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# DO TABLE TENNIS PLAYERS HAVE BETTER EYE MOVEMENTS?

## A study of the latencies of horizontal saccades in table tennis players and non-table tennis players.

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**Abstract**

*Previous research using qualitative measures of saccadic eye movements suggests athletes make faster and more accurate saccadic movements than do non-athletes. The latencies of horizontal saccadic eye movements were measured in a group of fifteen elite table tennis players and a group of non-table tennis players who had only a moderate involvement in sport. Subjects in each group had normal binocular single vision and little or no refractive error. To stimulate horizontal saccades a computer generated stimulus was presented at intervals of 0.5 and 0.3 seconds and at random horizontal amplitudes between 5 -10°. The resulting eye movements were recorded and analysed using an Ober2 infra-red eye movements system.*

*Results showed that, whilst the mean latencies of the table tennis players did not differ significantly from those of the non-table tennis participants, there was a group of table tennis players whose saccadic latencies were distinctly faster than the norm. These players demonstrated anticipatory saccades, ie, they predicted, and initiated a saccade before the presentation of the stimulus. It was concluded that future research should use larger number of subjects and investigate the role of training in the development of anticipatory saccades.*

**Key Words:** *Saccadic eye movements, Table tennis players, Saccadic latencies, Anticipatory saccades.*

INTRODUCTION

Many studies have demonstrated differences between athletes and their non-athletic counterparts on a number of visual tasks, such studies having their origins in the work of Winograd in 1942[1]. Many of the earlier studies listed below have used imprecise observation techniques to gather their data on eye movements of athletes. Trachtman[2] in a study of 36 little leaguers (baseball players) aged 10 to 12, compared ocular motility with batting averages. The results showed a correlation co-efficient of +0.44, significant beyond the 0.01 level between ocular motilities (saccades and pursuits) and batting averages. Falkowitz and Mendel[3], in a study similar to Trachtman's, showed that the best little leaguers generally have the best saccadic and pursuit movements. Christenson and Winkelstein[4] also found that the athletic population had significantly better visual performances, including saccadic movement. However, it appears that much of this research on saccadic movements and sport (including the above three studies) has been

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based on purely qualitative analysis of saccades. For example, Christenson and Winkelstein[4] had their subjects read numbers from left to right as quickly as possible and recorded the time it took to complete the task, whilst noting factors such as head movement, postural deviation and finger pointing.

Versino et al[6] emphasise that a quantitative rather than a qualitative approach to measuring saccades is important to improve the clinical applicability of saccadic eye movement analysis. Modern eye movement systems such as the EOG and infra-red systems are capable of documenting such eye movements to a high degree of precision and most current analyses rely on quantitative data from such systems.

Table tennis is a sport in which two opposing players hit a small ball back and forth across a table often at high speeds. To be played successfully and at a competitive level it requires precise reflexes, and accurate visual judgement and eye movements. Saccadic eye movements in these subjects must not only be accurate but, because of the speed of the game, must also be initiated as quickly as possible. Experienced and skillful players could then be expected to have eye movements superior in speed and accuracy to those of their non-athletic counterparts as has been suggested by the above authors[1,2,3]. This study aims to test one of the hypotheses that can be derived from the above arguments: that the latencies of horizontal saccades of a group of elite table tennis players will be shorter than the latencies of horizontal saccades of non-table tennis players.

## METHOD

### *Subjects*

The subjects consisted of 15 elite table tennis players (age range 15 to 25 years) who were recruited from New South Wales Table Tennis Association, and 15 university students (age range 18 to 25 years) who had no previous experience in competitive table tennis or any other competitive sport requiring precise vision. Subjects in each group had normal binocular vision and little or no refractive error.

### *Materials*

Eye movements were recorded and analysed using an Ober2 infra-red eye movements system. Infra-red reflectometry is based on the different reflective properties of the various parts of the eye: the sclera will reflect more infra-red light than the coloured iris. By using this difference, the position of the eye is defined, based on measurements made by optical detectors and associated electronics. With four such circuits arranged around the eye in a pair of goggles, both horizontal and vertical eye movements can be recorded and quantified. (Further information about this infra-red measuring technique can be obtained from the manufacturer [Permobil Meditech AB, S-861 00 Timra, Sweden]).

### *Procedure*

The procedure of the study was fully explained to subjects who then gave their informed consent.

