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The Role of Visual and Auditory Feedback during the Sight-Reading of Music

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This study examined the role of auditory and visual feedback during the sight-reading of a short piece of piano music. Its purpose was to identify errors that arose due to the removal of feedback and to compare the performances of pianists at different levels of sight-reading practice frequency, general musical experience and sight-reading ability. Subjects were tested under the following conditions: normal sight-reading, sight-reading when unable to view the keyboard (no visual feedback) and sight-reading where auditory feedback was unavailable (no auditory feedback). The findings indicated that performances where visual feedback was unavailable resulted in a significantly increased number of adjacent note errors, suggesting that visual feedback is utilised by pianists in order to guide the discrete movements of the hands over the keyboard, but that the degree to which it is relied upon is dependent on the pianist's familiarity with the sight-reading situation itself. Sight-reading when auditory feedback was unavailable proved to be indistinguishable from normal sight-reading, both being superior to performances where visual feedback was unavailable. General musical experience and sight-reading ability were significant factors in distinguishing between errors which might produce a breakdown in performance and those which will not impede fluency. This raises a series of questions concerning (*a*) differences between high ability and low ability pianists and (*b*) efficient practice techniques and objectives.

Introduction

Feedback is a relational concept that is used to describe a set of systems or mechanisms that, when acted upon, or are in turn acted on, can detect and correct errors, monitor and guide performance and enable the desired result to be obtained. Adams (1968) described feedback as the "sensory after-effects of responding" and feedback itself is one of the most important elements necessary for the learning, acquisition and execution of many skills. Miller (1953) distinguished two types of feedback—action feedback and learning feedback. Action feedback refers to feedback that arrives and can be used during a response. Learning feedback refers to information available after completion of the response, such that it can only be used to modify subsequent responses.

During normal, undelayed feedback conditions, studies have provided consistent evidence that vision dominates over other sensory systems. Colavita (1974) showed that if subjects were expecting to have to react as quickly as possible to either a light or a tone, and both the light and tone were present on some trials, subjects saw the light and responded to it without being able to report hearing the tone at all. It was therefore suggested that subjects attend primarily to vision as opposed to audition when required to make fast spatial responses. Walker and Scott (1981) however, found that visual dominance did not occur when the required task was temporal in character.

They asked subjects to estimate the duration of the presentation of either a tone, a light, or a tone and a light together. Their results indicated that estimates were more accurate for the tone, or the tone and the light together, but during trials when only the light was present, the estimates were much less accurate. Thus, when the visual cue was present with the auditory cue, subjects behaved in the same way as they did when the auditory cue alone was present. Walker and Scott suggested that the dominance of a sensory modality is related to the nature of the task. When the task is spatial, visual modality dominates, whereas when the task is non-spatial in nature, audition dominates. Hence, the dominance of a specific modality appears to depend on the type of information required in order to successfully complete a task. Research undertaken in the field of typing has produced interesting results with respect to the function of visual feedback. Diehl and Seibel (1962) restricted the visual feedback of typists by attaching a cardboard mask to a typewriter so the typed copy could not be seen. West (1967) attached a paper shield to the necks and waists of his subjects so the typed copy and the keyboard could not be seen. The results of these experiments indicated that visual consultation of both the printed copy and the keyboard forms an integral part of skilled typing. By masking the printed copy, the percentage of errors that were corrected was reduced. By masking the keyboard itself, the speed and accuracy of the performances was reduced, with more errors occuring with unfamiliar keys or keys placed horizontally adjacent to each other. The conclusions from these experiments identified two functions of visual feedback: to maintain the fingers in the home row position and to detect errors. With respect to skilled typists, the function of feedback altered slightly: to make the keystroke itself and to confirm the correctness of the stroke.

