32) for the younger group and 23.00 months ($n = 17$, $M = 23.00$, SD = 6.43) for the older group. The mean age of the entire group was roughly nine years ($M = 9.45$). In order to test the effect of age on the results in this study the sample was divided into two groups according to the age median, Younger: ($n = 18$, $M = 8.22$, SD = 0.88, *range* = 6–9 years) and Older: 2 ($n = 17$, $M = 10.76$, SD = 0.90, *range* = 10–13 years). The number of subjects and age distribution did not justify divisions into more than two comparable age groups. Gender distribution was similar in the two groups (Younger group: females $n = 11$, males $n = 7$; Older group: females $n = 9$, males $n = 8$).

Apparatus and procedures

The children played on a digital piano, connected to a computer via MIDI interface. The performances were recorded using a sequencing software. Recording started automatically at the first touch of a key on the keyboard. The subjects played all three pieces in a random order. There was no metronome or counting off by the researcher. The children played at their chosen pace.

Results

Types of errors

Three basic pitch error types were identified in the children´s performances: Erroneous pitches (pitches that did not match the target pitches in the score), Redundant pitches (correct pitches that were repeated as in hesitation) and Omitted pitches. The most frequent error type was Erroneous pitches (M = 12.14, SD = 12.25, N = 35), the second most frequent error type was Redundant pitches (M = 6.77, SD = 5.20, N = 35), and the least frequent type of errors was Omitted pitches (M = 1.03, SD = 2.80, N = 35).

A Mann-Whitney U test for two independent samples was performed on the frequency of each error type with Age as the grouping variable. The tests revealed significantly more Redundant pitch errors made by the younger group than by the older group (U = 62.5; Z = –3.0; p = .01). No significant age differences were found for the frequency of Erroneous or Omitted pitches.

Contour preservation

The erroneous pitches in melodic parts were analyzed in terms of preservation or violation of melodic contour. Contour preserving pitches were more frequent than contour violating pitches or 76 percent of erroneous pitches.

Mann-Whitney U tests performed on the frequency of contour preserving and contour violating errors with Age as the grouping variable revealed significant differences between the age groups in terms of the frequency of contour violating errors (U = 88.5; Z = –2.21; p = .03). The younger group made significantly more contour violating errors than did the older group. However, the frequency of contour preserving errors did not differ significantly between age groups.

Errors according to left or right hand placement

An Error-count average for all types of errors combined was calculated providing the average number of errors made per note in the score (or per chord as in the case of the left hand in Piece C) in right and left hand of each piece. The Error-count averages take into account the variation in note numbers between parts and are therefore more accurate than actual error frequencies for evaluating differences according to placement in left or right hand (Figure 2). Using a Wilcoxon Signed-Rank Test for each Piece, significantly higher Error-count averages were found in the left hand than in the right hand for all three pieces. More errors occurred on average in the left hand than in the right hand of all pieces. (A: *Mean Rank* = 8.0; *Sum of Ranks* = 80.0; Z = – 2.23; p = .03); (B: *Mean Rank* = 14.25; *Sum of Ranks* = 85.5; Z = – 3.34; p = .01); (C: *Mean Rank* = 12.50; *Sum of Ranks* = 112.5; Z = – 2.83; p =.01.)

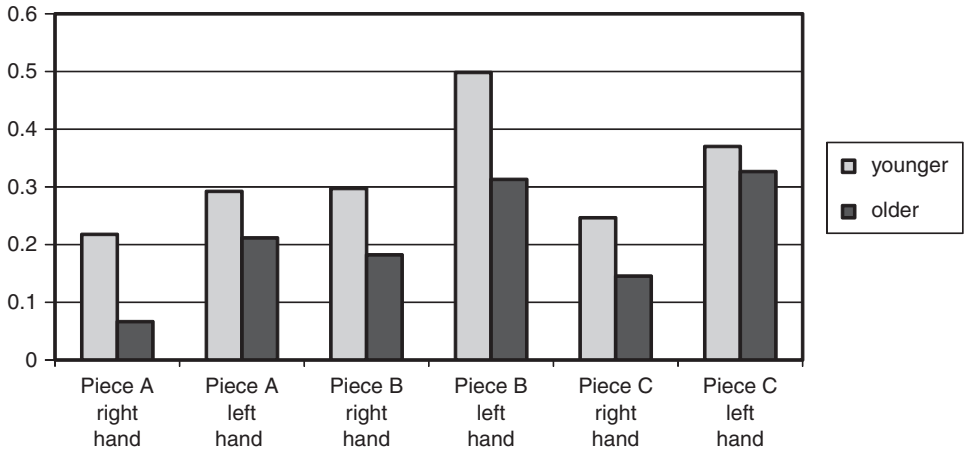

Figure 2. The average error in left and right hand of each piece, i.e., the error count divided with the number of notes in each part