The subjects were seated 50cms from a computer screen. A head stabilising frame was fitted and a bite bar was also used to minimise head movement. Both groups were tested in a room lit by a standard 15 watts fluorescent light, with no external distractions, to allow the subjects to concentrate on the computer screen and stimulus presentation. The computer generated stimulus of a vertical white cross 3mm high by 3mm wide was presented in random horizontal positions between 5 degrees and 10 degrees over a period of approximately 16.5 secs. Subjects were exposed to two series of presentations. For the first run the stimulus was presented at intervals of 0.5 secs then, for the second run, at intervals of 0.3 secs. It was decided to select a sample of saccades for analysis as analysing every saccade would have been very time consuming. In order to equalize the number of right and left saccades in a sample it was decided to select every third saccade. It was intended that, for the first run(where the stimulus moved every 0.5 secs) the saccadic movements analysed would be those made in response to the stimuli presented at 1.5, 3.0, 4.5, 6.0, 7.5, 9.0, 10.5, 12.0, 13.5,

Table 1

Results at each measured stimulus, presentation at 0.50 seconds

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 2.00 | 3.00 | 4.50 | 5.50 | 7.00 | 8.50 | 10.00 | 11.50 | 12.50 | 14.00 | 15.50 |
| Degree | 9.70 | 5.20 | 9.40 | 6.60 | 7.00 | 7.40 | 7.00 | 6.00 | 9.00 | 8.40 | 5.60 |
| Table Tennis Players | | | | | | | | | | | |
| Mean | 101.07 | 53.00 | 82.47 | 43.80 | 7.93 | 3.67 | -17.40 | 37.60 | -28.27 | -23.20 | 54.60 |
| Standard Deviation | 50.86 | 156.70 | 112.68 | 149.59 | 125.14 | 146.76 | 179.07 | 142.08 | 107.01 | 122.18 | 141.33 |
| Control Group | | | | | | | | | | | |
| Mean | 180.80 | 142.93 | 83.47 | 75.20 | 65.07 | 74.13 | 62.40 | 102.27 | 27.73 | 29.33 | 109.87 |
| Standard Deviation | 53.29 | 28.82 | 79.14 | 71.18 | 92.12 | 70.86 | 78.09 | 65.15 | 91.11 | 110.91 | 71.54 |

Table 1

Results at each measured stimulus, presentation at 0.30 seconds

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 1.30 | 2.20 | 3.40 | 4.90 | 6.30 | 7.70 | 9.10 | 10.60 | 12.10 | 13.60 | 15.60 |
| Degree | 5.00 | 7.30 | 9.40 | 6.90 | 9.20 | 8.20 | 8.90 | 6.30 | 10.00 | 7.10 | 5.60 |
| Table Tennis Players | | | | | | | | | | | |
| Mean | 152.62 | 68.92 | 103.69 | 103.38 | 123.69 | 128.00 | 127.08 | 100.62 | 126.85 | 103.54 | 115.69 |
| Standard Devistion | 14.79 | 89.24 | 86.95 | 92.82 | 63.10 | 78.31 | 75.56 | 120.18 | 84.91 | 123.06 | 115.50 |
| Control Group | | | | | | | | | | | |
| Mean | 167.20 | 113.07 | 134.07 | 125.13 | 140.53 | 153.13 | 177.00 | 147.80 | 147.53 | 151.13 | 154.33 |
| Standard Deviation | 29.18 | 45.41 | 62.78 | 80.43 | 43.20 | 43.44 | 54.00 | 75.10 | 115.67 | 79.20 | 75.14 |

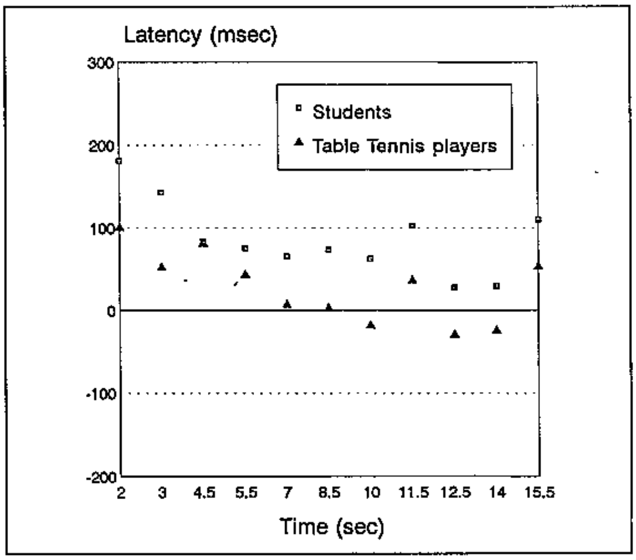


*Figure 1.* Mean latencies of saccadic eye movements at each measured stimulus in the experimental and control groups. Stimulus presented at 0.5 secs

