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THE MUSICIANS' GLANCE: A PILOT STUDY COMPARING EYE MOVEMENT PARAMETERS IN MUSICIANS AND NON-MUSICIANS

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ABSTRACT

The study aims to test whether the eye movements (saccades) of professional musicians differ from a corresponding non-musician control group. It is assumed that the early commencement of instrumental practice, which is characterized by demanding "visual input" for the perceptual system (such as the reading of musical notation), can modify the way visual information is processed in professional adult musicians. It can be assumed that the movement parameters of the oculomotoric system reveal a kind of "fingerprint" of a person's way of processing information. However, up until now, no data has been available that could illuminate special features of eye movements in musicians compared to non-musicians. An electrooculogram (EOG) was used to obtain eye movement data (horizontal movements only) from 8 professional musicians (pianists) while performing an oculomotoric tracking task on a screen (hereafter called the "jumping point"). The jumping point's velocity increased over 90 seconds from 0.2 to 1.5 Hz, following a rectangular waveform of movement. An extensive sample of psychology students (n = 254) served as the control group. The data revealed clear differences in eye movement parameters between musicians and non-musicians: The 'musicians' glance' of our sample was characterized by a considerably reduced frequency of omissions, shorter reaction time in reactive saccades, a higher proportion of anticipatory saccades, higher saccade velocity and shorter anticipatory latencies. Our carefully selected group of musicians seem to be characterized by extremely efficient strategies for the processing of visual information in an oculomotoric task. All findings indicate a strong tendency for optimized task adaptation in professional musicians for a task which is different from the domain of music. Results are discussed within the framework of general mental ability for the efficient optimization of task adaptation.

1. INTRODUCTION

During the last two decades, research into rapid eye movement (or so-called saccades) has highlighted numerous parameters which are useful indicators of general mental processes (for an overview see Galley, 1989; 1993a). For example, in the field of general visual information processing, saccadic movements can be used as a possible indicator of mental illness (Galley, Widera-Bernsen & Ishak, 1983) as well as for the measurement of the speed of mental processing (Galley & Galley, 1999; Jensen, 1998; Neubauer, 1995; Vernon, 1983).

In the area of music-related tasks, patterns of saccadic eye movement have proven to be of central importance for the reading of music and especially the sight-reading of music. Thus eye movement research in music reading has a long tradition. From the very first studies on the eye-hand span in typewriting (Butsch, 1932) to more specific studies in the last few decades, visual information processing in musicians has been widely investigated. Of particular interest here are the studies on the eye-hand span in music reading by Weaver (1943), Sloboda (1974), and Truitt (1997) or in the work on eye movement parameters in sight reading by Jacobsen (1942), Young (1971), Goolsby (1987), and Kinsler & Carpenter (1995) (for the general theory and mechanisms of eye movements see Hallett, 1986).

Due to the specific demands in reading music it seems reasonable to assume that the early commencement of instrumental practice, which is characterized by demanding "visual input" for the perceptual system (such as the reading of notation), can modify the way visual information is processed in adult musicians. It is however, difficult to draw parallels as to the acquisition of reading skills: because of a widespread similar age for the commencement of reading for all children, there are no studies which tackle the question whether the early commencement of reading could influence oculomotoric behavior in adulthood. The only parallel which can surely be drawn is that reading and music reading can be classified as highly automated saccades in the sense of Findlay and Walker's (1999) model.

Up until now, no data has been available that could compare features of eye movements in musicians to a non-musician control group under the condition of a non music-specific task. In summary, it can be assumed that the movement parameters of the oculomotoric system reveal a kind of 'fingerprint' of a person's way of processing visual information, and that musicians' 'fingerprint' will be different to that of non-musicians.

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2. METHOD

2.1. Participants

Eight professional musicians from a music academy participated in the experiment. An extensive sample of psychology students ($\underline{n}$ = 254) served as the control group.

2.2. Stimuli

The experimental paradigm used was an oculomotoric tracking task presented on a computer screen which consisted of a horizontally shifting dot (hereafter called the "jumping point"). The jumping point's velocity increased over 90 seconds from 0.2 to 1.5 Hz, following a rectangular waveform of movement.

