Evaluating new approaches to teaching of sight-reading skills to advanced pianists

Dr Katie Zhukov, School of Music, University of Queensland

k.zhukov@uq.edu.au

Abstract

This paper evaluates three teaching approaches to improving sight-reading skills against a control in a large-scale study of advanced pianists. One hundred pianists in four equal groups participated in newly developed training programs (accompanying, rhythm, musical style and control), with pre- and post- sight-reading tests analysed using custom-made software that provided four scores on accuracy: two on pitch and two on rhythm. Mixed-design ANCOVAs were used to analyse the performance data, showing improvement in one rhythm and one pitch variable for each of the training groups and progress in pitch for the control group. The results suggest that training does develop various aspects of sight-reading and that additional sight-reading activities enhance post-test performance. The curriculum combining all three teaching strategies is being currently trialled. Future research needs to focus on instruments other than piano to formulate generic approaches to teaching of sight-reading skills.

Keywords: sight-reading, advanced pianists, experimental design, software for analysis of performance.

Introduction

Just as literacy and fluency in reading text are central to success in academic achievement, so then musical literacy and fluency in reading music are central to being able to engage in the study of Western Classical music in higher education. Better sight-reading improves the rate of learning new music (Lehmann and Ericsson 1996). As a core skill in music, sight-reading has the potential to improve skills and thinking in music performance, such as faster learning of more repertoire, ability to play more complex scores, increased participation in music-making activities, greater retention rates in the music profession, and life-long satisfaction and confidence as a musician.

The question whether sight-reading of music is an inborn talent or a trainable skill is being currently debated in international music research, with some researchers suggesting that innate ability such as trilling speed (Kopiez and Lee 2006) and inherent traits such as working memory capacity (Meinz and Hambrick 2010) may restrict the ultimate level of achievement in sight-reading. The approaches to the teaching of sight-reading are fragmented with no dependable methodology available. This article reports on a large-scale project that provides a scientific basis for developing a new methodological framework for the teaching of sight-reading skills to advanced pianists. This was achieved by developing three new strategies for teaching piano sight-reading, comparing them against a control, and obtaining empirical results of their effectiveness in improving sight-reading ability in a large sample of advanced pianists.

Background

Sight-reading is defined as the initial playing music from a printed score after a brief perusal but prior to actual practising (Gabrielsson 1999). Reading of music is a complex skill that ‘draws on a variety of cognitive skills that include reading comprehension, audiation, spatial-temporal reasoning, and visual perceptions of patterns rather than individual notes’ (Gromko 2004, 6). To do this at sight without a prior rehearsal requires very fast processing and highly developed motor responses (Lehmann and Ericsson 1993).

Much work has gone into identifying predictors of good sight-reading and constructing models of skills involved during sight-reading. Hayward and Gromko (2009) suggest that aural-spatial patterning and technical proficiency interact during sight-reading to aid transfer of the player's mental representations of music into a physical reproduction. Similarly, Kopiez et al. (2006) proposed the view that high-level sight-reading achievement is determined by acquired expertise, speed of information processing and psychomotor speed. However, Wöllner et al. (2003) highlighted distracted inner hearing as a negative factor in forming aural representations of music that interferes with sight-reading. The difficulty of the sight-reading task could also have a direct impact on the skills required in sight-reading. Kopiez and Lee (2006) found that general pianistic expertise was sufficient when sight-reading examples were easy; at intermediate level of difficulty factors such as psychomotor skills, speed of information processing, inner hearing and sight-reading experience became more important; and in the most complex tasks the dominant factor was psychomotor skill measured by the speed of trilling. The authors conclude that sight-reading expertise is acquired by the age of 15 and is heavily dependent on innate ability such as trilling speed. While this interesting model is built on experimental research with 52 higher education participants, the findings may be limited to this particular sample, and suggest that little can be done to improve sight-reading skills of university-age students. This is a troubling position.

Research into sight-reading to date has had three main foci: eye movement, structural perception and teaching approaches (reviewed by Galyen 2005; Hodges 1992; Lehmann and Kopiez 2009; Lehmann and McArthur 2002; Lehmann, Slodoba, and Woody 2007, Chapter 6; Kopiez and Lee 2008; Thompson and Lehmann 2004; Wristen, 2005). The *eye movement* experiments investigate sight-readers responses to visual stimuli and demonstrate that the eyes of expert sight-readers tend to move forward more than non-experts' (Goolsby 1994; Truitt et al. 1997). At the same time good sight-readers are less dependant on visual input and are able to maintain their gaze on the score for longer periods (Banton 1995). While studio piano teachers try to instil these concepts in their students by urging them to glance ahead of playing and avoid looking down at their hands, there is little documented evidence to show that such teaching strategies result in improved sight-reading. Using eye-tracking devices recent experiments by Dra-Zerbib, Baccino and Begand (2012) established that expert sight-readers are more flexible in their intake of visual information and ability to ignore unsuitable fingerings, than non-experts. While eye movement research is resulting in better understanding of complexities of sight-reading, it is yet to be translated into pedagogical approaches.

Sight-reading research investigating *structural perception* has identified that beginning adult sight-readers tend to focus on individual notes and on intervallic leaps rather than rhythmical units (Penttinen and Huovinen 2011). The concept of 'chunking' when sight-reading has been proposed by Goolsby (1994) who found that expert sight-readers were able to realize longer 'chunks' of the score than less experienced sight-readers. The 'chunking' process appears to apply in particular to rhythmic components of music (Halsband et al. 1994; Waters et al. 1998). These ideas have been applied only recently to teaching practice: Pike and Carter (2010) taught rhythm and pitch chunking techniques to undergraduate students but found little difference between control and training groups in their sight-reading experiments. The question of how we can improve structural perception during sight-reading remains.

Research into *teaching* of sight-reading has been very fragmented, making it difficult to find clear directions (Hodges, 1992; Lehmann and Kopiez 2009). Is sight-reading an inborn talent or a skill that can be trained? Sight-reading is largely absent from studio lessons in higher education, perhaps due to time constrains and its' exclusion from practical examinations (Kornicke 1995; Zhukov 2009). Teachers of younger students are likely to include sight-reading in lessons because this is required by the music examining bodies. Australian students report that their experience of the 'teaching' of sight-reading often consists of attempting to play examples provided by examination systems for each grade and teachers identifying the errors (Zhukov, submitted). Simply practising sight-reading regularly, as advocated by many studio teachers, does not guarantee improvement. Meinz and Hambrick (2010) showed that while deliberate practice is necessary, it only accounts for half of the variance in sight-reading skills, the other important factor bring the working memory capacity. Since working memory capacity is a highly stable and inheritable trait, the authors suggest that natural ability may restrict the ultimate level of achievement in sight-reading. This finding reinforces commonly held view that sight-reading is a talent rather than a trainable skill.

From a pedagogical stance, research has proposed a number of approaches to enhance sight-reading, for example looking forward at the score in advance of playing, rehearsing playing by silently going over the keys, collaborative playing activities such as accompanying, rhythm training and better understanding of musical style (Lehmann and McArthur 2002; McPherson 2005; Wristen 2005). However, these ideas are yet to be tested in controlled studies. Three strategies (accompanying, training of rhythm and understanding of musical style) have been investigated in greater depth and, therefore, identified as potentially useful teaching approaches (Zhukov, 2006) .