Self-corrections

When an incorrect pitch was followed by the target pitch (i.e., the correct pitch), the error was labelled as 'self-correction'. Counting of self-corrections revealed that nearly a third of Erroneous pitches were subsequently self-corrected (29.88%). In order to test whether there was a significant difference between the age groups in terms of self-corrections, a Mann-Whitney U test was performed for each of the three pieces on the proportion of incorrect pitches that were corrected and that were not corrected with Age as the grouping variable. The results indicated that there was a significant difference between the age groups in terms of self-corrections in Piece C ($U = 88.0$; $Z = -2.24$; $p = .03$). The difference was not significant for Pieces A and B. The significant difference between the age groups in Piece C was because of a higher proportion of self-corrections among the younger children than among the older children (Younger: $n = 18$; *Mean Rank* = 21.61; *Sum of Ranks* = 389.0) (Older: $n = 17$; *Mean Rank* = 14.8; *Sum of Ranks* = 241.0).

Global characteristics of the music reading performances

There were certain trends found in the way the children made errors. In total, out of 105 (3 × 35) performances there were 37 that did not have any added pitches. That is, either all pitches were correct or, if there were incorrect pitches, they were not corrected. Music reading performances with no attempts to correct pitches were over three times more frequent by the older children than by the younger children. The younger children corrected some or all of the incorrect pitches they made in a performance twice as often as the older children did. In contrast, the older children made no pitch errors in twice as many performances as did the younger children.

Discussion

The study confirmed previous findings that capacities in pitch reading skills develop gradually through childhood regardless of formal training (Capodilupo, 1992; Pick et al., 1982). However,

general trends were similar in both age groups in terms of the types of pitch errors made. In both groups, the most frequent type was erroneous pitches and the second most frequent type was redundant pitches, while omitted pitches were few. It is fair to say that the music reading performances were marked by the children's apparent emphasis on playing all the pitches in the score correctly as reflected in the high frequency of redundant pitches as well as in instant self-corrections of pitch errors made and the low frequency of omitted pitches. Furthermore, from this data it is evident that the primary goal for the majority of the subjects seemed to be the playing of pitches at the expense of timing accuracy. These are along the same lines as the findings of Drake and Palmer (2000) who found that young pianists seemed less concerned with timing than with pitch information in a score reading task.

A high frequency of errors was expected in the music reading performances in this study, although little information is found in the research literature on music reading errors of young piano students. There is no indication in the literature of the types of errors to be expected. The present study found that analysis of errors into categories was not only helpful for identifying challenges in a music reading task, but also for comparing error-making trends between age groups.

The age differences found in this study were in terms of error frequency, continuity, contour preservation and stimulus complexity. The younger age group produced more incorrect pitches and made a higher number of redundant pitches than the older age group. More contour violating pitch errors were found in the younger group than in the older group and the complexity of the left hand (in Piece C) or playing both hands at the same time (Pieces B and C) prompted more errors from the younger children than the older children.

Age played a significant role in the children's ability to move the music reading forwards and minimizing hesitation in the performance. Redundant errors, as defined in this study, reflect hesitation in performance. A correct pitch is likely repeated either because one is not sure if the pitch was correct in the first place or because one is unsure of the pitches that follow. Interestingly, the highest frequency of redundant errors occurred among the younger subjects for Pieces B and C where both hands played simultaneously. The frequency of redundant errors was lower in Piece A where left and right hands played alternately. This indicates that the task of reading music in both hands simultaneously could have caused a greater strain on the younger subjects than on the older subjects. The task of music reading is demanding on short-term memory and it has been established that younger children's short-term memory is not as developed as that of older children (Brotz, 1992). The task of reading music on the piano, as compared to other instrumental music reading, has the added complexity of the reading from two staffs in two clefs with both hands. The duplicity of the input as well as the motor output in left and right hand simultaneously is bound to provide challenges for young piano students.