2.3. Equipment

An EOG amplifier device (PAR electronic, Berlin) was used for the recording of the changing electrical field caused by the moving dipole of the eye (for the theory of the EOG see Galley, 1993b; 2001 a). Temporal resolution of the EOG was 1 ms and spatial resolution about 1.5 degrees. Skin electrodes were applied to the subjects' face on the horizontal and vertical axis.

2.4. Procedure

Subjects were placed in front of a computer monitor at a distance of about 50 cm and room luminosity was kept constant. A head rest was used throughout the experiment to avoid disturbances produced by head movements. A sequence of 23 tasks (see Table 1) were given. The horizontally jumping point was presented repeatedly to obtain a sufficient number of saccades. The instruction given to the subjects was: "Try to track the jumping point as long and as exactly as possible." Additionally, a speed-tapping task (tapping as fast as possible for 30 s on a morse key), a mental speed test (paper and pencil Number Connection Test, (see Oswald & Roth, 1997)) and a selection of the Raven Standard Progressive Matrices (Series D) (Raven, 2000) was given to the subjects to receive information about subjects' psychomotoric optimization strategies, mental speed and general mental capacity.

General tasks		
Task No.	**Task**	**Comment**
1	Tapping task	Right and left hand
2	Number connection test	Mental speed
EOG tasks		
3	Looking at picture	Low-level task
4	Horizontally running point	Sinusoidal movement
5	Horizontally jumping point (1)	Rectangular movement
6	Horizontally jumping point (2)	
7	Vertically jumping point	
8	Horizontally jumping point (3)	
9	Horizontally counter-jumping point	Counter movements of eyes
10–21	Raven-SPM, Series D	12 items
22	Interview	Baseline EOG
23	Picture remembering	Closed eyes EOG

Table 1: Sequence of tasks used in the eye-tracking experiment.

3. RESULTS

In this experiment only response saccades from the horizontally jumping point were analyzed. Two criteria served for the discrimination between spontaneous and response saccades: (a) only saccades within the critical timeframe of between –300 and + 300 ms around the trigger signal were taken into consideration, (b) only saccades with an amplitude of > 40 % of the target amplitude were considered response saccades. In the experimental group, subjects showed a median of 344 response saccades and the controls a median of 292 ($\underline{U}$ = 796; $\underline{p}$ = 0.29). As the total number of response saccades did not differ, in the next step we looked for differences between both groups in the three categories of responses (misses, reactive saccades and anticipatory saccades). The different categories of oculomotoric responses were defined by different timeframes which are as follows: reactive saccades are saccadic responses within a timeframe of 150 to 300 ms after the occurrence of a trigger signal, anticipatory saccades are saccadic responses within a timeframe of –300 to +90 ms around the trigger signal, and misses are response saccades with an amplitude of less than 40 % of the target amplitude and which do not fall within the critical timeframe of –300 to + 300 ms around the occurence of the trigger signal.

Figure 1 clearly shows differences between the categories of response saccades over the whole range of movement frequencies (0.2-1.5 Hz) of the jumping point (within categories and between groups differences are all significant with $p < 0.03$ [Friedman- and Kruskal-Wallis-Test]). Figure 2 shows the deviation from the trigger point as so-called anticipatory latencies, which means an approximation towards the initial appearance of the jumping point trigger signal. As can be seen, music students optimize their anticipation even at the highest movement frequencies nearly perfectly (Friedman-Test between categories in both groups: $p < 0.01$; Kruskal-Wallis-Test between groups and frequency categories: $p < 0.04$ for 0.4 and 1.5 Hz).

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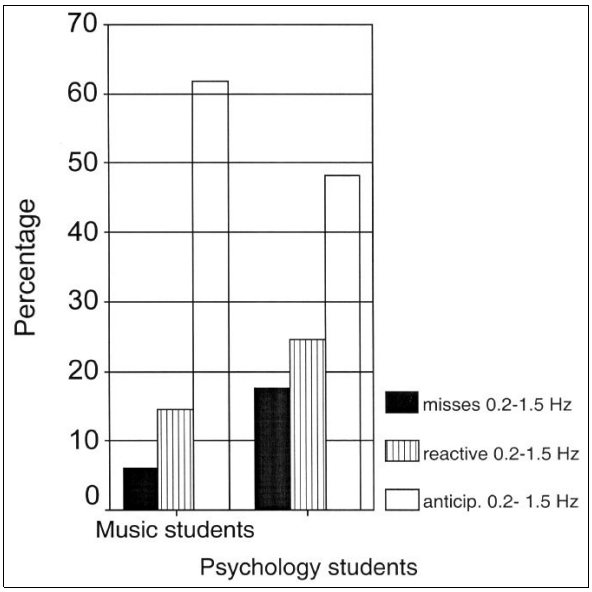