Accompanying

Vocal and instrumental accompanying involves a fine co-ordination between the soloist and the accompanist, and requires good prediction skills (Palmer 1997). Lehmann and Ericsson (1996) found that accompanists usually have expert sight-reading skills, because they often have limited rehearsal time and have to read three line of music when playing. Furthermore, the amount of accompanying experience and varied repertoire learnt has been identified as important factors in sight-reading ability (Lehmann and Ericsson 1993, 1996). Wristen (2005) suggested in her literature review that collaborative playing activities could contribute to the development of sight-reading skills in pianists. Therefore, providing students with accompanying opportunities and building their collaborative repertoire might be one teaching strategy to improve their sight-reading.

Rhythm Training

Pitch and rhythm accuracy are essential components of expert sight-reading. Recent study by Henry (2011) focused on relationship between rhythm and pitch in vocal sight-reading, showing that students able to perform rhythm accurately were likely to demonstrate pitch accuracy as well. However, the converse was not true: correct sight-reading of pitch did not necessarily produce accurate rhythm as well. This study suggests that greater emphasis on rhythm training could have beneficial effects on overall sight-reading. Technological approach to teaching rhythm sight-reading has been employed by Smith (2009) with middle high school students, using computer-assisted instruction. His study reported no significant difference in improvement on test scores between the experimental and the control groups, making recommendations to instrumental teaching problematic. Earlier research has shown that the greatest number of errors during sight-reading was in the rhythm category (Fourie 2004; McPherson 1994) and that error-detection training resulted in improved rhythm when sight-reading (Kostka 2000). These studies suggest that rhythm training could be another worthwhile teaching strategy in improving sight-reading.

Understanding of Musical Style

Musicians understand stylistic differences between compositional styles in terms of structure, texture, harmony, melody and rhythm. Pattern recognition and prediction skills are linked to the features of particular musical styles (Palmer and van de Sande 1993, 1995). For example, in polyphonic style the sight-reading errors are likely to be single notes due to the linear nature of the music; in homophonic style the errors tend to be in chords, the chordal accompaniment being typical of that style. This suggests that sight-reading errors are related to the musical units characteristic of a particular style. Waters, Townsend and Underwood (1998) have reported that skilled sight-readers process the notes more rapidly because they recognise familiar patterns in groups of notes in notation. Recognition of such patterns during sight-reading results in the usage of standard fingering patterns, which in turn produces greater consistency and accuracy of playing (Sloboda et al. 1998). These studies highlight the importance of focusing on characteristics of musical styles when teaching sight-reading skills.

The review of literature identified a gap in research on *teaching* of sight-reading skills and the need for a large-scale, well-structured study to evaluate the efficacy of three promising teaching approaches: accompanying, rhythm training and understanding of musical style.

Research question

The study investigates whether sight-reading skills in advanced pianists can be enhanced with training, and, if so, which of the three teaching approaches (accompanying, rhythm training and understanding of musical style) is the most effective.

Method

This Australian study sought to address many of the problems in previous research into sight-reading by utilising a large, homogeneous sample of participants with similar pianistic skill level, administering long-term treatments, supervising compliance with training, pre- and post-testing participants, analysing their playing using specially-designed software and subjecting the data to complex statistical analyses to evaluate the efficacy of each training condition against the control.

Sample

After obtaining ethical clearances, 100 participants from three higher education institutions, three high schools and private studios in Queensland, Australia, were recruited on voluntary basis over the period of two and a half years and placed in one of the training/control groups at random, without prior knowledge of participant's background and experience. The data collection was concluded when 25 participants in each of the four groups had completed their program.

To achieve a homogeneous sample, the study limited participation to advanced pianists, consisting of players of Eighth Grade (Australian Music Examination Board) and above level. It was thought that beginner and intermediate pianists could have different sight-reading problems from advanced players, simply due to less developed skills on the instrument. Another factor in limiting participation to advanced skill level was providing training materials of a consistent level of difficulty that could be managed by all participants.

Training Programs

The training programs were 10 weeks long to give the participants sufficient time to immerse in each approach and to fit within the university semester. In order to monitor treatment procedures and maintain engagement with the training, the researcher met with each participant at least three times over the 10-week period, asked them to play the materials from the preceding weeks and answered questions with regard to rhythmic and structural analyses, and approaches to practice.

The materials in each program were intended for quick study only: the chosen pieces were easier than the participants' level of playing to build their confidence in sight-reading and encourage continued participation in the training programs.

The Accompanying Training program consisted of two different well-known short pieces for violin/flute and piano per week (total of 20 pieces), and the participants were required, after learning the accompanying part, to practise once per week with a partner: one pianist played the solo part on the second piano while the other accompanied and vice versa. This program aimed at improving the flow of playing, horizontal eye movement across the staves, maintaining the pulse and counting.

The Rhythm Training materials comprised of one or two different short exercises each week (total of 18 exercises) involving complex rhythms. Prior to playing the participants had to answer a checklist that guided their analysis of music focusing on rhythmic aspects (see Appendix 1). The goal of this program was to improve understanding and execution of rhythms.

The Style Training focused on two styles in particular, Baroque and Classical. The participants were required to play two/three different short pieces per week (total of 24 pieces, the two styles delivered in varying order), with a checklist focusing on analysis of harmonic and structural aspects of music (see Appendix 2). This program aimed at developing the differentiation between the two styles, such as understanding of structure, typical formulas, harmony and phrasing to develop pattern recognition and prediction skills within the two styles.

The control group had no additional input from the researcher and asked to continue their typical study and extra-curricular activities to provide a comparison to the intervention groups.

Pre- and Post-testing

The participants were tested on three examples before commencing and after completing the training programs, and the control group was tested at the beginning and end of the semester. While there is a possibility of improvement in repeating the same activity, ten weeks of busy student life and involvement in the training programs that required learning 18–24 short pieces over the semester were considered sufficient time and distraction to ‘forget’ the test pieces. The procedure of using the same materials for pre- and post-tests has been adopted by previous sight-reading studies (Betts and Cassidy 2000; Smith 2009). The test pieces were of similar difficulty level but different for each program, reflecting the focus of each: Baroque and Classical pieces for the style program; rhythmically complex pieces for the rhythm program; three different styles (Baroque, Classical and 20th century) for the accompanying and control groups (Banton 1995 utilised similar but different materials for testing different conditions during sight-reading). The tests were conducted following a strict protocol. Each player was given one minute of peruse time before each piece. The researcher recorded their playing using *Cubase* software, with the metronome clicking out loud until the end of each example was reached. A moderate tempo was set for each sight-reading example, with all the participants attempting to play at this tempo. If the performance broke down, the participants were encouraged to keep going until they reached the end of the piece. All participants were tested on the same Rolland keyboard. While this required some adjusting on their part from playing on a real piano, it provided the same playing challenge to all participants and, therefore, uniformity of testing.

Analyses of Playing

To achieve reliability and consistency in analysing the large number of tests (600 tests from 100 participants playing three pre- and three post-tests) and due to a lack of any other existing program, custom-made software was developed for this study by a small team of consultants with expertise in data analysis and musicianship. Currently available commercial products require the pianist to play without stopping and would mark any notes played after an interruption as wrong. It was anticipated that some participants in this study could stumble and stop during the tests before resuming playing, thus the need for a custom-made software.

