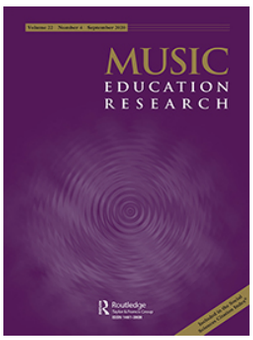

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Determining what expert piano sight-readers have in common

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ABSTRACT

Music sight-reading is a valuable skill that eludes and frustrates many musicians. Techniques for teaching sight-reading are varied, with teachers mostly falling back on personal experience or simply hoping that, somehow, the penny will drop for the student. This study reports on a survey of the music learning and playing habits of expert and non-expert piano sight-readers. Pianists were categorised as 'experts' according to their ability to perfectly perform a 6th Grade AMEB (Australian Music Examinations Board) sight-reading assessment piece. This grouping was determined by the analysis of eye movement patterns as pianists performed various sight-reading tasks (Arthur 2017). The data show significant differences in musical training and performance experiences between the two groups.

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Expertise; sight-reading; piano; eye-movements; pedagogy

Introduction

Defining a sight-reading pedagogy can be problematic because the skill is seldom overtly taught and the methods used are often based on intuition and personal experience (Lehmann and McArthur 2002). Compounding this, studies on sight-reading pedagogy rarely use similar strategies and fail to offer sound evidence for assisting students in their acquisition of sight-reading skills (Hodges and Nolker 2011). Also, sight-reading is generally not taught explicitly in college-level piano lessons (Kornicke 1995; Zhukov 2005). It was found that, of 73 advanced pianists, 68% reported that sight-reading was not included in their lessons (Kornicke 1995). This may be due to an assumption that sight-reading skills are innate (Kornicke 1995), or due to the time constraints of college-level piano lessons (Zhukov 2014b). However, teachers who do spend lesson time on sight-reading are more likely to be teachers of younger students. This is possibly because sight-reading is included in the curriculum of music examining organisations (Zhukov 2006), or because many popular beginning piano methods explicitly teach sight-reading skills (Dirkse 2009). In Australia, teaching sight-reading often involves asking students to play through sample sight-reading tests as set by examining bodies with the teacher identifying errors (Zhukov 2014a). However, simply practising sight-reading in this way doesn't necessarily ensure improvement. With sight-reading expertise having been shown to be linked with significantly greater working memory capacity (WMC) (Arthur 2017; Meinz and Hambrick 2010), there may be credibility in the view that at least some aspects of sight-reading performance are innate rather than teachable. This study, therefore, reports on a survey of the music learning and playing habits of expert and non-expert piano sight-readers to determine what expert piano sight-readers have in common.

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Literature review

The sight-reading pedagogy literature proposes teaching strategies that address findings of broader psychological research using typically small samples, across short timeframes, and these are very rarely replicated. In response to the apparent 'ad hoc' nature of sight-reading pedagogy, there has emerged a need for research to 'focus on finding effective means of sight-reading training at all stages of learning a musical instrument' (Zhukov 2006, 5). The paucity of research was recognised and addressed by the undertaking of a large-scale meta-analysis of existing experimental studies that used a pre-test/post-test, control-group design to determine which variables had the greatest effect on participant groups (Mishra 2014a). Pedagogical foci in areas of 'Aural Training,' 'Controlled Reading,' and 'Creative Activities and 'Singing/Solfege' were shown to have the greatest effect on sight-reading skill.

A sight-reading curriculum was developed using another three single-focus strategies to address rhythmic and pitch variables in sight-reading accuracy: rhythm training, stylistic understanding and accompanying (Zhukov 2014b). Results suggested that training in each of these areas improved sight-reading. Zhukov further built on the findings with the development of a combined approach strategy, which created a single teaching resource from the three aforementioned individual strategies (2014b). This hybrid curriculum significantly improved sight-reading skills in all three categories relative to the results of each single-focus strategy. The efficacy of this curriculum with intermediate and beginning pianists is yet to be tested.