Movement requires advance organisation, and where the success of movement organisation is based on the accuracy of the motor system, movement guidance is typically based on visual feedback. One issue arising from early studies on sight-reading was the suggestion that experienced musicians had a better motor response organisation due to greater familiarity with notation. Sloboda (1976, 1978) examined this suggestion by comparing subjects with no musical training with those who were good sight-readers. Subjects were asked to copy highly simplified excerpts of musical notation onto a bare stave after a brief viewing time. Results indicated that although no differences were found between groups for a 20-millisecond exposure time, musicians retained the contour (up/down relationship of adjacent notes) better than non-musicians during a two-second exposure time. Thus, it seems that increased performance by musicians in a response task is not due to a superior motor response organisation or highly speeded input scanning rate, but to a superior encoding system that encodes both the global and specific attributes of an array.

Research developing from the recording of eye movements (Weaver, 1943; Rayner, 1978; O'Regan, 1979) has led to the investigation of how much text is previewed visually during the execution of a task. Levin and Kaplan (1970) employed a technique to estimate the difference in number of words being spoken and the words being processed visually. To test how far in advance text was being previewed, they asked subjects to continue reading a piece of prose after the text had been unexpectedly removed. The distance between the word uttered at the time of removal and the final correct word gave the eye/voice span of the subject. The results indicated that in normal reading situations, the eye/voice span of an experienced reader is between four and six words. Sloboda (1974, 1977) adapted the technique used by Levin and Kaplan in prose reading to the sight-reading of a melody line in order to estimate the eye/hand span of sight-readers. Structural groupings of melodic extracts, harmonic progressions and rhythmic patterns create natural phrase boundaries within music and Sloboda found that by manipulating these structural units he could vary the eye/hand span of the readers. The results showed that good sight-readers had an average eye/hand span of six to seven notes, whereas poor sight-readers had an average span of three or four notes. When the removal of the score coincided with a natural phrase boundary that was just beyond average span, the span increased. Likewise, when the phrase boundary was just inside the average span, the span contracted.

Based on the research findings relating to feedback and the processing of information during sight-reading, one might expect the function of feedback during the task of sight-reading to vary in nature depending on a number of factors: the difficulty of the music required to be sight-read, the degree to which the motor system can operate accurately without guidance, and the performer's ability to comply with the requirements of the task.

The present study aimed to extend the literature on the function of visual and auditory feedback by examining the role of these two forms of feedback during sight-reading for subjects assigned to groups according to their degree of general musical experience, frequency of sight-reading practice and sight-reading ability.

Method

Subjects and Design

Fifteen subjects took part in the experiment. All were pianists who had attained grade 6 or above in the Associated Board of Piano Examinations and were practising the piano regularly at the time of the experiment.

A repeated measures design was used for the experiment. Each subject sight-read three test pieces in each of three conditions: normal sight-reading, sight-reading when unable to view the keyboard, and sight-reading when unable to hear what was being played.

Apparatus and Procedure

Each subject was required to perform on an electronic keyboard (Korg Sampling Grand) which was linked via MIDI to an Atari computer (SM124). The performances were recorded and notated using the C-Lab music software package. During the no visual feedback condition, a 3-ft (92 cms) long screen of wooden board with the wrist height allowance of 6″ (15 cms) was placed over the keyboard to prevent subjects from seeing their hands. The keyboard was connected to two external speakers (Boss MA-12) which were turned off during the restricted auditory feedback condition. The subjects were given 10 minutes in which to become accustomed to the keyboard and to experience performing under each of the respective test conditions. Subjects were then presented with three different pieces to sight-read under the three different testing conditions: normal sight-reading, sight-reading when unable to see the keyboard, and sight-reading when unable to hear what was being played. Subjects were given up to one minute to view each piece before sight-reading was attempted. Subjects were instructed to adhere to the general sight-reading rules of keeping to a steady tempo of their choice, to refrain from repeating sections, and to "keep on going" to the best of their ability. The three pieces required for sight-reading were excerpts taken from the Associated Board of Music Sight-Reading Examinations Grade 5 (1985). The musical material was different for each of the three conditions and the pieces were selected on the basis of their similar difficulty level and contrapuntal style. As the three pieces each had different time signatures: duple, triple and quadruple respectively (see Figures 1–3), the presentation order of the test music was randomly varied across conditions to eliminate any possible bias towards any one piece. As the material itself was novel and also relatively short (10 to 12 bars), it was assumed that practice effects would be negligible and so the order of the sight-reading conditions was fixed. The normal sight-reading condition was attempted first to establish the base-line ability of the subjects, followed by the no visual feedback and no auditory feedback conditions respectively.