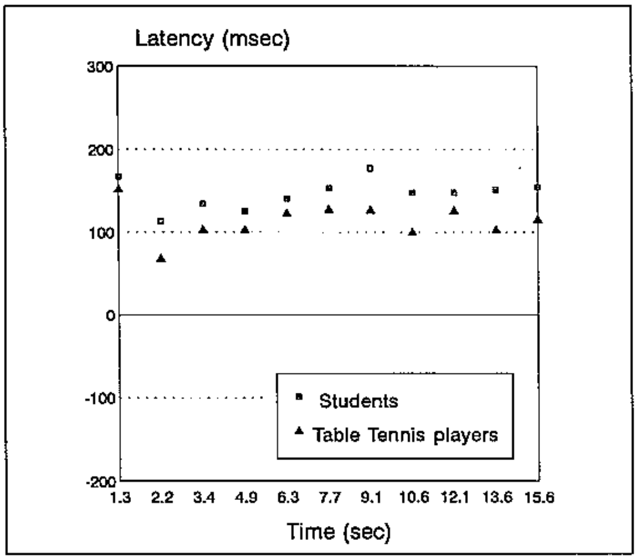


*Figure 2.* Mean latencies of saccadic eye movements at each measured stimulus in the experimental and control groups. Stimulus presented at 0.3 secs.

15.0, and 16.5 secs. Unfortunately at some of these times there were more than two corrupt measurements (usually due to a blink) across the group. To avoid including these corrupt measures the sampling times were slightly adjusted, in that if there were more than two corrupt recordings within the group at a particular time the next non-corrupted recording time was taken. Similar adjustments were also necessary at the 0.3 secs level. (See figs. 1 & 2)

*Design*

There were two groups of subjects; table tennis players, and non-table tennis players. There were two conditions of measurement; targets moving at 0.5 secs, and targets moving at 0.3

secs. Results from these two measurement conditions were analysed separately, In each measurement condition 11 repeated responses were sampled from each subject. consequently the research design for each one of the two latency conditions was a 2 (subject type) x 11 (saccadic movements) analysis of variance with repeated measures on the second factor. These data were analysed using the MANOVA program from SPSS.

*Results*

The research hypothesis tested in this study was that the latencies of horizontal saccades of the group of elite table tennis players will be shorter than the latencies of horizontal saccades of non table tennis players.

The mean latencies and standard deviations for each group are summarised in Tables 1 & 2. A comparison of the mean values at each measured presentation between groups can be seen in Figures 1 & 2, and show that the table tennis players appear to have shorter mean latencies than the non-table tennis players for all occasions at both 0.3 and 0.5 sec stimulus presentation. However, the variation in each group for each measured presentation was considerable, giving large standard deviations, particularly amongst the table tennis players. These larger standard deviations meant that the differences between each group were not significant at the p=<0.05 level. A two (group) x 11 (presentations) analysis of variance, with repeated measures on the 2nd factor, showed there was no difference between the table tennis players and the non-table tennis players at 0.5 secs ($F_{1,28}$ = 3.86, p=0.06) nor was there a group by time interaction ($F_{10,280}$ = 0.68, p=.739). Similarly, there was no group difference at 0.3 secs ($F_{1,26}$ = 1.76, p=.196) and no group by time interaction ($F_{10,260}$ = 0.39, p=.948). Consequently, the research hypothesis has not been supported by the analysis.

## DISCUSSION

Failure to support the research hypothesis suggests either that it is wrong or that the method of testing has been inappropriate. The present results are inconsistent with those of previous researchers[1,2,3] whose work led to the hypothesis. This study used more trustworthy measures of saccades so its results would be expected to be more reliable. This argument would lead to rejection of the hypothesis as being false. However, inspection of the data indicates another possible explanation. As noted in the results section, there was considerable variation in subjects' latencies. Figures 3 and 4 illustrate the mean individual latencies in each group When the stimulus was presented at 0.5 sec intervals, it can be seen that, whilst the mean latencies of nine table tennis players did not differ from those of the students, six (40%) players had saccadic latencies which were

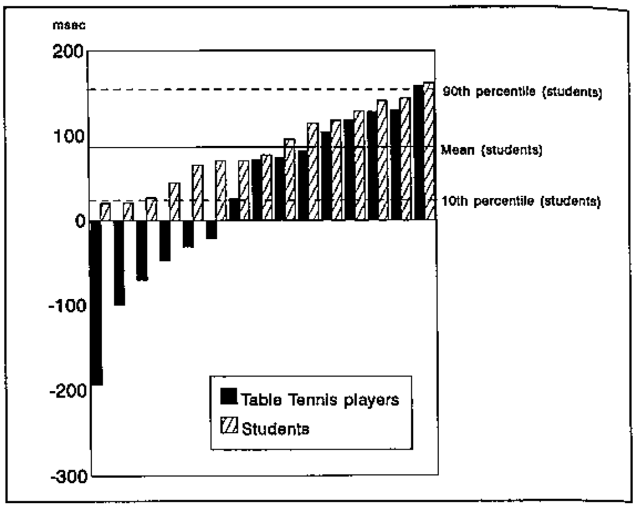


*Figure 3.* Individual mean latencies of all subjects. Stimulus presented at 0.5 secs.