The teaching areas found to be most likely to offer sustained improvement in sight-reading ability were: collaborative playing, rhythm training and pattern recognition training. Collaborative playing opportunities can include giving students the chance to accompany others (Wristen 2005) through live or electronic (Midi or recorded backing tracks) and ensemble performance (Kopiez and Lee 2006; Lehmann and McArthur 2002). Other researchers found a similar correlation between sight-reading proficiency and hours spent accompanying (Lehmann and McArthur 2002), another collaborative activity. It was also found that pianists who engage in collaborative performance, i.e. accompanying, are more adept sight-readers than pianists who predominantly focus on solo repertoire (Lehmann and Ericsson 1993). While such activities show positive correlations with sight-reading expertise, the comparisons occur over different instruments, including voice, and suffer from lack of consistency in defining expertise (Daniels 1986; Gudmundsdottir 2010; Kopiez and Lee 2008; Mishra, 2014b; Waters, Townsend, and Underwood 1998; Woody 2012).

Research has suggested a correlation between rhythmic ability and sight-reading (Boyle 1970; Elliott 1982; McPherson 1994). Rhythm training has been found to positively benefit sight-reading skills (Fourie 2004; Kostka 2000; McPherson 1994) and students vocalising the rhythm while clapping the beat have been shown to remediate poor rhythmic sight-reading (Zhukov 2006). The ability to chunk individual rhythmic values into larger groups seems to result in greater rhythmic accuracy in sight-reading (Halsband, Binkofski, and Camp 1994; Waters, Townsend, and Underwood 1998). This may enable other features of performance, such as dynamics, to be processed more effectively (Dirkse 2009). Likewise, it has been noted that 'when music contains predictable or straightforward patterns, a musician is more likely to look ahead and anticipate the flow of music' (McPherson 1994, 217). Skilled sight-readers have highly-developed pattern recognition and prediction skills (Waters, Townsend, and Underwood 1998) with studies showing that pattern recognition comes from a familiarity with predictable tonal patterns (MacKenzie et al. 1986), phrasing (Sloboda 1977) and chord recognition (Cox 2000). It has also been shown that performance errors increase (Alexander and Henry 2012) and expert sight-readers' eye movements change (Arthur, Blom, and Khuu 2016) when music shifts away from easily predictable patterns.

A non-expert group of piano sight-readers was found to execute more forward saccades (the movement of the eye in a forward direction to the next fixation) when compared with the expert group playing the same piece of music (Arthur 2017). This finding was unexpected and brings

into question the sight-reading teaching strategy of simply 'looking ahead' as one which encourages visual processing ahead of the point of performance. Encouraging such an approach for a non-expert without the requisite theoretical knowledge to facilitate 'chunking,' may actually be cognitively impossible and, consequently, counterproductive. As Sloboda (1985) notes, 'It may well be that increased ability for preview is the result of some other skill, such as the ability to detect pattern or structure in the score, and that simply trying to look ahead will not improve this skill' (68–69). This idea brings into question how expertise has traditionally been defined and whether features of musical experience might correlate with such measures.

The definition of expertise has often relied on subjective ratings or self-reporting. For example, earlier studies examining sight-reading expertise used a teacher's estimate (Halverson 1974), the researcher's estimation (Goolsby 1987) or the test pieces being designated as being 'medium' or 'difficult' with no examples given or justification behind the classifications (Young 1971). In young's study, expertise was considered to be present if the pieces were performed 90% correctly in the 'difficult' category. Waters, Townsend, and Underwood (1998) attempted to develop an objective classification of expertise based on a participant's ability to detect differences in musical note presentations shown for 800ms duration (Waters, Townsend, and Underwood 1998). It could be argued that this task simply measures the ability to match patterns and may not be indicative of sight-reading expertise at all as there was no requirement to play the music presented on the screen. Nevertheless, Waters et al found that this ability was significantly related to participants having attained 6th Grade level of musical proficiency, however, there is no indication which grading system is being used. More recent research has shown a significant relationship between the objective measures of eye movement patterns associated with expertise (specifically the ability to 'chunk' and be hampered by unexpected visual presentation of the music) and the ability to perform a 6th Grade Australian Music Examinations Board (A.M.E.B.) sight-reading assessment piece (Arthur 2017). Consequently, these findings indicate that a pianist who performs successfully at this level can be classified as an expert in terms of visual processing. Furthermore, division of participants into expert and non-expert on this basis can be used to further examine aspects of expertise including possible links with past and present music-learning behaviours.