FIG. 1

FIG. 2

FIG. 3

The subjects were asked to rate their performances as very bad, poor, average, quite good, or very good immediately after having sight-read each piece and then again after having heard a sound recording of their performances. Subjects were also asked to complete a general musical background questionnaire which served to assign them to their respective testing groups.

Data Analysis

Based on the answers provided on the general musical background questionnaire, subjects were assigned to one of the three mutually exclusive groups for each of three independent scales:

1. **General Musical Experience**

Subjects were assigned to groups according to the last grade that they had attained at examination level. Piano examinations are graded according to the difficulty factor of the examination. As the grade level increases, the requirements necessary for attaining a proficiency certificate at that grade also increase. Such requirements include the number of pieces required, the difficulty (both technical and "musical") of the pieces involved, technical ability required (scales and arpeggios), aural ability (listening tests) and sight-reading ability. Thus, pianists who have attained grade 8, will have undergone a more rigorous examination over a greater number of musical components than pianists at the grade 6 and 7 level.

2. **Frequency of Sight-Reading Practice**

Subjects were also assigned to one of three groups according to their self-reported frequency of sight-reading practice: often (at least once every two weeks), occasionally (once every few months) and rarely (only in preparation for an examination, *i.e.* about once a year).

3. **Sight-Reading Ability**

Subjects were further assigned to one of three groups according to whether their total individual error scores for normal sight-reading (condition 1) placed them in the upper, middle or lower third of the total error results. Pianists in the top group (upper third) incurred the least number of total errors during normal sight-reading.

Whilst a certain degree of overlap might have been expected between groups, the subject distribution pattern that emerged (see Table 1) suggested that the groups were sufficiently dissimilar to warrant independent analysis.

TABLE 1
Frequency distribution of subjects between groups.

		Sight-Reading Ability			*General Musical Experience*		
		Good	*Average*	*Poor*	*Gd 6*	*Gd 7*	*Gd 8*
Sight-Reading Practice Frequency	Often	2	2	1	2	1	2
	Occasionally	1	1	3	1	3	1
	Rarely	2	2	1	2	1	2
General Musical Experience	Grade 6	0	2	3	—	—	—
	Grade 7	3	1	1	—	—	—
	Grade 8	2	2	1	—	—	—

Analysis of Performance

Subjects had been asked to rate each of their sight-reading performances as "very bad", "bad", "average", "quite good" or "very good". Subjects' ratings before having heard the sound recording of their performances were then compared with the ratings assigned to each performance after having heard the sound recording. In order to establish the degree of rating change, a 5-point numeric scale was used and a change in rating was recorded in terms of the numerical difference of the two ratings. For example, subjects who had initially rated their performance as having been "quite good" and then altered their rating to "average" following play back, consequently achieved a performance change rating of -1. Thus, these subjects had overestimated the success of their performance initially and subsequently re-evaluated their performance.

The computer notated scores for each of the subjects' sight-reading performances were compared to the original scores of the test material. These scores were then examined to establish what errors had occurred during specific performance conditions and for which ability group.