The new software imported MIDI data from the digitally captured performances. The validity and reliability of the import process was verified with a series of manual checks. The software analysed MIDI files of performances and provided four numerical results: two on pitch accuracy and two on rhythm accuracy. The categories of performance analysis are listed in Table 1. The software was trialled on pilot data recorded by the researcher to validate its effectiveness in analysing accurate and inaccurate performances of the test pieces. The algorithm developed for the program provided greater consistency and reliability of analysis of pre- and post-tests than manual marking of errors utilised in many previous sight-reading studies (Banton 1995; Betts and Cassidy 2000; Kostka 2000; Meinz and Hambrick 2010; Penttinen and Huovinen 2011).

[Insert Table 1 here]

If a pianist skipped a beat or stopped during the test, this was counted as a Beat Adjustment. The duration of this break was not measured, but simply the number of times this occurred during the test. This category provided information on the overall flow and continuity of playing. Any wrong notes played during the tests were counted as Extra Notes. Some participants missed several notes along the way: these were counted as Missing Notes. *Cubase* software used for recording of tests is very sensitive to the slightest timing deviations from the metronome: even expert versions of tests recorded by the researcher with no Beat Adjustments, no Extra Notes and no Missing Notes, had on average 17-19 RMS errors per example, indicating the ‘human’ factor in performance. This provided a benchmark for evaluating RMS accuracy in the participants’ tests.

Additional Data Collection

In addition to pre- and post-tests the participants were required to answer Background Questionnaires, keep Practice Diaries during the training programs and take part in brief Exit Interviews. These additional measures were put in place to obtain contextual information and confirm compliance with the training programs.

All 100 interviews were transcribed and participants’ responses to the question of additional sight-reading undertaken during the study were coded using 0–3 scale:

- 0 = “None” = “no additional sight-reading”;
- 1 = “Little” = “minimal sight-reading, only when starting new repertoire”;
- 2 = “Moderate” = “regular short sight-reading sessions”;
- 3 = “Extensive” = “extensive amount of sight-reading, in regular long sessions or through substantial accompanying activities”.

The reliability of the coding process was established through comparison of the author’s scores with those of another researcher at the same institution who was trained in the usage of codes and marked 10% of randomly selected interviews. Spearman’s rho of .90, $p < 0.01$, indicates the high level of agreement in the coding of data.

Statistical Analyses

Mixed-design ANCOVAs have been used in health (e.g., Horswill et al. 2010) and psychology research (e.g., von Hippel et al. 2011; Karnadewi and Lipp 2011) to investigate complex 3-way interactions amongst the variables. This study aimed to evaluate the changes in participants’ performance from pre-test to post-test in relation to their training group and to the three music pieces played in each condition. Therefore, a series of 2 (prepost: pre-training, post-training) x 4 (training condition: control, accompanying, rhythm, style) x 3 (piece: piece 1, piece 2, piece 3) mixed ANCOVAs were carried out, controlling for the effects of additional sight-reading undertaken during the study (discussed further in the Results). Both pre-post and piece were within-participants factors, while training condition was a between-participants factor. Partial η^2 was used as a measure of effect size, with larger numbers indicating the greater importance of the variable (Heiman, 2011). All statistical analyses were performed using SPSS Version 20.0.

Results

Performance Analyses: Within-group Improvement (Mean Changes)

The software analysis of pre- and post-tests showed that after training the accompanying group improved in all four categories in every test example: decreasing numbers of errors in Beat Adjustments, Extra Notes, Missing Notes, RMS Accuracy from pre- to post-test in Test Piece 1, 2, and 3 (see Figure 1).

[Insert Figure 1]

The rhythm group improved in all categories in Test Piece 1 and Test Piece 3, but in Test Piece 2 had an increase in Missing Notes and RMS Accuracy at the post-test (see Figure 2).

[Insert Figure 2]

The style group had a slight increase in Extra Notes in Test Piece 1 and Test Piece 2 at post-test, but otherwise improved in all other categories (see Figure 3).

[Insert Figure 3]

Despite no intervention from the researcher, the control group had also improved in all categories and in all Test Pieces at post-test (see Figure 4).

[Insert Figure 4]

This necessitated further investigation as to why the control group improved with no training. The transcripts of Exit interviews showed that eight out of 25 control group participants were involved in extensive self-motivated sight-reading activities during the study, in comparison to seven participants out of the accompanying group, six out of the style group and five out of the rhythm group. This offered an explanation for means changes of the control group and suggested that additional sight-reading activities during the training phases of the study could have an impact on the effects of training. Further statistical analyses of data were carried out controlling for the effects of *During Sight-Reading*, since raw means would not represent true effects that were taking place.

Statistical Analyses: Cross-group Improvement

To evaluate the efficacy of the training programs above the control group, a mixed ANCOVA was calculated for each improvement outcome, controlling for the effects of *additional* sight-reading activities taken during the training phase. Partial η^2 calculations (η^2_P) were used in conjunction with these as a measure of the size of effect. Significant interactions were followed up with planned pair-wise comparisons assessing improvement within each training condition from pre-test to post-test. Given that these four follow-up tests were determined *a priori*, an α-level of .05 was used for each comparison. Results with p in .05–.1 range were considered to be marginally significant as is typically reported in psychology. This allows highlighting of results that approach significance, as these may still be thought worthy of note.

Beat Adjustment Improvement

Results showed overall significant improvement in beat adjustment (i.e., fewer mistakes) across training groups from time 1 (pre) to time 2 (post), $F(1, 95) = 17.20$, $p < .001$, $\eta^2_P = .15$. However, this result was qualified by a significant interaction such that the degree of improvement displayed differed according to training condition, $F(3, 95) = 5.68$, $p = .001$, $\eta^2_P = .15$ (see Figure 5). In order to determine exactly what these differences were, a series of four *a priori* pair-wise comparisons of pre-post at each level of training group were conducted to follow up this result, using $\alpha = .05$ for each contrast. Results revealed significantly fewer beat adjustment mistakes following training for the rhythm group, $p < .001$, $\eta^2_P = .25$. Marginally significant improvement was also seen for the control group, $p = .099$, $\eta^2_P = .03$.

[Insert Figure 5]

Extra Notes Improvement

Overall improvement was also indicated through the significant reduction of inappropriate extra notes following training group intervention, $F(1, 95) = 17.95$, $p < .001$, $\eta^2_P = .16$. This effect was qualified by a marginally significant interaction, such that the extent of participant improvement was different as a function of the training condition in which they had participated, $F(3, 95) = 2.47$, $p = .067$, $\eta^2_P = .07$ (see Figure 6). Follow-up *a priori* pair-wise comparisons of pre-post for each training condition were performed, using $\alpha = .05$ for each of the four contrasts. Significant decreases in the performance of extra notes were seen for both the rhythm and control training groups, $p = .001$, $\eta^2_P = .10$, and $p = .001$, $\eta^2_P = .11$, respectively. Additionally, the accompanying condition also displayed marginally significant improvement regarding the reduction of extra notes, $p = .052$, $\eta^2_P = .04$.

