THE ROLE OF WORKING MEMORY AND SHORT-TERM MEMORY IN SIGHT READING

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ABSTRACT

Background. Sight reading is a functional skill which is required by all musicians, however the differences between individuals in sight reading achievement have not yet been fully explained. Until now, most research compared different methods of teaching sight reading without providing a feasible theory behind sight reading.

Aims. Sight reading can be divided into 3 stages; information intake, information processing and performance. This paper emphasises the importance of the second stage of sight reading by studying the role of working memory, short-term memory and mental speed in sight reading. This paper demonstrates that working memory and short-term memory capacity and mental speed could be three important predictors for sight reading achievement.

Method. (a) Sight reading task. For the sight reading task, Lehmann and Ericsson's (1993) paradigm of a pre-recorded pacing melody was used. Stimulus consisted of 2 warm up pieces and 5 pieces with increasing complexity. These pieces were taken from existing sight reading literature and a solo part was added. Subjects were required to accompany the pre-recorded violin part.

(b) Memory task. For the measurement of working memory capacity and short-term memory capacity, the procedure used in Oberauer et al. (2000) is used in this paper. Working memory test requires the subjects to do more than one simple numerical calculations simultaneously which are presented in different active cells on the computer screen. The short-term memory test requires the subjects to recall the correct order of numbers which are shown one after the other on the computer screen. Both tests increase in complexity.

c) Mental speed task. To measure the mental speed, we used the Oswald and Roth's (1987) *The Number Connection Test* (Der Zahlen-Verbindungs-Test, ZVT). 52 piano students from the Hanover University of Music and Drama served as subjects.

Results. Results from Spearman's rank correlations show a clear relationship between general cognitive skills and sight reading performance. It will be demonstrated that this may lead to a feasible theory behind sight reading achievement.

Conclusion. The main conclusion is that sight reading skill should be explained within the framework of general cognitive skills. Working memory, short-term memory and mental speed are significant predictors for sight reading achievement. The relationship between cognitive factors and acquired sight reading expertise will be addressed.

1. SIGHT READING

Sight reading is the ability to play music from a printed score or part for the first time without the benefit of practice (Wolf, 1976). Sight reading is a functional skill which is required by all musicians to be able to learn new pieces in a limited time, to accompany or to play ensemble or to improvise. After 80 years or research in sight reading, there is still no theory based method or text books which can be used to teach sight reading and this is due to that there is no feasible theory behind sight reading.

Instead of focusing on the effectiveness of teaching methods as the other researchers have done, we start at the very bottom and approach sight reading from the bottoms up approach by investigating the different component skills involved in sight reading. Amongst these component skills we focused on the cognitive skills required for sight reading in this paper which will contribute to the construction of a theory.

1.1. Different Stages Involved in Sight Reading

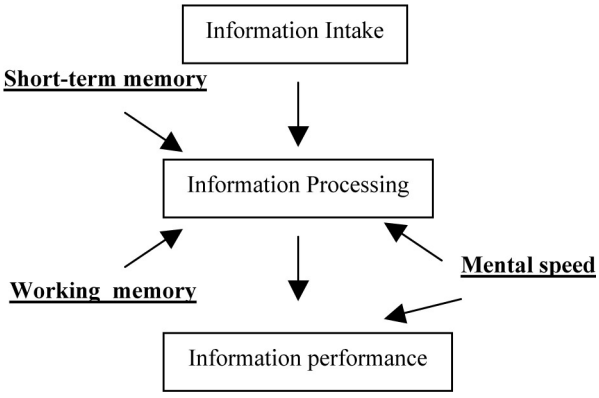

Figure 1: The three different stages involved in sight reading and where the two cognitive skills are required.

Figure 1 shows that sight reading can be divided into 3 stages; information intake, information processing and performance of the information. This paper focuses on the role of three cognitive skills involved in the second stage and they are the working memory, short-term memory and mental speed. These three skills could be two important predictors and explain where the bottleneck lies for sight reading achievement.

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2. THE ROLE OF MEMORY AND MENTAL IN SIGHT READING

Short-term memory (STM) is necessary to store the information for a short time period. The role of STM in sight reading has been studied by recalling the number of notes which could be remembered when the piece was taken away. A better sight reader could remember up to 5 to 6 notes and a bad sight reader only up to 2 to 3 notes. Lehmann and Ericsson (1993) used a different method of testing short term music specific memory. A piece was given to a subject to be sight read and the second time it was played, some measures were covered. Subjects were required to try to play these parts by recalling from their first sight reading performance. A better sight reader could recall and improvise and play these bars with more accuracy than a bad sight reader.

If we can look at STM as the passive memory and working memory (WM) can be considered as the active memory. WM in sight reading is a new subject of research. Berz (1995) was the first to come up with a new model of WM based on Baddeley's (1990) model which included a music memory loop. WM is an essential part of information processing in sight reading because WM enables subjects to store and process information simultaneously (Engle, 2002). In sight reading, there is a constant flow of information which must be stored and processed to be able to perform without stopping.