Errors were subsequently categorised into one of ten error types:

1. Accidental (flat/sharp) errors.
2. Step errors (errors between notes positioned adjacently to each other).
3. Leap (interval larger than a third) errors.
4. Omitted note errors.
5. Correction to previous note errors.
6. Incorrect movement assumption errors, *i.e.* the played music moves in a direction that is directly contrary to the written score.
7. Notes played instead of tied errors.
8. False starts, *i.e.* no errors incurred during first attempt but section is repeated.
9. Repeats due to error/errors during first attempt.
10. Rhythmic errors, *i.e.* the incorrect on/off timing values of individual notes.

Error types were also grouped according to the following classifications:

Total errors (types 1–10).
Melodic errors (types 1–7).
Rhythmic errors (type 10).
Specific errors (types 1–9).

It should be noted at this point that because the total error category is comprised largely of melodic errors, the results of the melodic error scores across conditions will inevitably be reflected in the results of the total error scores across conditions.

Results

Table 2 provides a summary of the mean frequency scores for main errors and specific error types. One-way analysis of variance was performed on the melodic, rhythmic, total and specific errors over the three sight-reading conditions. A Tukey HSD test was performed to follow up the significant main effects for conditions.

TABLE 2

Mean frequency of sight-reading errors across conditions.

	Normal Sight-Reading	*No Visual Feedback*	*No Auditory Feedback*
1. Accidental Errors	2·06	2·67	2·93
2. Step Errors	0·87	15·93*	1·67
3. Interval Errors	0·27	0·73	0·13
4. Omitted Note Errors	1·33	2·93	1·13
5. Correction Errors	0·40	0·87	0·26
6. Incorrect Mvmt Assumptions	0·00	0·47	0·07
7. Tied Errors	0·40	0·06	0·13
8. False Starts	0·27	0·20	0·00
9. Repeats	1·00	0·93	0·33
10. Rhythmic Errors	4·47	4·47	2·80
Melodic Errors (1–7)	5·47	24·87*	6·74
Total Errors (1–10)	11·53	30·40*	10·07

*$p<0{\cdot}01$.

Both the number of melodic errors [$F(2,28) = 12{\cdot}73$, $p<0{\cdot}01$], and total errors [$F(2,28) = 9{\cdot}73$, $p<0{\cdot}01$] increased significantly when subjects were unable to view the keyboard during sight-reading compared with normal sight-reading [$p<0{\cdot}01$] and sight-reading when unable to hear what was being played [$p<0{\cdot}01$]. There were no significant differences found between conditions for the number of rhythmic errors incurred [$F(2,28) = 0{\cdot}53$, *NS*].

One-way ANOVA for each specific error type over conditions indicated that the number of step errors incurred by subjects was also significantly different [$F(2,28) = 8{\cdot}85$, $p<0{\cdot}01$] with there being a significant increase in step errors during restricted visual feedback as compared with both normal [$p<0{\cdot}01$] and restricted auditory feedback sight-reading conditions [$p<0{\cdot}01$].

A separate two-way analysis of variance was performed for each error type on the sight-reading conditions (3) X group levels (3) for musical experience, practice frequency and sight-reading ability groups. Tukey's HSD test was performed to follow up the significant main effects for levels and conditions.

General Musical Experience

Table 3 gives a summary of the mean scores for main error types and significant specific error types over the different subject group experience levels.

The overall sight-reading results revealed significant main condition effects for the total error scores [$F(2,24) = 8{\cdot}97$, $p<0{\cdot}01$], melodic error scores [$F(2,24) = 12{\cdot}37$, $p<0{\cdot}01$] and specific errors of the step error type [$F(2,24) = 8{\cdot}63$, $p<0{\cdot}01$]. Significant grade level effects were found for the total number of errors [$F(2,12) = 6{\cdot}75$, $p<0{\cdot}01$], rhythmic errors [$F(2,12) = 5{\cdot}52$, $p<0{\cdot}05$], corrections to previous note errors [$F(2,12) = 4{\cdot}86$, $p<0{\cdot}05$] and repeats due to errors [$F(2,12) = 4{\cdot}56$, $p< 0{\cdot}05$]. Tukey's post-hoc test indicated that sight-reading when unable to view the keyboard resulted in significantly more total errors, melodic errors and step errors than either normal sight-reading

TABLE 3

Mean frequency of total, melodic, rhythmic and significant specific error types over sight-reading conditions for general musical experience group levels.