[Insert Figure 6]

Missing Notes Improvement

Overall, the performance of significantly fewer missing notes was shown across the various training conditions from time 1 (pre) to time 2 (post), $F(1, 95) = 11.05$, $p = .001$, $\eta^2_P = .10$. Yet again, this result was better explained by a significant interaction, which signified that the extent of participant improvement regarding missing note errors was dependent upon the training condition participants were in, $F(3, 95) = 5.02$, $p = .003$, $\eta^2_P = .14$ (see Figure 7). A series of four *a priori* comparisons for pre-post at each level of training condition were used to follow-up this effect, employing $\alpha = .05$ for each test. Results of this revealed that both the control and style training groups omitted significantly fewer notes from time 1 (pre) to time 2 (post), $p < .001$, $\eta^2_P = .19$, and $p = .024$, $\eta^2_P = .05$, respectively.

[Insert Figure 7]

RMS Accuracy Improvement

Overall, significant improvement occurred in RMS accuracy across the groups following training intervention, $F(1, 95) = 8.78$, $p = .004$, $\eta^2_P =.09$. However, a significant interaction was also observed which qualified this finding, suggesting that the rate of RMS accuracy improvement depended on which training condition participants completed, $F(3, 95) = 4.27$, $p = .007$, $\eta^2_P = .12$ (see Figure 8). *A priori* comparisons for pre-post at each level of training condition were carried out as follow-up analyses to this, making use of $\alpha = .05$ for each of the four pair wise contrasts. Results showed that the style group produced significantly higher levels of RMS accuracy following training, $p < .001$, $\eta^2_P = .24$. Marginally significant improvements were also achieved by those in the accompanying and control training conditions, $p = .054$, $\eta^2_P = .04$, and $p = .068$, $\eta^2_P = .04$, respectively).

[Insert Figure 8]

Discussion

This study is the first large-scale investigation into approaches to teaching sight-reading skills to advanced pianists. It evaluated three teaching strategies against a control group, using a reliable evaluation tool (software) to analyse sight-reading performance before and after training. The results indicate that training does have a positive impact on various aspects of sight-reading and that additional sight-reading activities improve post-test performance.

Beat Adjustment Improvement

The results show overall improvement at post-test for all the groups, with significant interaction. In particular, significant results for the rhythm group (large effect) suggest that rhythm training improves the overall flow and continuity of playing, supporting previous findings (e.g., Kostka 2000; Smith 2009).

Extra Notes Improvement

Overall improvement at post-test was observed in all the groups, with marginally significant interaction. The significant results for the rhythm and control groups (medium effect), taken together with Beat Adjustment improvement, suggest that fewer interruptions and continuity of playing when sight-reading produces fewer extra notes, thus implying that rhythm training and participation in sight-reading activities have a positive effect on reducing wrong notes in sight-reading as shown in previous studies (e.g., Kostka 2000; Smith 2009).

Missing Notes Improvement

With exception of the rhythm group, the other groups improved at post-test, with significant interaction. The significant results for the control group (large effect) suggest that extensive sight-reading activities can have a positive effect on reducing missing notes during sight-reading, so that as a player becomes accustomed to sight-reading regularly he/she omits fewer notes when playing. The significant results for the style group (small effect) demonstrate that training focusing on particular styles does improve pitch accuracy in sight-reading of the same styles as was suggested by previous experimental research on pattern recognition and prediction skills (Sloboda 1984; Thompson and Lehmann 2004; Waters, Townsend, and Underwood 1998).

RMS Accuracy Improvement

The findings indicate overall improvement at post-test for all the groups, with significant interaction. The significant results for the style group (large effect) demonstrate the substantial impact of style training on improving timing accuracy of sight-reading. This suggests that improved pattern recognition and prediction skills, highlighted by previous research as important factors in sight-reading (Thompson and Lehmann 2004; Waters, Townsend, and Underwood 1998), allowed the style group participants more time to focus on rhythmic accuracy of their playing.

Summary of Significant Improvement

The findings demonstrate that three groups had improved in two of the four categories measured（Accompanying group showed only marginal improvement in Extra Notes and RMS (small effects);

- Rhythm group: significant improvement in Beat Adjustment (large effect) and Extra Notes (medium effect);
- Style group: significant improvement in Missing Notes (small effect) and RMS (large effect);

- Control group: significant improvement in Extra Notes (medium effect) and Missing Notes (large effect).

It is interesting to note that while the Rhythm and Style training groups improved in one pitch and one rhythm category, the control group improved only in the two pitch categories. This suggests that rhythm and style training had a more holistic effect on improving participants' sight-reading skills than mere sight-reading practice. Surprisingly, the Accompanying group demonstrated least improvement among all participants. This might be explained by the difficulties some participants experienced in co-ordinating accompanying sessions with their partners, the greater length of the pieces in the Accompanying program (74 pages of music versus 19 pages in the Rhythm and 22 pages in the Style programs), and fewer directives (both Rhythm and Style programs utilised checklists to guide student practice while Accompanying group simply had to learn the accompanying part and practise with the partner).

Conclusions

This study has described new approaches to teaching sight-reading skills to advanced pianists. While no single training program demonstrated significant improvement in all four variables measured in comparison to the control, progress in at least one pitch and one rhythm category was achieved after training in two of the programs, providing evidence that training does have a positive impact on sight-reading. In addition, the findings demonstrate that supplementary sight-reading activities improve post-test pitch accuracy, as shown by the progress made by the control group.

The study focused on advanced pianists of Eighth Grade level and above, and the participants were placed into the training programs randomly, without taking in account their previous experience in sight-reading and accompanying, and their particular strengths and weaknesses with regard to understanding of rhythm and musical style; therefore, the training did not specifically target their individual problems. This suggests that to achieve a greater impact on sight-reading skills of a wide range of advanced pianists, particularly in a higher education setting, combining all three training strategies into a single curriculum might prove to be even more effective than the individual programs. Such a curriculum is currently being trialled in four higher education institutions in Australia and the findings will be reported in upcoming publications.

Future research needs to continue investigating approaches to teaching of sight-reading skills to pianists of all levels, ages and experiences. It is also important to focus on sight-reading issues on instruments other than piano to formulate generic approaches to teaching of sight-reading skills with the aim of improving music literacy and fluency of reading in all musicians that has the potential to impact all aspects of music-making.

References

Banton, L.J. 1995. The role of visual and auditory feedback during the sight-reading of music. *Psychology of Music* 23: 3–16.

Betts, S. L., and J. W. Cassidy. 2000. Development of harmonisation and sight-reading skills among university class piano students. *Journal of Research in Music Education* 48, no. 2: 151–161.

Drai-Zerbib, V., T. Baccino, and E. Bigand. 2012. Sight-reading expertise: Cross-modality integration investigated using eye tracking. *Psychology of Music* 40, no. 2: 216–235.

Fourie, E. 2004. The processing of music notation: Some implications for piano sight-reading. *Journal of the Musical Arts in Africa* 1: 1–23.

Gabrielsson, A. 1999. The performance of music. In *The Psychology of Music* (2nd Ed), ed. D. Deutch, 501–602. New York: Academic Press.