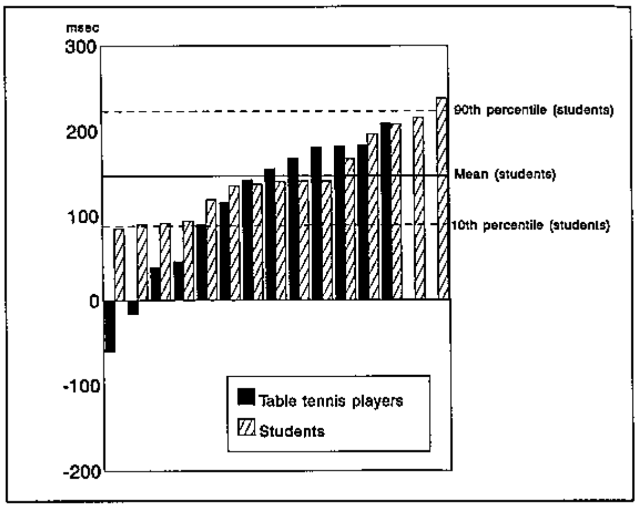


*Figure 4.* Individual mean latencies of all subjects. Stimulus presented at 0.3 secs.

distinctly faster than the normal, being below the tenth percentile of the student group. These players usually had negative latencies i.e. they predicted and initiated a saccade before the presentation of the stimulus. (In fact any latency shorter than approximately 80 milliseconds can be regarded as a prediction, as this represents the minimum processing time for a saccade to be initiated.)[6]

This pattern persisted when the stimulus was presented at 0.3 sec intervals. Although the latencies of the saccade were relatively longer, there was still a group of four table tennis players (30%) whose latencies were below the tenth percentile of the student group (Unfortunately the data from two table tennis players was corrupted and could not be used). Although the stimulus in this study was presented in a random position with regard to position from the midline, there was a consistent pattern in that the stimulus was always presented in a horizontal position, always crossed the midline, and was between 5° and 10° from the previous stimulus. This pattern was deliberately chosen, not only to limit variables, but to simulate, to a certain extent, the pattern that exists during table tennis. Therefore the subjects were able to make certain predictions before the onset of the saccade, that is, the better subjects were able to make predictive saccades which were affected by cognitive as well as neuromuscular factors. Kowler discusses the evidence that saccadic programs can be prepared, at least in part, before the location of targets is fully discerned.[7] Fischer[6] mentions that anticipatory saccades can have a latency of less than 80 msecs. This form of saccade is when the motor reaction (the refixation saccade) is initiated before the sensory event (the displacement or appearance of the visual target). It is likely that the movements of the table tennis players are examples of such anticipatory saccades.

If a saccade to a random position is predicted, it is likely that it will not be precise, and that additional correcting saccades would need to be made, and this was seen to be the case. One might therefore question the value of such anticipated saccades, however, the corrections were usually very small, and allowed time for another anticipated saccade to be made before the next stimulus appeared. It could be that a final small corrective movement was more effective than a larger, precise saccade made after the stimulus appeared. It is also possible that the saccade was not made to foveate the target (the ball is moving so quickly in table tennis that this would be impossible), but rather to move its image close the the fovea in order to make correct judgements regarding its position.

Corrective movements were not usually made when the saccade was not anticipated. In most cases they were remarkably accurate showing little evidence of over or undershoots.

The ability of some players to successfully anticipate stimulus movements has two implications for testing the research hypothesis. One is that the large variations in latencies between players means large numbers of subjects would have to be tested before statistical analysis would detect a significant difference between players and non-players, even if one exists.

The second implication is that one of the assumptions made in designing the experiment may well have been wrong. It was assumed that all competition-level players would be of approximately equivalent ability. This may not have been the case. Future research should use larger numbers of subjects, and should compare non-players to player of superior ability, as defined by criteria other than their saccadic speed.

## CONCLUSION

It appears that 40% of the table tennis players when presented with a stimulus moving at 0.5 secs, and 30% when the stimulus is presented at 0.3 secs are better at predicting the position of a saccadic stimulus than their team mates and the non-table tennis players. Further research will be aimed at determining whether these skills, and other aspects of saccadic eye movements, can be improved with training and ultimately, whether such training can effect sporting performance.

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