	Normal Sight-Reading			*No Visual Feedback*			*No Auditory Feedback*		
	Grade 6	*Grade 7*	*Grade 8*	*Grade 6*	*Grade 7*	*Grade 8*	*Grade 6*	*Grade 7*	*Grade 8*
Step Errors	1·0	0·2	1·4	25·0	13·2	9·6	2·2	2·0	0·8
Correction Errors	0·8	0·4	0·0	1·0	1·2	0·4	0·4	0·4	0·0
Tied Errors	1·2	0·0	0·0	0·2	0·0	0·0	0·4	0·0	0·0
Repeats	2·0	0·8	0·2	2·4	0·4	0·0	1·0	0·2	0·0
Rhythmic Errors	10·0	2·2	1·2	7·4	3·2	2·8	4·2	3·2	1·0
Melodic Errors	6·0	4·2	6·2	34·6	23·8	16·2	10·4	4·8	5·0
Total Errors	20·0	7·0	7·6	44·8	27·2	19·2	15·8	8·4	6·0

TABLE 4

Mean frequency of total, melodic, rhythmic and step errors over sight-reading conditions for sight-reading practice frequency group levels.

	Normal Sight-Reading			*No Visual Feedback*			*No Auditory Feedback*		
Sight-Reading Frequency	*Rarely*	*Occasionally*	*Often*	*Rarely*	*Occasionally*	*Often*	*Rarely*	*Occasionally*	*Often*
Step Errors	1·8	0·8	0·0	37·2	8·8	1·8	1·2	1·8	2·0
Rhythmic Errors	1·4	11·2	0·8	5·4	7·2	0·8	2·0	5·2	1·2
Melodic Errors	6·8	6·6	3·0	49·0	17·8	7·8	9·6	7·8	2·8
Total Errors	9·6	20·8	4·2	55·8	26·6	8·8	11·8	14·4	4·0

[$p<0{\cdot}01$ in all cases] or sight-reading when unable to hear what was being played [$p<0{\cdot}01$ in all cases]. Grade 6 pianists made significantly more total errors and rhythmic errors than either grade 7 [$p<0{\cdot}05$] or grade 8 pianists [$p<0{\cdot}05$], more corrections to previous note errors than grade 8 pianists [$p<0{\cdot}05$]; played more tied notes than either grade 7 [$p<0{\cdot}05$] or grade 8 pianists [$p<0{\cdot}05$] and repeated musical sections more often than grade 8 pianists [$p<0{\cdot}05$].

Frequency of Sight-Reading Practice

Table 4 gives a summary of the mean scores for main error types and significant specific error types for the different subject group practice levels.

The effects of practice level were significant [$F(2,12) = 26{\cdot}40$, $p<0{\cdot}01$] with pianists who reported that they rarely practised sight-reading making significantly more melodic errors during sight-reading than pianists who reportedly either practised sight-reading occasionally [$p<0{\cdot}01$] or often [$p<0{\cdot}01$]. The interaction of practice level X sight-reading condition was also significant [$F(4,24) = 10{\cdot}73$, $p<0{\cdot}01$] with pianists who reported rarely practising sight-reading making significantly more melodic errors when unable to view the keyboard. A significant level X condition effect was also found for the number of step errors [$F(4,24) = 12{\cdot}37$, $p<0{\cdot}01$], with pianists who reported that they rarely practised sight-reading incurring significantly more step errors during the no visual feedback condition than either pianists who reported occasional [$p<0{\cdot}01$] or frequent sight-reading practice [$p<0{\cdot}01$]. Rhythmic errors were also found to be incurred significantly more often for pianists who reported that they occasionally practised sight-reading, but this was not found to be dependent on the sight-reading conditions imposed [$F(2,12) = 15{\cdot}46$, $p<0{\cdot}01$].

