

Exploration of the effect of EEG Levels in experienced archers

TWIGG, Peter, SIGURNJAK, Stephen, SOUTHALL, Dave and SHENFIELD, Alex <<http://orcid.org/0000-0002-2931-8077>>

Available from Sheffield Hallam University Research Archive (SHURA) at:

<http://shura.shu.ac.uk/8307/>

This document is the author deposited version. You are advised to consult the publisher's version if you wish to cite from it.

Published version

TWIGG, Peter, SIGURNJAK, Stephen, SOUTHALL, Dave and SHENFIELD, Alex (2014). Exploration of the effect of EEG Levels in experienced archers. *Measurement and Control*, 47 (6), 185-190.

Copyright and re-use policy

See <http://shura.shu.ac.uk/information.html>

Exploration of the Effect of EEG Levels in Experienced Archers

Journal:	<i>Measurement and Control</i>
Manuscript ID:	MAC-13-0003.R1
Manuscript Type:	Original Paper
Date Submitted by the Author:	15-May-2014
Complete List of Authors:	Twigg, Peter; Manchester Metropolitan University, School of Engineering Sigmundjak, Stephen; Manchester Metropolitan University, School of Engineering Southall, Dave; Manchester Metropolitan University, School of Engineering Shenfield, Alex; Sheffield Hallam University, Engineering
Keywords:	EEG, Archery, Brainwaves
Abstract:	This preliminary study aims to record the brainwaves of two experienced archers, whilst undertaking the process of aiming and shooting arrows at a target. The brainwaves are then analysed for repeatability and dominant characteristics within individual EEG activity. Images of the archers are also recorded to establish reference points within the shot cycle for correlating the EEG data sets.



1. Introduction

Archery is a sport, which has increased in popularity since the London 2012 Olympic Games. It is now an Olympic core event and has recently seen its Olympic funding increase from group D for London 2012 to group C for Rio 2016. This highlights the sport's popularity.

Archery involves the coordination of the muscular and skeletal system to provide a repeatable pattern whilst under loading during the drawing, aiming and release of the arrow. The hold and aim phase of the shot are of particular importance. At this time, the archer must resist the weight of the bow (both the physical weight of the bow in the hand and the draw weight) whilst aiming at the target and expanding until the release of the string. Within this critical point of the cycle the archer is processing visual information with regards to the position of the sight on the target as well as maintaining motion prior to release.

The aiming process and the visual relationship is also noted within basketball; when an experienced player throws a ball to the hoop the player first fixates on the target but then as the aiming action is performed the vision is suppressed [1].

The brain is very much like a computer system, using brain cells to transmit messages to one another in order for us to function; these signals are well known as brainwaves. The billions of brainwaves we send produce an enormous amount of electrical activity in the brain, and this activity can be detected using sensitive medical equipment such as an Electroencephalograph (EEG), to measure the different electricity levels over areas of the scalp. Each brainwave has its own characteristic, and they can be characterised into five groups known as Delta, Theta, Alpha, Beta and Gamma frequency bands [2-4].

Table 1 shows the detail of the of the brainwave band and its relation to the amplitude and frequency [5]

Brainwaves	Freq (Hz)	Amplitude (μ V)
Gamma	35-100	Lowest
Beta	13-35	Very low
Alpha	8-12	Medium
Theta	4-7	High
Delta	0.1-3	Highest

Table 1 – brainwave frequency band with relation to frequency & amplitude

The examination of the cognitive process during rifle and pistol shooting as well as Archery has used EEG to measure the brain activity during the process of target

1
2
3 shooting [6-7]. This has given rise to consistent findings that the brain activity differs
4 between professionals and novices with experts having a greater EEG alpha power
5 during the final few seconds prior to the shot release.
6

7
8 EEG Alpha reflects the visual attention where an increase in the Alpha power gives a
9 reduction in the visual attention [8]. With pistol shooters, the increase in the alpha
10 power is due to the subjects' maintaining an optimal sight picture during the aiming and
11 the trigger pull, and the alpha power providing an index of the amount of aim related
12 information processed within the execution of the shot [6]. Alpha wave involvement is
13 noted to decrease when anticipatory attention tasks are performed, such as recognising
14 a visual target [9]. In addition to the decrease in alpha during attention phases, the beta
15 waves increase during active concentration [10].
16
17