There is evidence that early exposure to musical training improves word decoding abilities in text reading (Standley 2008). This may be of benefit if music sight- reading was simply a sophisticated form of pattern recognition (Wolf 1976). However, these skills may diminish in importance as a child matures and comprehension skills become more important to the text reading process (Corrigall and Trainor 2011). Regardless, the age of commencement of formal music training has been found to positively correlate with sight-reading expertise (Ericsson 1996; Gudmundsdottir 2010; Kopiez and Lee 2008), as well as a higher level of theoretical musical understanding in expert wind players (Elliott 1982). It may well be that the brighter, more highly motivated children with the opportunity to do so will start music lessons early (Corrigall and Trainor 2011). Therefore, any correlations found are by no means causatory and may have no bearing on the end result when compared with a musician who started learning later in life, but for a greater length of time.

It has long been known that speech and language share similar auditory processing structures (McMullen and Saffran 2004; Moreno and Besson 2006; Rogalsky et al. 2011). Of interest in this context is the notion of 'far transfer', that is, the effect of one skill on the performance or acquisition of another unrelated skill (Rauscher and Hinton 2011). It is not unreasonable to suggest that 'far transfer' may occur if the visual processing of musical skills is trained in order to enhance the visual processing of text and vice versa.

It seems, therefore, that despite having limited objective information available to clearly define sight-reading expertise, as well as no specific pedagogical method for attaining it, a deliberate exploration of musicians' learning and performance experiences may provide some insight when moving forward in developing this area of music pedagogy.

Method

Surveys have been used before (Chin and Rickard 2010; Werner, Swope, and Heide 2006) to investigate aspects of musicians' background in relation to general music engagement and emotional responses to music respectively. The purpose of the survey in the present study was to purposefully draw out aspects of musical engagement and measure their correlation with music sight-reading expertise. The questions asked of participants (see Table 1) were based on either testing the validity of the 6th grade classification of expertise in relation to previous findings linked with music sight-reading expertise, or simply trying to tap in to other possible connections between music engagement and sight-reading expertise.

- Age at which formal training commenced and years of formal training: early commencement of music training has been found to be related to sight-reading expertise (Ericsson 1996; Gudmundsdottir 2010; Kopiez and Lee 2008).
- Grade of Practical and Theory Achieved: a higher level of theoretical knowledge was found in expert wind players (Elliott 1982).
- Training beyond Grades: to further clarify if the level of exposure to the form at a more complex level is a factor that characterises expertise in sight-reading.
- Ensemble experience, playing other Instruments, and improvisation: While sight-reading proficiency has been linked with hours spent accompanying (Lehmann and McArthur 2002), it is not known whether skills/far transfer may occur when playing music in a different to usual context or on different instruments (Rauscher and Hinton 2011).
- Second language proficiency: as there are shared brain structures in speech and language processing (McMullen and Saffran 2004; Moreno and Besson 2006; Rogalsky et al. 2011) and, anecdotally, music has been likened to learning another language, this question may provide some insight into this issue.
- Current frequency of playing and of sight-reading: to further extend our understanding into the current characteristics of music sight-readers.

Subjects were recruited from an Australian university student body for an eye movement study investigating expert and non-expert music sight-readers of piano. Each participant completed a survey as part of the data collection for the main eye movement study. Categorisation into the expert or non-expert group was based on the ability to perform a 6th Grade AMEB sight-reading examination task at or near perfection on the piano (Arthur 2017). The expertise groups were determined by one of the researchers who have an undergraduate degree in music and is a pianist with 8th Grade AMEB practical and 6th Grade AMEB musicianship qualifications. The musician participants were then

Table 1. *P* values by category according to expertise with median, percentage and descriptors.