Sight-Reading Ability

Table 5 gives a summary of the mean scores for main error types and significant specific error types for the group sight-reading ability levels.

The effects of ability level were found to be significant for both the number of rhythmic errors incurred by subjects [$F(2,12) = 4{\cdot}32$, $p<0{\cdot}05$], accidental (flat/sharp) errors [$F(2,12) = 8{\cdot}7$, $p<0{\cdot}01$] and repeated section errors [$F(2,12) = 5{\cdot}26$, $p<0{\cdot}05$]. Pianists of a comparably low sight-reading ability made significantly more rhythmic and accidental errors than either average ability [$p<0{\cdot}01$ in both cases] or high ability pianists [$p<0{\cdot}01$ in both cases]. Low sight-reading ability pianists also repeated sections of the music significantly more often than high ability pianists [$p<0{\cdot}01$]. There were no significant ability X condition interactions found for this group.

Pearson's product moment correlation was computed between the degree of performance rating change and the total number of errors incurred for each sight-reading condition. Results indicated that for normal (unrestricted feedback) sight-reading, more successful sight-reading performances were characterised by subjects initially underestimating the success of their performances prior to playback [$r = -0{\cdot}51$, $p<0{\cdot}05$]. No significant correlations were found for either the restricted visual feedback condition, or the restricted auditory feedback condition.

TABLE 5

Mean frequency of total, melodic, rhythmic and significant specific errors over sight-reading conditions for sight-reading ability group levels.

	Normal Sight-Reading			*No Visual Feedback*			*No Auditory Feedback*		
	Poor	*Average*	*Good*	*Poor*	*Average*	*Good*	*Poor*	*Average*	*Good*
Accidental Errors	3·6	1·4	1·2	3·8	0·4	3·8	4·8	2·6	1·4
Step Errors	1·8	0·8	0·0	13·0	23·4	11·4	0·6	3·0	1·4
Repeats	2·2	0·8	0·0	2·2	0·4	0·2	0·8	0·0	0·2
Rhythmic Errors	10·4	2·0	1·0	6·8	5·0	1·6	3·8	1·6	3·0
Melodic Errors	9·6	5·2	1·6	25·2	29·4	20·0	8·4	8·0	3·8
Total Errors	23·8	8·2	2·6	34·6	35·0	21·6	13·6	9·6	7·0

Discussion

The present study sought to evaluate the role of feedback during sight-reading and to identify common errors associated with skill level and feedback removal. The results are comparable to those of West (1967) and Diehl and Seibel (1972), in that visual feedback appears to be a necessary requirement of skilled performance which facilitates movement accuracy. Sight-reading in the absence of visual feedback resulted in poorer performances comprising mainly of adjacent note errors (step errors) which were reflected in the increase of melodic errors. These errors were found however to vary depending on a number of characteristics possessed by the performer. All pianists were disrupted by the removal of visual feedback—independent of their musical experience and sight-reading ability. Pianists who had reported that they rarely practised sight-reading however, made significantly more adjacent note errors (step errors) when unable to view the keyboard than pianists reporting more frequent practice. Because one of the main objectives of practising sight-reading is to improve the speed and fluency of reading, the visual checking and guidance of each movement would be expected to disrupt the intended fluency. Hence, a certain amount of trust and confidence in one's own ability to move around the keyboard unguided, in order to concentrate on reading the music, has to be attained. These results suggest that pianists who rarely practise sight-reading, rely more on visual feedback in order to execute discrete movement actions that cannot be left unattended due to their lack of practise in moving around the keyboard unguided.