Galyen, S. D. 2005. Sight-reading ability in wind and percussion students: A review of recent literature. *Update: Applications of Research in Music Education* 24: 57–70.

Goolsby, T. W. 1994. Profiles of processing: Eye movements during sight-reading. *Music Perception* 12, no. 1: 97–123.

Gromko, J. E. 2004. Predictors on music sight-reading ability in high school wind players. *Journal of Research in Music Education* 52, no. 1: 6–15.

Halsband, U., F. Binkofski, and M. Camp. 1994. The role of perception of rhythmic grouping in musical performance: evidence from motor-skill development in piano playing. *Music Perception* 11, no. 3: 265–288.

Hayward, C. M., and J. E. Gromko. 2009. Relationships among music sight-reading and technical proficiency, spatial visualization and aural discrimination. *Journal of Research in Music Education* 57, no. 1: 26–36.

Heiman, G. W. 2011. *Basic Statistics for the Behavioral Sciences*. Australia: Wadsworth Cengage Learning.

Henry, M. L. 2011. The effect of pitch and rhythm difficulty on vocal sight-reading performance. *Journal of Research in Music Education* 59, no. 1: 72–84.

Henry, M. 2001. The development of vocal sight-reading inventory. *Council of Research in Music Education* 150: 21–35.

Hodges, D. A. 1992. The acquisition of music reading skills. In *Handbook of Research on Music Teaching and Learning,* ed. R. Colwell, 466–471. New York: Schirmer Books.

Horswill, M. S., C. N. Kemala, M Wetton, C. T. Scialfa, and N. A. Pachana. 2010. Improving older drivers' hazard perception ability. *Psychology and Aging* 25, no. 2: 464–469.

Karnadewi, F., and O. V. Lipp. 2011. The processing of invariant and variant face clues in the Garner paradigm. *Emotion* 11, no. 3: 563–571.

Kopiez, R., and J. I. Lee. 2008.Towards a general model of skills involved in sight-reading music. *Music Education Research* 10, no. 1: 41–62.

Kopiez, R., and J. I. Lee. 2006.Towards a dynamic model of skills involved in sight-reading music. *Music Education Research* 8, no. 1: 97–120.

Kopiez, R., C. Weih, U. Ligges, and J. I. Lee. 2006. Classification of low and high-achievers in music sight-reading task. *Psychology of Music* 34, no. 1: 5–26.

Kornicke, E. 1995. An exploratory study of individual difference variables in piano sight-reading achievement. *The Quarterly Journal of Music Teaching and Learning* 6, no. 1: 56–79.

Kostka, M. J. 2000. The effects of error-detection practice on keyboard sight-reading achievement of undergraduate music majors. *Journal of Research in Music Education* 48, no. 2: 114–122.

Lehmann, A. C., and K. A. Ericsson. 1996. Performance without preparation: Structure and acquisition of expert sight-reading and accompanying performance. *Psychomusicology* 15*:* 1–29.

Lehmann, A. C., and K. A. Ericsson. 1993. Sight-reading ability of expert pianists in the context of piano accompanying. *Psychomusicology* 12: 122–136.

Lehmann, A. C., and R. Kopiez. 2009. Sight-reading. In *The Oxford Handbook of Music Psychology,* ed. S. Hallam, I. Cross and M. Thaut, 344–351. Oxford: Oxford University Press.

Lehmann, A. C., and V. McArthur. (2002). Sight-reading. In *The science and psychology of music performance: creative strategies for teaching and learning, ed.* R. Parncutt and G. E. McPherson, 135–150. Oxford: Oxford University Press.

Lehmann, A. C., A. J. Sloboda, and R. H. Woody. 2007. *Psychology for Musicians: Understanding and acquiring the skills.* Oxford: Oxford University Press.

McPherson, G. E. 2005. From child to musician: Skill development during the beginning stages of learning an instrument. *Psychology of Music* 33: 5–35.

McPherson, G. E. 1994. Factors and abilities influencing sightreading skill in music. *Journal of Research in Music Education* 42, no. 3: 217–231.

Meinz, E. J., and D. Z. Hambrick. 2010. Deliberate practice is necessary but not sufficient to explain individual differences in piano sight-reading skill: The role of working memory capacity. *Psychological Science* 21, no. 7: 914–919.

Palmer, C. 1997. Music Performance. *Annual Review of Psychology* 48: 115–138.

Palmer, C. and C. van de Sande. 1995. Range of planning in skilled music performance. *Journal of Experimental Psychology: Human Perception and Performance* 21: 947–62.

Palmer, C. and C. van de Sand. 1993. Units of knowledge in music performance. *Journal of Experimental Psychology: Learning, Memory, Cognition,* 19: 457–70.

Penttinen, M., and E. Huovinen. 2011. The early development of sight-reading skills in adulthood: A study of eye movements. *Journal of Research in Music Education,* 59, no. 2: 196–220.

Pike, P. D., and R. Carter. 2010. Employing cognitive chunking techniques to enhance sight-reading performance of undergraduate group-piano students. *International Journal of Music Education* 28, no. 3: 231–246.

Sloboda, J. A., E. F. Clarke, R. Parncutt, and M. Raekallio. 1998. Determinants of fingering choice in piano sight-reading. *Journal of Experimental Psychology: Human Perception and Performance* 24, no. 1: 185–203.

Sloboda, J. A. 1984. Experimental studies of music reading: a review. *Music Perception* 2: 222–236.

Smith, K. H. 2009. The effect of computer-assisted instruction and field independence on the development of rhythm sight-reading skills of middle school instrumental students. *International Journal of Music Education* 27, no. 1: 59–68.

Thompson, S., and A. C. Lehmann. 2004. Strategies for sight-reading and improvising music. In *Musical Excellence,* ed. A. Williamon, 143–159. Oxford: Oxford University Press.

Truitt, F. E., C. Clifton, A. Pollatsek, and K. Rayner. 1997. The perceptual span and the eye-hand span in sight-reading of music. *Visual Cognition* 4, no. 2: 143–161.

Von Hippel, C., C. Wiryakusuma, J. Bowden, and M. Shochet. 2011. Stereotype threat and female communication styles. *Personality and Social Psychology Bulletin* 37, no. 10: 1312–1324.

Waters, A. J., E. Townsend, and G. Underwood. 1998. Expertise in musical sight reading: A study of pianists. *British Journal of Psychology* 89, no. 1: 123–149.

Watkins, A., and M. A. Hughes. 1986. The effect of an accompanying situation on the improvement of students' sight reading skills. *Psychology of Music* 14: 97 –110.

Wöllner, C., E. Halfpenny, S. Ho, and K. Kurosawa. 2003. The effects of distracted inner hearing on sight-reading. *Psychology of Music* 31, no. 4: 377–389.

Wristen, B. 2005. Cognition and motor execution in piano sight-reading: A review of literature. *Update: Applications of Research in Music Education,* 24: 44–56.

Zhukov, K. 2009. *Instrumental music teaching and learning in Australia*. Köln: Lambert Academic Publishing.

Zhukov, K. 2006. Good sight-readers: Born or bred? Paper presented at the 7th Australasian Piano Pedagogy Conference, 12–16 July 2005, in Adelaide, Australia. Available at www.appca.com.au : Proceedings 2005.

Zhukov, K. (submitted). Exploring advanced piano students' approaches to sight-reading.