The younger children made significantly more contour violating errors than did the older children. This means that, even when they made errors, the older children were closer to the target pitch than the younger children and tended to preserve the melodic contour. Thus, it can be hypothesized that the visual perception and reproduction of a melody on a staff should follow a developmental trend similar to that found in auditory perception of melodies (Bartlett & Dowling, 1980; Pick et al., 1988; Trainor & Trehub, 1993), the developmental trend being a gradual move from a global perception of melodic attributes towards a more accurate perception and reproduction of precise intervals. Further studies are needed on the strategies used to read melodies and the possible effects of development on these strategies.

A sign of difficulty among the younger children in coping with increased input information was notable in the reading of Piece C, where the children had to read and play a block chord in the left hand at the same time as they read and played a melody in the right hand. This was reflected in a

significantly higher frequency of self-corrected pitches among the younger children as compared to the older children in Piece C only. It seems that not just playing simultaneously with both hands as in Piece B, but also the complexity of playing chords in the left hand, did prompt increased self-correcting behavior in the younger children.

Left-hand inaccuracy was consistent in this study. Across both age groups, significantly more errors occurred on average in the left hand of all three pieces, even for Piece A, where left and right hands alternate. A similar right hand bias in piano students is found in other studies. One study found that college keyboard students produced a higher error rate in left hand than in right hand (Lowder, 1973). Yet another found that young piano students relied on playing the right hand for retrieving the left hand in a memorized piece of music but not visa versa (Parbery-Clark, 2007). These findings suggest that the right hand tends to have a dominating role at least among young piano players and beginners. In a reading task as in the present study it is not clear how much left-hand inaccuracy is because of the alleged secondary status of the left hand in piano playing and how much may be attributed to difficulties in reading the bass clef.

The present study sheds light on what may be typical music reading errors of piano students in their second year of study and indicates some of the developmental trends to be expected in piano students at different ages. The findings need to be replicated, confirmed and extended in future studies for the purpose of creating a reliable knowledge base on the challenges of reading music, because, when obstacles have been identified in music reading, the next step is to overcome them and therein lies the key to improvement of music reading instruction.

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Abstracts

Analyses d'erreurs de fréquences et de performances en lecture musicale chez de jeunes élèves pianistes

Cette étude vise à analyser les performances en lecture musicale chez des élèves âgés de 6 à 13 ans en deuxième année de piano (N = 35). Trois pièces pour lesquelles la main gauche variait en complexité et en simultanéité des données ont été utilisées en tant que stimuli. Les performances en lecture musicale étaient enregistrées de façon numérique et un code d'analyse d'erreurs a été conçu suite aux des données recensées. Les effets de l'âge sur la catégorie d'erreurs ont été examinés. La différence d'âge s'est manifestée dans les erreurs de fréquences, la fluidité de l'interprétation, la préservation du contour et la complexité du stimulus. Cette étude met en lumière, d'une part, les erreurs types en lecture musicale chez les élèves en deuxième année d'étude du piano. D'autre part, cette étude permet d'observer des tendances associées à l'âge et le développement lors de la lecture musicale des élèves.

Análisis de los errores de altura en la lectura musical de jóvenes estudiantes de piano durante sus interpretaciones

Este estudio analizó la capacidad de lectura musical de 35 estudiantes de segundo de piano de entre 6 y 13 años. El estémulo fueron tres piezas de piano sistemáticamente construidas para variar la complejidad de la mano izquierda y la simultaneidad de acciones a realizar. Las interpretaciones se grabaron digitalmente y a partir de los datos se codificaron para analizar los errores cometidos. Se investigó el efecto de la edad en cada tipo de error, encontrándose diferencias en la frecuencia de los mismos, la continuidad de la interpretación, el mantenimiento del fraseo, y la complejidad del estémulo. El estudio arroja luz sobre lo que podrían ser los errores más usuales en la lectura musical al piano en estudiantes de segundo y sugiere algunas líneas de desarrollo de la lectura musical en función de la edad.