Performances in the absence of auditory feedback were found to be both indistinguishable from normal sight-reading and superior to performances in the absence of visual feedback. Although these findings indicate that auditory feedback does not appear to affect the accuracy of movement during sight-reading, the correlational findings suggest that it is utilised in order to monitor performance. The significant correlations between performance success and rating changes suggest that pianists who achieve successful sight-reading performances during normal sight-reading, tend to initially underestimate their performances. Conversely, subjects who had originally overestimated their performances were also those subjects who had made the most errors during the performance. These results suggest that the manner in which auditory feedback is being utilised, varies depending on the skill level of the pianist. More capable pianists appear to be consulting auditory feedback when the performance begins to deviate from the intended sound, thus enabling the appropriate performance adjustments to be administered. Hence, the initial memory of the performance is one based primarily on the transgressions made from the intended performance which causes pianists to underestimate their performance. Less competent pianists, however, tend initially to overestimate their performances during normal sight-reading. One possible explanation for this is that less skilled sight-readers are unable to formulate a clear mental representation of the performance prior to attempting the music, and so utilise auditory feedback in order to confirm the correctness of the proceedings. It may be the case that they are only monitoring the performance when there is a limited workload on the motor system. Hence, when the workload increases, their attention may become diverted away from the produced sound, and directed towards the immediate processing of the information and instigation of the movement itself. Hence, the initial memory of the performance would reflect those performance areas that were expected to be successful and which were successful—thus encouraging the pianist to overestimate the performance prior to playback.

As sight-reading is a complex motor task, the necessary procedures employed in order to complete the task must be highly flexible and able to operate quickly. Successful performances can only be attained if the performer can structure significant units of information during processing and maintain a clear representation of the sound to which the performed sound can be compared in order to administer necessary performance adjustments. Given that perfection in sight-reading is a distant goal for the majority of pianists, it is accepted that errors will be made during the average sight-reading performance and that the initial representation of the sound held by the performer, will not always be reproduced. Each performer therefore has to cultivate a sense of proportion and distinguish between those errors that will invariably produce a breakdown in performance (vital errors) and those which will not impede fluency (non-vital errors).

The results of ther present study indicate that musical experience and sight-reading ability are significant factors in distinguishing between vital and non-vital errors. Pianists with less musical experience (*i.e.* grade 6), and pianists of a relatively low sight-reading ability made significantly more rhythmic errors during sight-reading than higher level pianists in their respective groups. Although the occurrence of rhythmic errors alone does not directly imply a breakdown during performance, subsequent errors were incurred by these pianists which did directly disrupt the fluency of performance. Both groups of pianists were found to repeat musical sections more often than higher level pianists. Less musically experienced pianists were found to correct previous note errors to a significant degree, thus displaying signs of being unable to distinguish between vital and non-vital performance errors. Instead of accepting the occurrence of pitch errors and continuing as required, pianists attempted to rectify their mistakes, but in doing so, forced the occurrence of more severe errors which subsequently led to performance breakdowns. Poor sight-readers were also found to have significantly more breakdowns during performances due to the repetition of musical sections that had initially contained accidental (flat/sharp) errors. Poor sight-readers were therefore displaying signs of being unable to structure large enough units of information that would enable them to carry over flat/sharp accidental information from the present note to subsequent notes outside of close proximity. These findings support previous findings on the discrepancies between the eye/hand spans of good and poor readers (Sloboda, 1974, 1978; Halpern and Bower, 1982).

In summary, the study reported here has both confirmed earlier findings by researchers regarding the roles of visual and auditory feedback in complex motor skills, and extended these findings to the realm of music education. For fluency in sight-reading to be achieved, the performer must not only be acquainted with what constitutes a fluent performance, but must also be able to distinguish between those errors that might lead to a breakdown in performance, and those that might not. Furthermore, whilst visual consultation of the keyboard forms an integral part of sight-reading behaviour, the findings revealed that poor sight-readers can be overly dependent on visual consultation in order to secure accurate movement judgements.

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