Table 1. Categories of Performance Analyses

Category	**Definition**
Beat Adjustment	Number of times the playing was interrupted, beat missed or skipped
Extra Notes	Extra notes played that were not on the score
Missing Notes	Correct notes missing from performance
RMS Accuracy	“Root mean squared” = average number of timing errors per correct note played

Figure 1. Accompanying Group Results (Mean Changes)

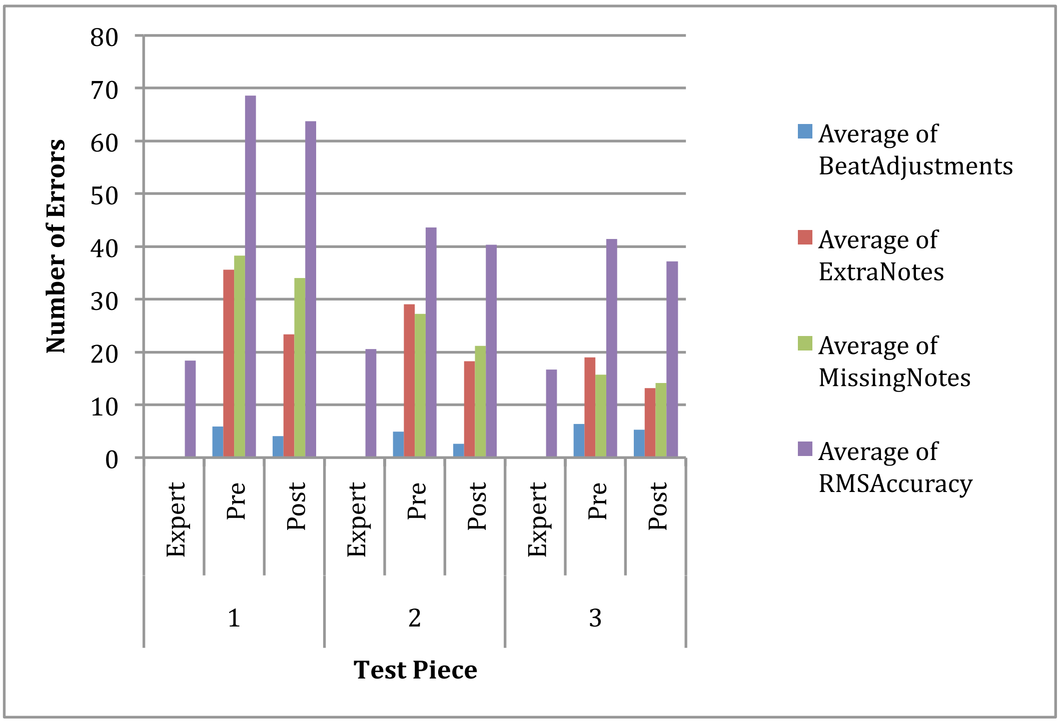


Figure 2. Rhythm Group Results (Mean Changes)

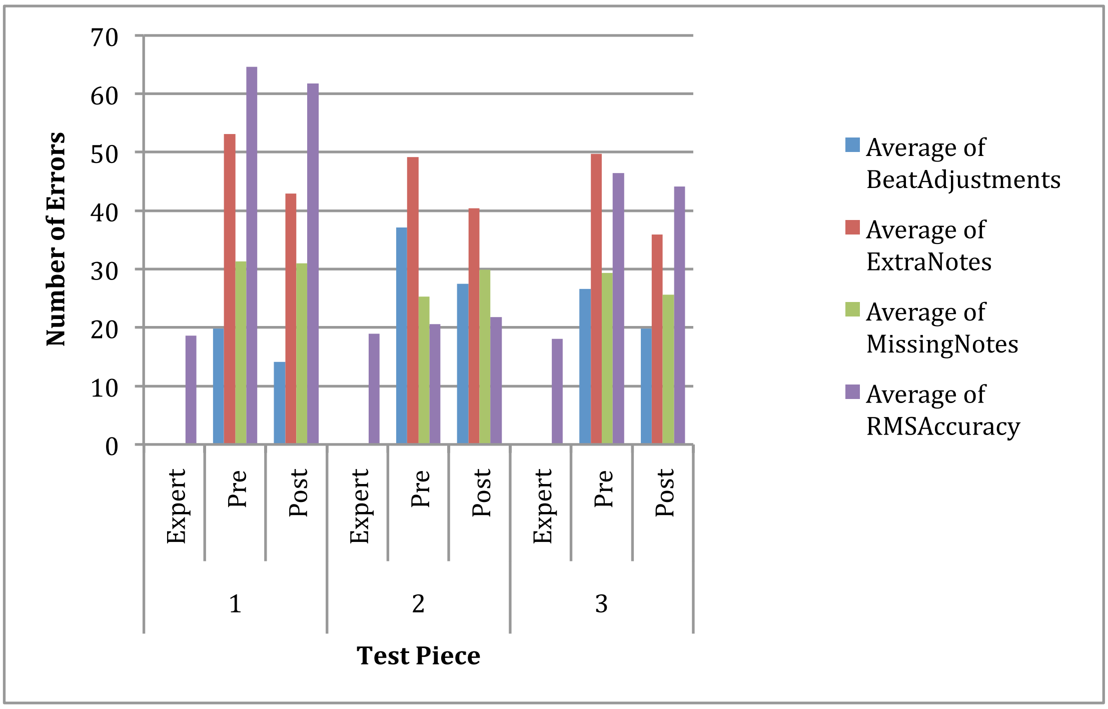


Figure 3. Style Group Results (Mean Changes)

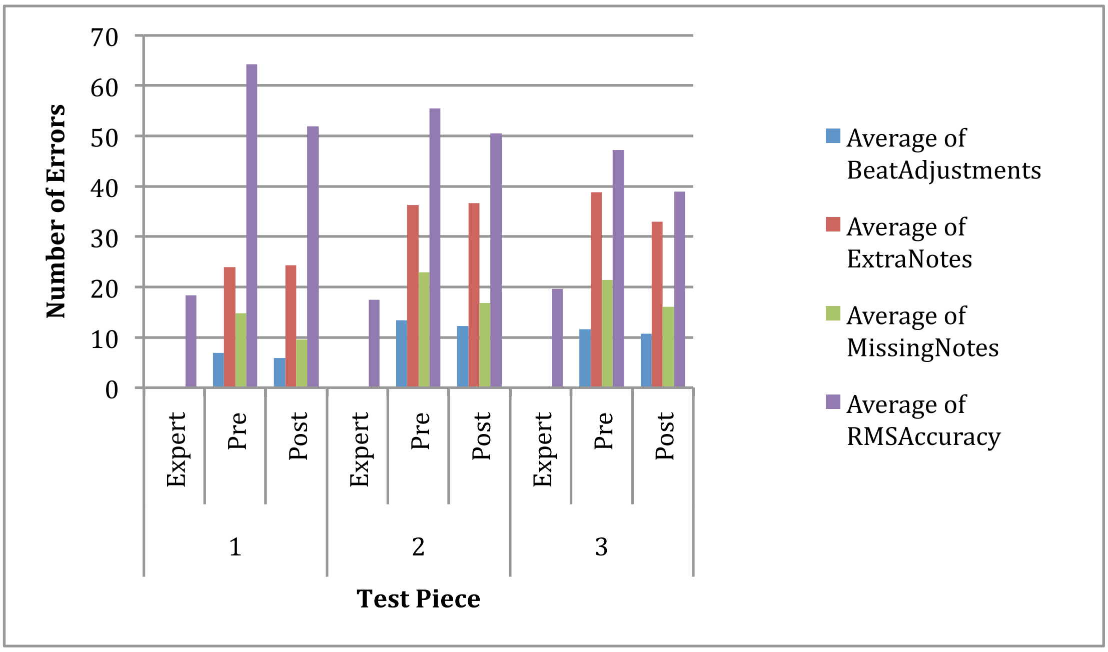


Figure 4. Control Group Results (Mean Changes)

