9th International Conference on Music Perception and Cognition

Alma Mater Studiorum University of Bologna, August 22-26 2006

The advantage of being non-right-handed in a piano performance task (sight reading)

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ABSTRACT

Background and Aims

In this study, the unrehearsed performance of music, known as 'sight reading', is used as a model to examine the influence of motoric laterality on highly challenging musical performance skills. As expertise research has shown, differences in this skill can be partially explained by factors such as accumulated practise and an early start to training. However, up until now, neurobiological factors (such as laterality) that may influence highly demanding instrumental performance have been widely neglected.

Method

In an experiment with 52 piano students at a German university music department, we could show that the most challenging musical skill, sight reading (which is characterized by extreme demands on the performer's real time information processing), is positively correlated with decreasing right-hand superiority of performers. Laterality was measured by the differences between left and right hand performance in a speed tapping task. SR achievement was measured using an accompanying task paradigm.

Results

An overall superiority of 22 % for non-right-handed pianists was found. This effect is gender-related and stronger in non-right-handed males ($r(24) = -.49$, $p < .05$) than in non-right-handed females ($r(28) = -.16$, $p > .05$).

Conclusions

We conclude that non-right-handed motoric laterality is associated with neurobiological advantages required for sight reading, an extremely demanding musical subskill.

Keywords

Music performance - laterality - handedess.

INTRODUCTION

An increased prevalence of non-right-handed laterality has been found in musicians (Götestam, 1990) and in some athletes (for an overview see Gorynia & Egenter, 2000, p. 15) and can be a neurological advantage. It has been hypothesized that non-right-handed laterality may be associated with neurobiological advantages required for music

In: M. Baroni, A. R. Addessi, R. Caterina, M. Costa (2006) Proceedings of the 9th International Conference on Music Perception & Cognition (ICMPC9), Bologna/Italy, August 22-26 2006.

making. As could be shown in previous studies, creative musical abilities in males, such as improvising or composing, are positively correlated with a tendency to left-handedness (Hassler & Birbaumer, 1988). However, nothing is known about the influence of motoric laterality on the acquisition of extremely demanding sensorimotor skills in music performance. In our study, we investigated the influence of hand laterality on the unrehearsed performance (so-called 'sight reading' [SR]) of piano accompaniment. SR is one of the most challenging performance skills (McPherson, 1995). The immediate translation of the music score's symbolic notation into finger movements and the extremely time-critical accompaniment of a singer or instrumentalist require excellent pianistic skills, as well as an extensive knowledge of stylistic musical features. However, excellent piano technique alone is not sufficient to be a good sight reader. Expertise, as measured by the life-long accumulated amount of SR practice, is a strong predictor for SR achievement (Lehmann & Ericsson, 1996), but it remains open as to whether performance differences in SR could also be attributed to the brain's functional asymmetry as represented by laterality bias in hands.

Motoric laterality is a well-known phenomenon and about ninety percent of humans are self-declared right hand writers (Perelle & Ehrman, 1994). According to the majority of studies, this asymmetry in the use of hands is a result of differences in brain organisation (see for example Annett, 2002; Halpern, 1996; Jones & Martin, 2000; Laland, Kumm, Van Horn & Feldman, 1995). Since the 19th century it has been known that language is also lateralized and primarily controlled by the left hemisphere (for a review see Price, 2000). The reasons for laterality have been discussed intensively, but without a clear preference for the evolutionary or the ontogenetic perspective (Corballis, 2003). To obtain a better understanding of the relationship between brain asymmetry and psycho-motor performance, we decided to use a selected music performance task as a model. For our study we chose the unrehearsed (sight read) accompaniment of a solo instrument. SR in the field of piano accompaniment is characterized by extreme demands on the performer's real time visual, auditory and sensorimotor information processing. It depends on the performer's capacity to process complex visual input (the score) under real-time constraints (e.g. the accompaniment of a solo instrument) and without the opportunity of error correction. As Sloboda (1985, p. 68) describes, many musicians find fluent SR very difficult. However, as McPherson (1993) and Rayner (1998) claim, sight reading is a skill which is required by all musicians, and is not only of particular interest for musical occupations such as the piano accompanist, the conductor, or the correpetiteur (for a more detailed explanation of the flow of influences between these skills see McPherson, 1995; McPherson, Bailey & Sinclair, 1997; McPherson & Gabrielsson, 2002). However, as Sloboda (1985, p. 69) states, it may well be that increased ability in SR is the result of other variables. In our study, we assume that the degree of brain asymmetry could be one of these influential variables. Nevertheless, up until now, there has been no study that considers the influence of neurobiological factors on musical achievement. As Lee (2004) and Kopiez & Lee (2006) could demonstrate in regression analyses, speed of information processing (so-called 'mental speed') plays a crucial role in SR and is assumed to be primarily determined by individual neurological conditions. Another influential factor, which, in this study, is assumed to be of importance for pianists, is the degree of left-right laterality (see Kopiez, Galley & Lee 2006). It is obvious that outstanding achievement in a bi-manual challenging task is only reached if performance differences between hands are minimal and bi-manual coordination is high. The degree of laterality could therefore be of central importance for the total achievement in a bi-manual task such as piano SR.