Category	*P* value	Experts (n = 16)	Non-experts (n = 25)
Years of formal training	$P < .0001$***	>10 years	5–8 years
Practical grade achieved	$P = .0001$***	>AMUS	Grades 4–6
Theory grade achieved	$P = .0009$***	Grades 4–6	Grades 2–4
Current frequency of sight reading (>weekly/<monthly)	$P = .02$*	36% >Weekly	4% >Weekly
Training beyond Grades	$P = .03$*	43%	12%
Age commenced formal training	$P = .04$*	5–7 years	8–10 years
Ensemble experience (yes/no)	$P = .06$	93%	64%
Play other musical instruments (yes/no)	$P = .19$	79%, yes	56%, yes
Improvisation (yes/no)	$P = .51$	71%, yes	60%, yes
Read/write another language (yes/no)	$P = .73$	57%, yes	68%, yes
Current frequency of playing (>weekly/<monthly)	$P > .9999$	64% <Monthly	64% <Monthly

subdivided into 9 experts (5 males and 4 females; all between 18–20 years of age) and 12 non-expert music sight-readers (6 males and 6 females all aged between 18 and 20 except for 1 male: aged 25 years).

Results

A *t*-test was performed for each category to assess its significance in relation to sight-reading expertise. To summarise, an expert piano sight-reader is significantly more likely to have had formal music training for over 10 years, commencing before the age of 7. While achieving moderate to high grades in theory, he/she has attained their AMusA (The Associate in Music, Australia) and approximately 1/3 of this group will have a more advanced performance qualification. Currently, the expert does not generally play more often than the non-expert, but does sight-read more often and is more likely to have played in an ensemble, but not at a statistically significant level when compared with the non-experts. He/she is almost equally likely to be a bi-lingual, multi-instrumentalist and improviser as their non- expert counterpart.

Discussion

Starting formal training early in life showed a significant correlation with sight-reading expertise: $p = 0.01$ and is in agreement with several other studies (Ericsson 1996; Gudmundsdottir 2010; Kopiez and Lee 2008). Nevertheless, it still needs to be considered that these individuals may simply be more intelligent and/or highly motivated individuals with the opportunity to learn music (Corrigall and Trainor 2011). Recent research has shown that there is no difference in the structure of children's brains with the drive to learn music when compared with those who do not; despite findings of structural differences in adult musicians' brains (Norton et al. 2005). Therefore, the argument that some are predisposed to excelling in certain aspects of musical endeavour, as a result of brain structure, is unlikely.

Current sight-reading frequency of practice approached significance in relation to sight-reading expertise: $p = .08$. However, this does not imply that continuing to sight-read will improve these skills to expertise level. It may be that those who are not good at the skill will be less likely to apply it in their current musical practice.

The study findings did not indicate that the ability to improvise was correlated with sight-reading expertise: $p = .63$. This result is contrary to other findings, as is the correlation with ensemble playing: $p = .12$, and playing other instruments: $p = .63$ (Daniels 1986; Gudmundsdottir 2010; Kopiez and Lee 2008; Mishra 2014a, 2014b; Waters, Townsend, and Underwood 1998; Woody 2012). One possible explanation is that the survey participants were all piano players. In this context, the piano is mainly a solo instrument and expert sight-readers in this study were highly correlated with high achievement in solo performance. Achieving such a level involves exhaustive amounts of commitment and practice; probably at the exclusion of other musical pursuits. Regardless, sight-reading expertise was achieved without significant engagement in such activities. While the survey results do not confirm the correlation of improvisation or ensemble playing with sight-reading expertise, it is not to say that such activities have no value in learning to sight-read in the general sense. However, they do not appear to be a factor in relation to expertise in the piano sight- reading domain.

Fluency in another language does not appear to be significantly related to sight-reading expertise: $p = .87$. Considering approximately 2/3 of both groups were bilingual, this aspect of visual processing appears to have no relevance in this context.