For working memory and short-term memory to work efficiently, the speed of how fast one can store and process information is essential for working memory and short term memory. Due to the characteristics of working memory, mental speed is important because working memory only stores information for a short time and if there is an information overload, then some essential information can be lost.

3. METHOD

3.1. Subjects

52 pianists (28 females, 24 males) from the Hanover University of Music and Drama served as subjects. Their ages varied from 16 to 40 and the mean age was 24.56 (SD = 4.9). These pianists had to have piano as a major or were experts in chamber music or accompanying.

3.2. Sight Reading Task

A pre-recorded pacing melody paradigm (Lehmann and Ericsson, 1993) was used. This paradigm uses a solo melody which is pre-recorded and the subjects are required to sight read the accompanying piano part. This method creates time constraints which forces the subjects to play in tempo. Stimulus consisted of 2 warm-up pieces and 5 pieces with increasing complexity. These were taken from existing piano sight reading literature (UNISA) and a composer recomposed these pieces for a solo melody and piano accompaniment.

The pre-recorded solo melody was played by a violinist and before each piece, tempo indications were given by clicks which were also pre-recorded. Usually, these clicks were 2 full bars and this also gave the subjects an indication of when they should start playing.

3.3. Memory Tasks

For this paper, we based our hypothesis on the general intelligence theory which disagrees with the domain specific intelligence model. General intelligence theory (Jensen,1998) states that intelligence is not domain specific but is to do with the speed of information processing which can be applied to different domains and that is why we used numerical tests to test STM and WM. We compared these results with the results of the sight reading performance test. We also used a short term music specific test and compared these results to the results of sight reading performance tests.

Two numerical tests used in Oberauer et al. (2000) for testing WM and STM were used for this study. For short term memory, numerical and custom-made music specific tests software was used.

Working memory test. Subjects were required to do more than two simple numerical calculations simultaneously which are presented in different active cells on the computer screen. An arrow pointing upwards means plus one and an arrow pointing downwards means minus one. The number of simple calculations increase from 2 to 7 calculations.

Short term numerical memory test. Subjects are required to recall the correct order of numbers which are shown one after the other on a computer screen. The number of digits increase from 4 to 9 digits.

Short term music memory test. Drösler (1989) tested short term music memory (STMM) by presenting subjects a melody of 12 bars for 1 minute and then after it was taken away, subjects were required to say the note names of the melody. In this paper, Power Point Presentation program was used to present the test and the subjects were required to play the melody on a MIDI keyboard. The number of correct notes played was used for scoring.

3.4. Mental Speed Task

A simple method of testing mental speed (this is the perceptual and processing speed in the cognitive processes of an individual) which is reliable is the Number Connection Test [ZVT] (Oswald and Roth, 1987). It is a standardised numerical test with reliability of 90 % and is also used to test mentally disabled or injured patients. This is a pencil and paper test and the subject is required to connect consecutive number from 1 to 90 as fast as possible. These numbers are written in a table which has been divided into 90 squares and the consecutive numbers are always next to, above, below each other. The time taken to complete this test is recorded and used for scoring.

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4. RESULTS

Scoring for the sight reading performances was done by using a computer program called 'MidiCompare' which was written by Dixon (2002). This program compares a subject's recorded sight reading performance with the score recording and the output gives us the number of matches and then number of mismatches of right and left hand separately. It also shows how many extra notes were played. When comparing the score file with performance file, the window size (critical time frame in which performed note events have to occur) was critical. We chose a window size of 0.25 seconds before and after each note. This was done after comparing 4 different window times, because we wanted to use a cautious and objective approach to data analysis, to avoid ceiling effects and to obtain the maximum variances. For WM and STM, we used the average percentage value of correct responses over all items in each test.

Results from regression analysis show a clear relationship between general cognitive skills and sight reading performance (see Figure 2).

WM percentage scores and the total percentage of scores from level 1 to 5 of sight reading performance were compared and Figure 2 shows the regression line. A positive correlation definitely exists between these two variables. [Spearman r(52) =.261 ;p = .031* (one-tailed)]

Note: * = Correlation is significant at the .05 level (one-tailed).

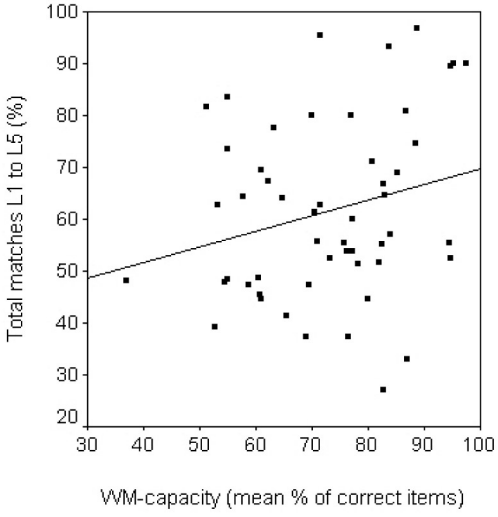

Figure 2. Total percentage of scores from level 1 to 5 and the working memory percentage score value.