Figure 1: Proportion of all categories of response saccades in experimental and control group.

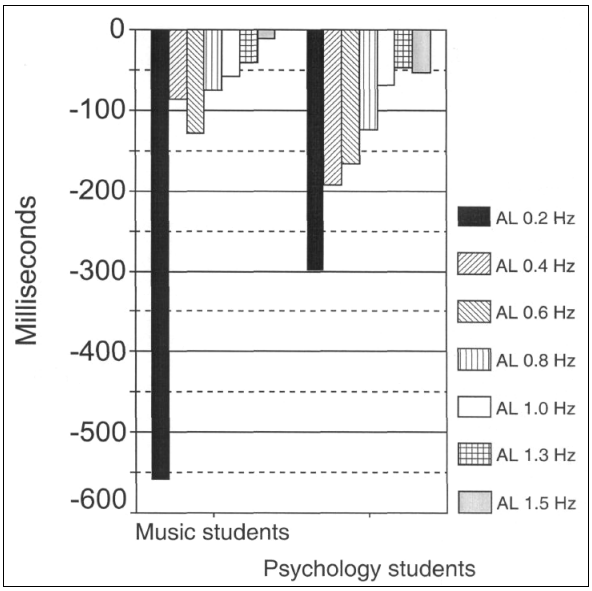

Figure 2: Anticipatory latencies (deviations from the trigger point) over the complete range of movement frequencies.

In summary, the data showed clear differences in eye movement parameters between musicians and non-musicians. The 'musicians' glance' was characterized by a considerably reduced frequency of misses, shorter reaction times in reactive saccades, a higher proportion of anticipatory saccades, higher saccadic velocity and shorter anticipatory latencies. All findings indicate higher performance in professional musicians.

4. DISCUSSION

Our results show that professional musicians of our carefully selected sample seem to be characterized by outstandingly efficient strategies for the processing of an oculomotoric task. However, in the current state of research the question remains open whether the above average oculomotoric performance in the musician group is the result of general optimization skills in the sense of higher mental capacities in professional musicians due to the early commencement of music practice, or whether it is an effect based on the transfer from the domain of musical expertise. In the latter case the musicians' superiority over the non-musicians performance could be explained by the generally known optimized performance of musicians in time-critical tasks such as in tapping etc. As the oculomotoric task of the jumping point contains quasi-musical elements (e.g. rhythmic elements in the form of an increasing movement frequency – musically termed 'accelerando' – and a clearly perceivable periodicity of visual rhythms) a benefit from musical expertise cannot be excluded. For example, investigations into the motor performance (tapping asymmetry) of musicians and non-musicians showed that musicians predominantly playing keyboard instruments demonstrated a superior tapping performance than non-musicians and musicians playing predominantly string instruments. The diminished tapping asymmetry in musicians was related to early commencement of, but not to the duration of musical training. The authors interpreted the results as an adaptation process due to performance requirements interacting with cerebral maturation during childhood (see Jaencke, Schlaug & Steinmetz, 1997).

Nevertheless, there might be a difference in the task-specific demands between the performance of a motoric (tapping) and a oculomotoric task (jumping point). At least until now there is no empirical data which could support the assumption of a superior performance of musicians in the detection of visual rhythms. The influence of musical expertise on the oculomotoric task used in our experiment can be tested in two steps: firstly, by drawing a parallel between both groups by the use of the oculomotoric reaction time (this is a strong predictor for general mental capacity) and secondly, by comparing the dispersions of response saccadic parameters between both groups. In the case of the influence of expertise in the oculomotoric task, the musicians group should show a much smaller dispersion in saccadic response parameters. This point remains open for future research.

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