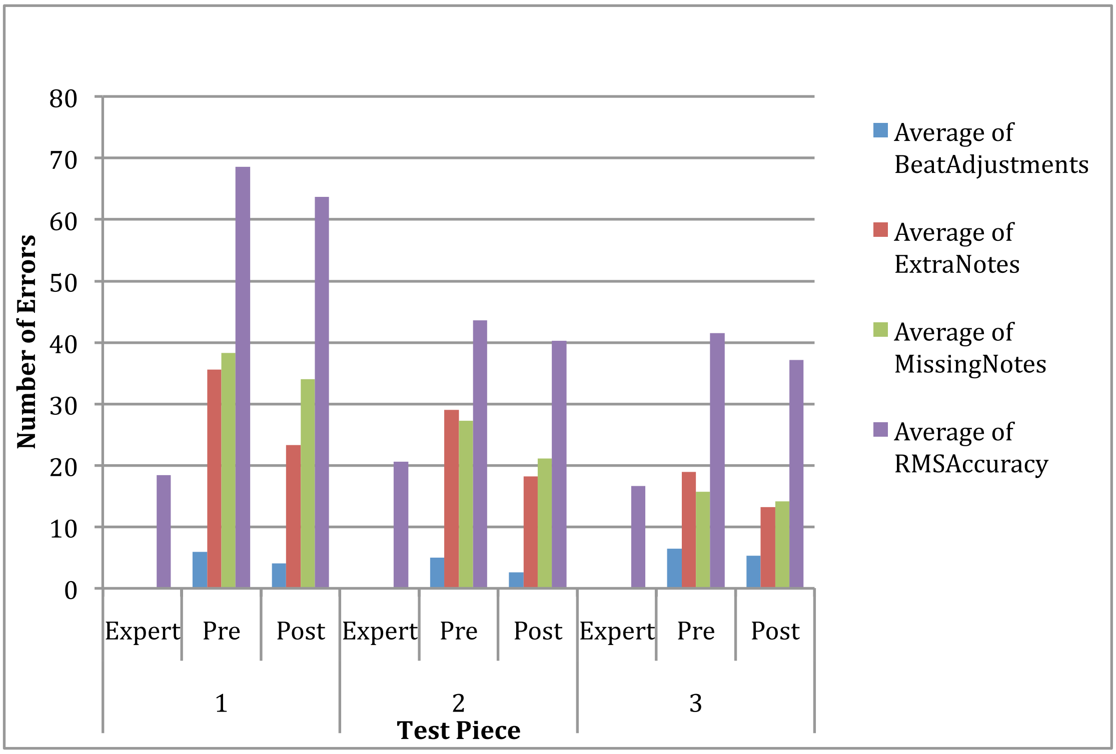
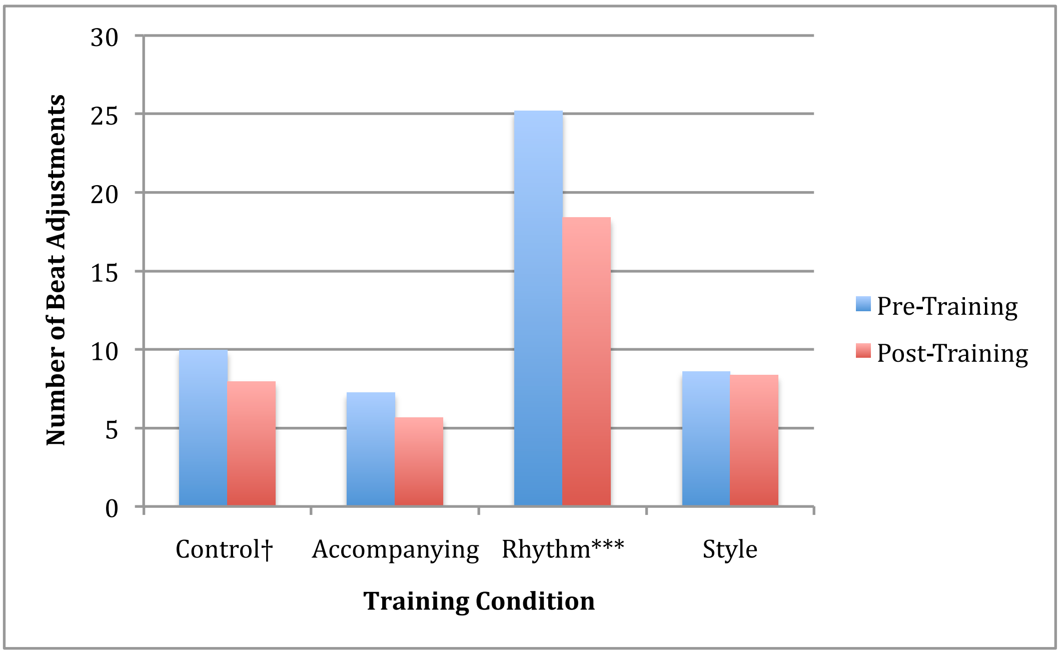
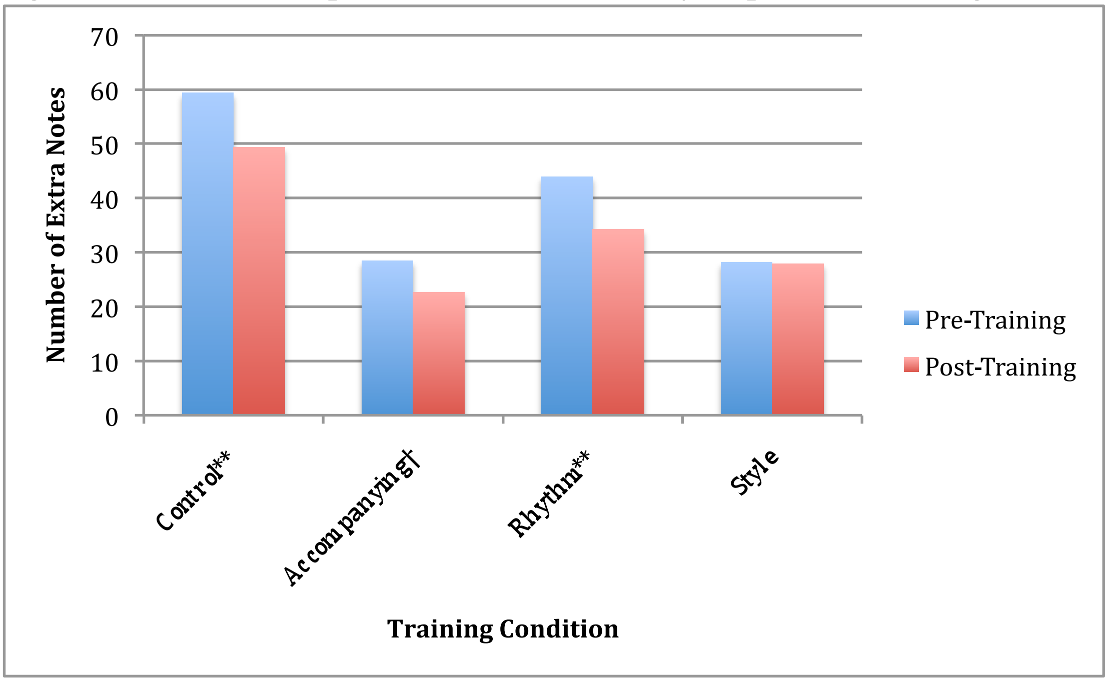