Laterality and psychomotor performance

Laterality has an influence on psychomotor performance differences between hands. As Gorynia & Egenter (2000) could show, intermanual coordination in alternating finger tapping is higher in left-handers than in right-handers, especially in those left-handers who are less lateralized. The authors conclude that handedness is a decisive factor for intermanual coordination. In the study by Nalçacr et al. (2001), the authors were able to show that the distribution of hand preference is associated with left hand speed.

A possibile explanation for the observed performance difference is given by the testosterone hypothesis of Geschwind & Galaburda (1985): here, the authors assume that the intrauterine environment (hormones) influences laterality and the cerebral dominance in early stages of foetal development. An enlargement of the right hemisphere (resulting in a tendency to non-right-handedness) could result in higher than average levels of abilities related to the right hemisphere (however, for a contrary opinion see Mathews et al., (2004)). With this background in mind, some findings from psychomotor research are of particular interest: Peters & Durding (1979) found that inter-hand differences in a finger tapping task were smaller in left-handers than in right-handers, but Peters (1981) also found that the relative magnitude of the inter-hand performance difference remained stable for most subjects even after a period of prolonged practice. Kilshaw & Annett (1983) found that left-handers tend to be faster than right-handers in a peg-moving task. However, this effect was only clear-cut for the non-preferred hand. In general, these studies support the assumption that weaker right hand superiority (and a stronger tendency to non-right-handedness) can result in better motor skills and various other types of performance skills (Annett & Kilshaw, 1982; Annett & Manning, 1989).

ISBN 88-7395-155-4

General measurment of laterality

The classification of subjects into the two groups of right-handed and non-right-handed people is a crucial point in laterality research which requires an underlying theory. This study is based on the widely accepted 'right-shift theory' by Annett (1985; 2002). The 2-component theory assumes that handedness as a consequence of asymmetry in brain functions in humans and nonhuman primates is determined by chance, but that difference in handedness in humans is weighted towards right-handedness in most people by the genetic factor of left-hemisphere advantage and right-hemisphere disadvantage of hand skill. This means that only the preference for right-handedness is determined genetically, and whether non-right-handed people end up left-handed or ambidextrous is a matter of chance and of social pressure on behavior. Annett distinguishes between a 'subjective' preference for handedness (as measured, for example, by the Edinburgh Inventory; see Oldfield, 1971) and the 'objective' or 'true' performance handedness, which refers to the underlying random and genetically determined hand skill differences. She believes that the degree of hand skill is strongly related to preference behavior. McManus (1999; 2002; McManus & Bryden, 1992) proposed an alternative genetic theory of handedness, which is, however, similar to Annett's theory in several respects: he differentiates between a genetically determined right-handedness (D = Dexterality) and a chance factor (C). According to McManus, the determination of phenotypical handedness should primarily be based on hand preference in general and on the preferred writing hand in particular. He argues that preference precedes performance and that the latter cannot be used to determine handedness. For example, he argues for a view of handedness as a dichotomous category. For the unresolved issue of the relationship between preference and performance in handedness research see discussion in Bishop (1990, p. 70 ff.), Peters (1998, p. 78 and 92) or Rigal (1992). However, as new evidence has since come up for gradual hemisphericity -- which is related to handedness and speech lateralisation -- (see Knecht et al., 2000; 2001), gradual laterality in handedness remains a useful variable.

Hypothesis

It is hypothesized that a weaker laterality of hands will result in a higher SR achievement due to better balanced hand skills.

METHOD

Subjects

52 pianists (28 females, 24 males) from the Hanover University of Music and Drama served as subjects (mean age = 24.5, SD = 4.9). The subjects had to have piano as a major subject or be experts in piano chamber music or accompanying (mean professional playing experience, 19.3 years; minimum, 12.0 yrs). A group of 1,185 students of psychology (mean age = 26.3, SD = 5.3), parallelized for age and gender distribution, served as controls for laterality scores.