Figure 3 shows the correlation between STM capacity and the total percentage of scores from level 1 to 5 sight reading performance. A small positive correlation exists between these two variables. [Spearman r(52) = .178; p = .104 (one-tailed)]

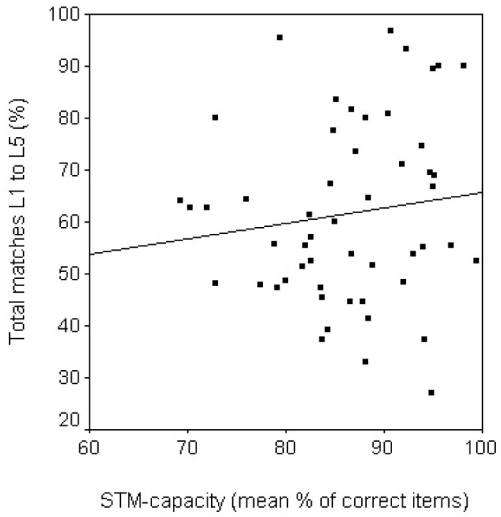

Figure 3. Total percentage of matches from level 1 to 5 and the short term numerical score value.

In the third step, short term music specific memory scores and the total percentage of scores from level 1 to 5 of sight reading performance were compared. Figure 4 shows that there is a small positive correlation between these two variables. [Spearman r(52) = .191; p = .088 (one-tailed)]

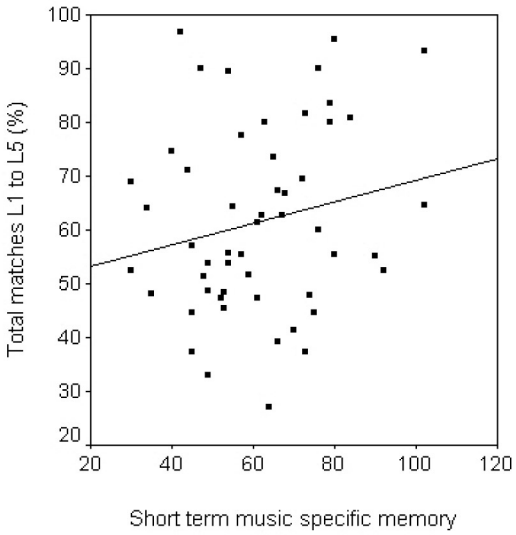

Figure 4. Total percentage of scores from level 1 to 5 and the short term music specific memory value.

For mental speed, the time taken to complete the Number Connection Test was taken and compared to the total percentage of scores from level 1 to 5. There exists a high significant correlation [Spearmanr r(52) = -.447; p = .001** (one-tailed)]. It is a negative correlation because the subject who took less time to complete the test did better at the sight reading performance test.

Note: **= Correlation is significant at the .01 level (one-tailed).

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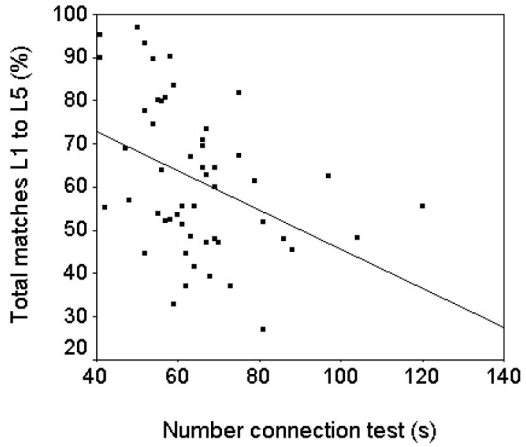

Figure 5. Total percentage of scores from level 1 to 5 and the time taken to complete the Number Connection Test.

SUMMARY

Sight reading has been divided into three stages; information intake, information processing and performance of the information. Three component skills involved in the second stage of sight reading, the role of WM, STM and mental speed were investigated in this study by use of numerical tests for STM, WM and mental speed. An extra short-term music specific test was designed to explore what kind of relationship exists between STM or music specific memory and sight reading.

Mental speed test results explained the most variances with 19.4%. WM capacity explained 6.8% of variance, STM showed no significant explanation and music specific STM accounted for 3.1% of variances in sight reading performance.

It is interesting to note that WM plays a slightly more important role in sight reading achievement than short-term music specific or non-music specific memory. This ability to simultaneously store and process information seems to be a higher prerequisite than the ability to simply store information for sight reading achievement. One reason could be that sight readers play under time restrictions and the pressure to perform without stopping. For STM, it seems that music specific short-term memory has a slightly higher correlation than with STM, but the difference is insignificant.

One of the characteristics of WM is that the essential information gets lost if there is an overload of information. Speed plays also an important role in WM and the correlation between WM and mental speed is highly significant [Spearman r(52) = -.540; p = .000 (one-tailed)]. The Number Connection Test have more similarity with sight reading performance because of the movements of the arm and the speed factor in storing and processing information and it is the best predictor for sight reading achievement.

Starting with a bottom up approach and experimenting with the component skills involved in sight reading shows that sight reading skill should be explained within the framework of general cognitive skills and that WM and mental speed of processing are significant predictors for sight reading achievement. The relationship between cognitive factors and acquired sight reading expertise will be addressed and it will be demonstrated that this may lead to a feasible theory behind sight reading achievement.

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