The high significance of the level of theoretical grade attained, $p = .001$, was second only to the years of formal training and is somewhat surprising considering sight-reading ultimately involves a performance output. However, an 'expert' in any processing domain is characterised by the ability to 'chunk' elements of their skills into smaller units for efficient processing (Ashby, Rayner, and Clifton 2005; Gobet et al. 2001; Heller 1982; Kowler 2011; Legge 2007; Meseguer, Carreiras, and Clifton

2002; Rayner 1998; Rayner et al. 2006; Truitt et al. 1997; Underwood, Hubbard, and Wilkinson 1990). Expert music sight-readers have been shown to exhibit these characteristics in many past eye movement studies (Furneaux and Land 1999; Goolsby 1987; Kinsler and Carpenter 1995; Schmidt 1981; Sloboda 1974, 1977; Truitt et al. 1997; Wolf 1976; Wurtz, Mueri, and Wiesendanger 2009). Further evidence of this 'chunking' characteristic is that musicians' eye movement patterns are known to be disrupted when unusual or unexpected rhythmic or harmonic structures are encountered (Arthur, Blom, and Khuu 2016; Sloboda 1977; Wurtz, Mueri, and Wiesendanger 2009). The experts in this current study were categorised by the ability to perform to a prescribed sight-reading level, Grade 6 AMEB, which had been shown to be the demarcation of expertise according to eye movements as part of a broader work (Arthur 2017). Therefore, extensive knowledge of the 'rules' of western art music would be a logical prerequisite for efficient visual processing of music score and help to explain these results.

The findings in this study significantly supported the claims of past researchers regarding the age at which formal music training commenced, the years of formal training, the grade of practical and theory achieved and the attainment of advanced performance qualifications appear to support the theory that deliberate practice alone will result in expertise (Ericsson, Krampe, and Tesch-Romer 1993). However, this does not address the role of WMC regarding expertise.

Participants in this study were part of a larger study exploring other characteristics of expert piano sight-readers. A key characteristic of visual processing expertise generally is superior WMC (Meinz and Hambrick 2010) and this same group of sight-reading experts possessed significant higher WMC when compared with the non-expert group: $p = .02$ (Arthur 2017). This finding suggests that superior WMC is necessary for piano sight-reading expertise to develop and that 6th Grade AMEB sight-reading capability may be a reasonable indicator that expertise exists in that group. Further testing with respect to 5th Grade abilities relative to eye movements patterns would be needed to be sure if there is an absolute cut-off at 6th grade level.

In relation to previous categorisations of sight-reading expertise, it cannot be concluded from these data that a tertiary music student is an expert sight-reader. Only one of the participants was currently enrolled in an undergraduate music programme. This participant was categorised as an expert sight-reader according to the study criteria. However, another participant had recently completed an undergraduate music degree and this individual was categorised as a non-expert sight-reader. Consequently, conclusions drawn from studies that use enrolment in a tertiary music programme as the definition of sight-reading expertise may be misleading. Also, those that had training beyond AMEB grades in this study, apart from these two with university training, had performance-based certificates and diplomas. Perhaps a more appropriate characteristic is that an expert sight-reader is more likely to have an advanced performance qualification than a non-expert, rather than be a tertiary music student or have attained an undergraduate music degree.

Having said that, when interpreting these data, one must keep in mind that the results are correlational in nature with testing performance using pianists only. Therefore, care needs to be taken if extrapolating across all instruments and assuming that simply engaging in any or all of these practices causes one to become an expert sight-reader. In addition, the study does not seek to suggest that those musicians who were categorised as 'non-expert' were not *competent* sight-readers. Expertise was categorised on the basis of objective eye movement patterns conforming to the criteria for expertise, including fewer forward eye movements with fewer regressive (backward) eye movements to complete the sight-reading task (Arthur 2017).

If WMC is needed to achieve functional expertise in piano sight-reading, this could explain why 'some normally functioning people (may) never acquire expert performance in certain domains, regardless of the amount of deliberate practice they accumulate' (Hambrick et al. 2014). That is, no matter how hard they try, some students never become proficient at sight-reading, let alone become an expert. Another reason for this observation may be the finding that text reading dyslexia and music reading dyslexia have similar processing components and commonly co-exist in the same individual (Gaser and Schlaug 2003). As for this not being commonly recognised, it could be that

those who take formal music lessons and struggle with sight-reading are free to discontinue lessons or succeed in a more ear-based mode of instruction. On the other hand, students are not free to leave school if they struggle with text reading and the condition will become progressively apparent with increasing educational demands.