Materials

For the SR task, the paradigm of a pre-recorded pacing melody was used (Lehmann & Ericsson, 1993). This method creates time constraints that force the subjects to play in tempo. Materials consisted of 2 warm-up pieces and 5 pieces of increasing complexity. These were taken from existing piano SR literature (UNISA, no date), rearranged by a composer for solo melody and bi-manual piano accompaniment. The pre-recorded solo melody was played metronomically (i.e., synchronized to a metronome) by a violinist. Before each piece, tempo indications were given by clicks which were also pre-recorded. These clicks were usually for 2 full bars, which also gave the subjects an indication of when they should start playing. Table 1 shows the number of notes for each hand at each task level and the total sum of notes. In this study, we only considered the total matches between the performance and the musical score for levels 1 to 5.

Procedure

Subjects were required to accompany the pre-recorded violin part on a MIDI piano. The violin part was played back through loudspeakers. The accompaniment was recorded onto a PC using the sequencer software 'Cubase'. Retrospective interviews and measurement of predictor variables were carried out after the SR tasks. The entire procedure lasted approximately 2 hours.

Scoring for the SR performances (target variable) was done using a researcher-developed computer program called 'Midicompare' (Dixon, 2002). This program matches the pitches of a subject's recorded SR performance with the score. Sight reading achievement was calculated for three categories: (a) matched played notes (matches), unmatched played notes (missed) and extra notes (extra). In this study, achievement analysis is focused on the category 'matches'. The output shows the number of events in each category within an adjustable critical time frame of ± 0.25 s. The total performance score (as a percentage) of each subject for both separate and combined hands was used (100 × [matches / total pitches in the score]).

Measurement of laterality

Handedness as an environment-reduced indicator for genetically determined 'true' or 'objective' handedness was measured by means of a hand performance task (speed tapping). This method was adopted from Peters & Durding (1978). In our study we used a speed tapping task over 30 seconds for both hands. A morse key (model by Junker Ltd., Germany; trigger point = 300 g) was used, connected to a PC, and tap intervals were recorded using researcher-developed software. The start hand was allocated randomly. Wrist tapping was used and movement was con-

ISBN 88-7395-155-4

trolled by resting the forearm on the desk. Fingers 2 and 3 were used together and released from the key after each tap. The degree of laterality for each subject was calculated by the performance difference between the left and right hand in a speed tapping task over a total tapping duration of 30 seconds.

Following Annett's (1985; 2002) right-shift theory, the 'objective' performance differences constitute the preference handedness. Since measures of performance differences between hands result in near normal distributions, the allocation to handedness groups has to be determined by a laterality threshold. Because there is no generally accepted consensus as to where such a threshold should be placed, we decided to choose the most conservative value to separate right-handers from non-right-handers: subjects who tapped faster with their right hand were designated as (performance) right-handers, while subjects with a difference value smaller than zero or a faster tapping speed with the left hand were designated as non-right-handers.

RESULTS

The total distribution of SR achievement for RH and NRH pianists is shown in Figure 1. As a pattern of performance, we can see that NRH subjects performed with a higher proportion of matches (NRH: median = 77.5 %; RH: median = 55.5 %) in combination with a lower proportion of missed and extra notes. This pattern is valid for combined hands as well as for separate hands. The general advantage of 22.0 % for NRH pianists in sight reading achievement is an impressive result (Mann-Whitney *U* test, p = .03 [2-tailed]).

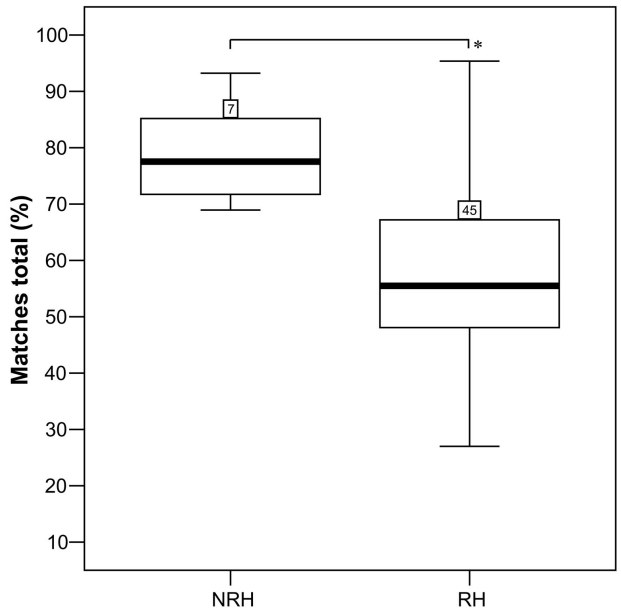

Figure 1. Boxplot of differences in sight reading achievement (matched notes) between right-handed (RH) and non-right-handed (NRH) subjects. (Mann-Whitney *U* test: * = p < .05 [2-tailed]).