Figure 5. Beat Adjustment Improvement as a Function of Prepost and Training Condition



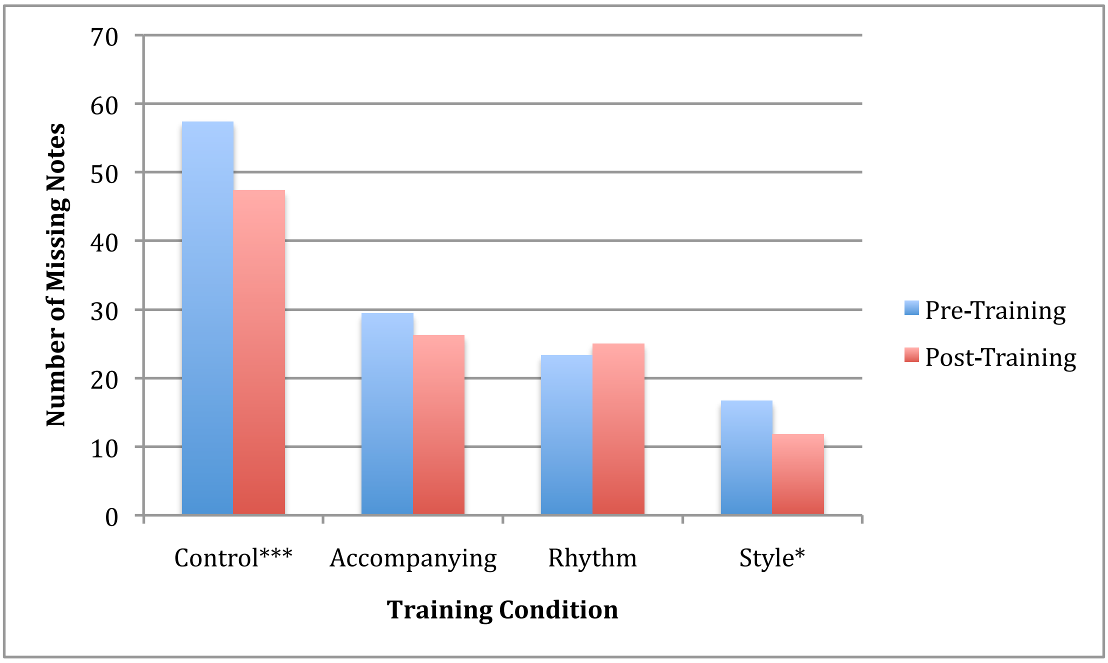
Note. Significance levels are denoted as: † *p < .10, * p < .05, ** p < .01, *** p < .001.*

Figure 6. Extra Notes Improvement as a Function of Prepost and Training Condition



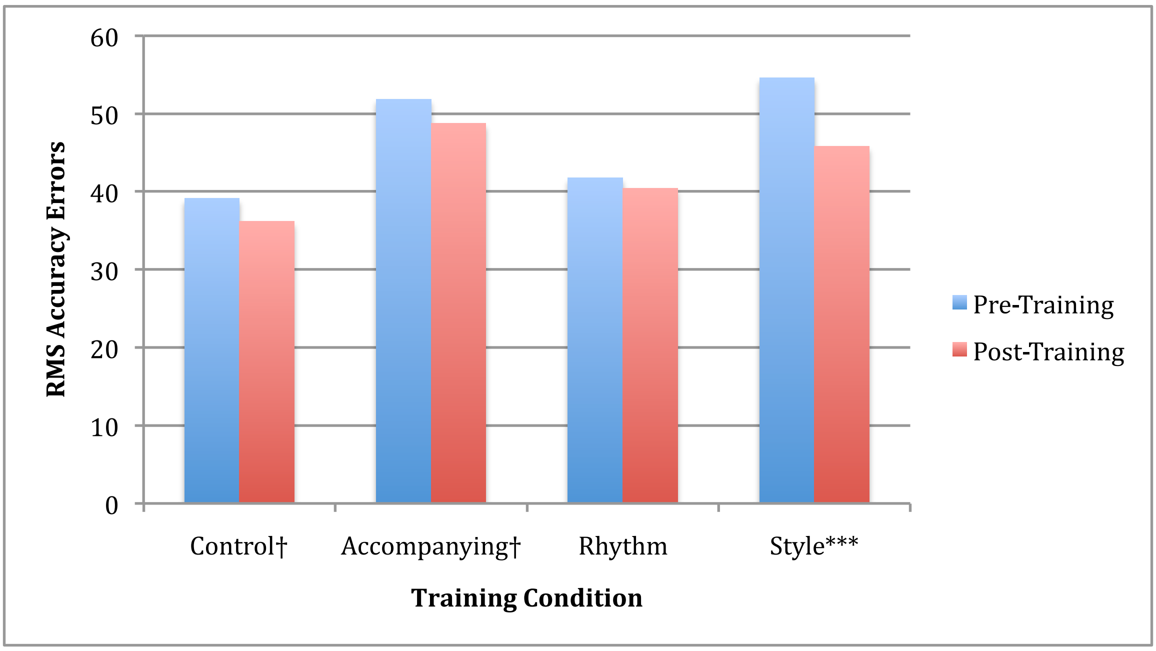
Note. Significance levels are denoted as: † *p < .10, * p < .05, ** p < .01, *** p < .001.*

Figure 7. Missing Notes Improvement as a Function of Prepost and Training Condition



*Note. Significance levels are denoted as: † p < .10, * p < .05, ** p < .01, *** p < .001.*

Figure 8. RMS Accuracy Improvement as a Function of Prepost and Training Condition



*Note. Significance levels are denoted as: † p < .10, * p < .05, ** p < .01, *** p < .001*

Appendix 1

Rhythm Checklist

Title of piece	Time Signature	Tempo	List bars with unusual rhythms (e.g., triplets)	List bars with ties/rests	Vocalise the rhythm while tapping the beat

Appendix 2

Style Checklist

Title of piece	Time / Key Signature	Bars with imitations	Bars with sequences	Identify basic harmonies on the score	Sing through the melody

List bars with chords, scales and arpeggios (which hand?)	Identify basic structure and phrase length	Do you think it is in Baroque or Classical style? Why?