While the results indicate that both superior WMC and a sound knowledge of theory are critical for sight-reading expertise to develop, what appears to be lacking are strategies for teaching these skills. If 'sight-reading is a teachable activity rather than a stable characteristic and … .. is a skill that improves with the musicality of the performer' (Mishra 2014), could it be that what needs to be taught in order to facilitate improvement in sight-reading skill is a deep knowledge of the theory of western art music and its stylistic characteristics? How might this be taught in a way that enhances sight-reading abilities or does this just happen automatically over time?

Some strategies informed by the literature are: developing students level of theoretical understanding (Elliott 1982); use of chord symbols to 'reinforce transfer of theory skills and to solidify the connection between the written chunks and the associated motor skills'; identifying harmony notes in the melody so students recognise non-chord notes (Pike 2012, 26); and developing an understanding of style including structure, formulas, harmony and phrase 'to develop pattern recognition and prediction skills … ' (Zhukov 2014b, 75). Such strategies might all be facilitated by engagement in activities such as student research as a way of developing an understanding of western art music; teacher demonstration and student experimentation of various styles and genres; helping students develop a sound knowledge of harmony through learning chords early on; and lastly, understanding in a practical way, how chords generally move and the ways that they fit together in various genres and eras.

It should be understood that, even with the strategies outlined, not all students will become expert sight-readers; but they could well become adequate sight-readers and competent musicians. The survey results suggest that high levels of theoretical knowledge are related to sight-reading expertise. Is this the 'stylistic understanding' that Zhukov is referring to? Is this then the aspect of 'musicality' that needs to be further explored?

Conclusions

The present study has shown that piano music sight-reading experts – so defined according to eye movement patterns – possess certain characteristics related to their musical education that are similar to expertise development in other domains, including early age of skill acquisition, extensive practice and superior WMC. While the acquisition of sight-reading skill improves with the increased 'musicality' of the individual, the process still remains elusive (Elliott 1982; Meinz and Hambrick 2010).

Improvisation and collaborative ensemble playing were not found to be significantly related to sight-reading expertise but are, nevertheless, most enjoyable and valuable in the development of a well-rounded musician and may play a role in the acquisition of sight-reading skills at the beginner level.

Of particular interest is the significance of theoretical domain knowledge. It may be that the more a student becomes familiar with the theory of Western Art Music, through teacher-directed research and/or a sound knowledge of chordal harmony, as an example, the better able they are to take advantage of the predictability of the music's visual presentation. This may be what facilitates the 'chunking' necessary for increased efficiency in visual processing and calls for more controlled studies to investigate this phenomenon in the musical domain.

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Data Availability statement

The data that support the findings of this study are available from the corresponding author, Patricia Arthur, upon reasonable request.

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P. Arthur is an Optometrist (UNSW 1981) with a degree in music (Dean's Medalist from Western Sydney University, 2012) and PhD in Vision Science (UNSW, 2017). Her research involves the visual processing characteristics of expertise, music sight-reading expertise in relation to eye movements and the role of innate versus environmental factors in the development of visual processing expertise generally.

E. McPhee is an instrumental teacher and ensemble director with over twenty years' experience. Her PhD (Western Sydney University, 2014) investigated the ways that instrumental teachers learn to teach. She was awarded the 'Australian Society for Music Education Callaway Doctoral Award' for the best doctoral thesis in music education from an Australian university (presented biennially). When not teaching, Eleanor performs with *The Moving Picture Show;* creating historical performances of silent films from the 1920s with a live orchestra and sound effects.

D. Blom is a composer and pianist, published on higher education music performance, the artist as academic, student popular songwriters, auto-ethnography and preparing contemporary classical Australian piano music for performance. She has co-curated several composition/performance/CD projects. Scores and CD publications have been released by Wirripang P/L., Orpheus Music and Wai-te-Ata Press. She is co-author of composition textbook, *Music Composition Toolbox* (Science Press). Diana is an Associate Professor of Music at Western Sydney University.

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