After finding a general tendency towards better achievement in NRH subjects, we must now consider the reasons for this difference. Figure 2 shows the source of the performance advantage for NRH pianists. Although we find a tendency towards a general superiority of the right over the left hand in both groups (which is significant for the RH group), there are important differences in left-right performance between groups: hands in NRH differ by 15.8 %, while the difference between hands in RH is 14 % (Mann-Whitney *U* test, p = .00 [2-tailed]). This means that the difference between hands in both groups is similar, but that the absolute level of performance for both hands is higher in the NRH group. Additionally, left hand performance in NRH is significantly better than in RH (Mann-Whitney U test, p = .00 [2-tailed]). This performance pattern of NRH superiority for both hands can be found in the categories of matched notes, missed notes and extra notes.

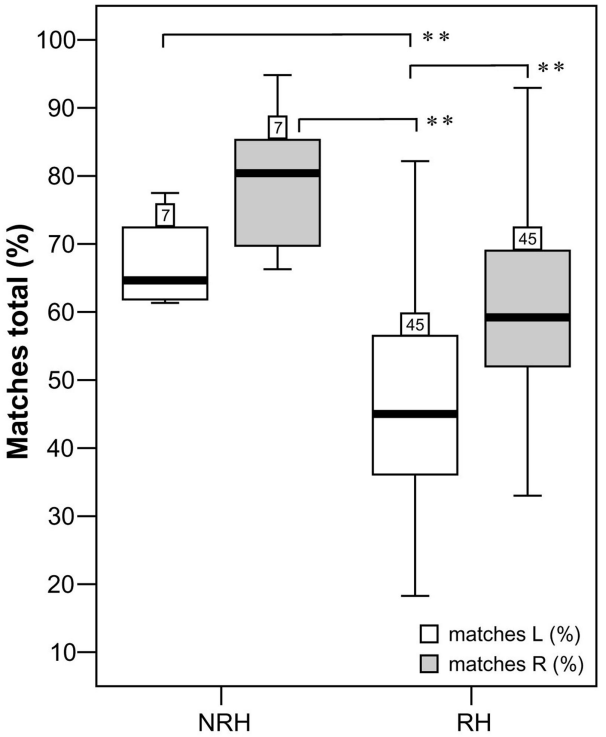

Figure 2. Boxplot of differences in sight reading achievement (matched notes) between right and left hand in right-handed (RH) and non-right-handed (NRH) subjects. (Mann-Whitney *U* test: * = p < .05, ** = p < .01 [2-tailed]).

DISCUSSION

Our main finding is the superior achievement in sight reading of non-right-handers with a performance advantage of 22 % (see Figure 1). The correlation was $r(52) = .37$ between the performance result and the decrease in right hand superiority. In other words, the faster the left hand the higher the sight reading performance.

In our sample of male musicians, we found a correlation between a superiority in sight reading and a decrease of right hand laterality which seems not to be dependent on difficulties in defining handedness. This could be an independent confirmation for the assumption that non-right-handedness provides an advantage in selected musical skills. But the substantial lower correlation in females confirms the well known gender differences in laterality research.

Two questions remain open: (a) the question of incidence and relevance of reduced laterality for other professional musical or non-musical skills; and (b) the 'chicken-egg question' of a possibly higher proportion of NRH in musicians. The first question cannot be answered with the current results, and additional research is required to find out whether hand performance scores, such as the difference value used in this study, are comparable to those of pianists in subgroups of the musician population with less demands on bi-manual motor skills (e.g. violinists, percussionists, brass players).

The second question can only be answered by a long-term study, starting at a very early age (e.g. with 4 to 5-year-old piano pupils), in order to test the effect of bimanual practice on laterality in later adulthood. It may be that such a study will reveal a possible selection effect: only less lateralized pianists with a less functional hemispheric asymmetry will be successful as professional accompanists or correpetiteurs. Such a tendency of positive selection for ambidexterity is supposed to be effective in other occupations, such as orthodontic specialists (Henderson, Stephens & Gale, 1996) or in sports (for an overview see Gorynia & Egenter, 2000, p. 15).

Conclusions

To conclude, our study gives a new perspective on the structure and acquisition of exceptional musical skills. The concept of the expertise theory should be extended, and for a sufficient explanation of peak performances, accumulated practice must be complemented by consideration of selection processes through neurobiological factors, such as mental capacity and laterality (McPherson, 2005). It remains open as to whether other underlying neurobiological factors could also be of importance for exceptional musical achievement (McPherson, 2001; Pitts, Davidson & McPherson, 2000). For some musical activities, weaker laterality could be the 'egg' and practice the 'chicken'. From this perspective, laterality would be one facet of musical ability.

ACKNOWLEDGMENTS

A more extensive version of this study has been published in Kopiez, Galley & Lee (2006).

Sound examples, and a video of the procedure can be obtained from the website http://musicweb.hmt-hannover.de/sightreading.

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ISBN 88-7395-155-4