18
19 This preliminary study aims to record the brainwaves of two experienced archers (all
20 with 10+ years of experience) whilst shooting arrows and analyse them for repeatability
21 patterns and dominant individual EEG activity characteristics during the process of the
22 shot. Images of the archer are also captured throughout the process for correlating the
23 EEG data across reference points of the shot cycle.
24
25

26 27 2. Method

28
29 Two subjects were used for the study both with 10+ years of archery experience and
30 both having attained scores above the "Master Bowmen" standard as prescribed by
31 Archery GB. A series of 12 shots were recorded with the target placed at a distance of 90
32 meters for the test. Prior to the test, the subjects were allowed to practice at the target
33 wearing the EEG device to become accustomed with the device whilst shooting.
34 Placement of the device whilst the archer is shooting is shown in figure 1. Both subjects
35 reported that the device was very light and non-intrusive, and after a few minutes
36 familiarisation, they were not aware of any influence that the device was having on their
37 archery performance.
38
39
40
41
42



Figure 1 - Subject wearing the EEG device whilst at the aiming phase of the shot

The phases of shooting an arrow are as follows:

1. Setup
2. Draw
3. Aim
4. Release
5. Follow through

Data was collected from the archers using the EEG device during the different phases of the shot along with corresponding images of the archer at a frequency of 30Hz. Data was captured wirelessly to a laptop in real time and stored for processing. A block diagram of the system is shown in figure 2.



Figure 2 - Block diagram of the capture system

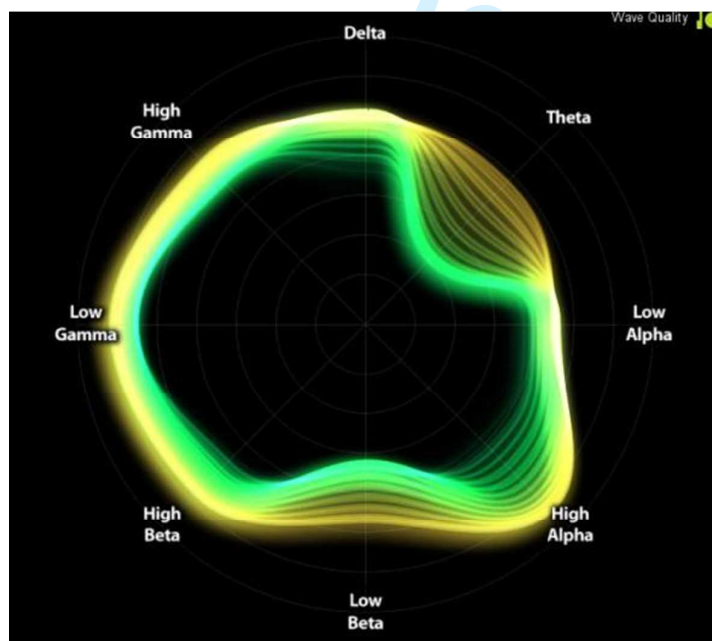


Figure 3 - Image of brain wave activity map

Figure 3 shows a brainwave activity map where the magnitude of a particular brainwave band is indicated by the radius from the origin and the frequency of the brainwave is related to the angle around the map. This provides a simple visual indicator of the brain activity at any time.

Data sets were divided into individual shots for each archer. The data collected from the EEG device was then traced with the captured images for brainwave exploration at landmark points within the shot. Data samples were then analysed for repeatability, and dominant brainwave characteristics of each archer compared at the landmark points within the shot.

3. Results

The results of the preliminary tests are shown in the line graphs below plotting the percentage levels of attention against samples being taken at 1/10th of a second (10Hz) from the EEG device. The data in figures 4 to 7 shows the basic proprietary signals of 'Attention' and 'Relaxation' provided by the Neurosky headset. The data in figures 8 to 13 show graphs of individual brainwave bands – Alpha, Beta and Delta.

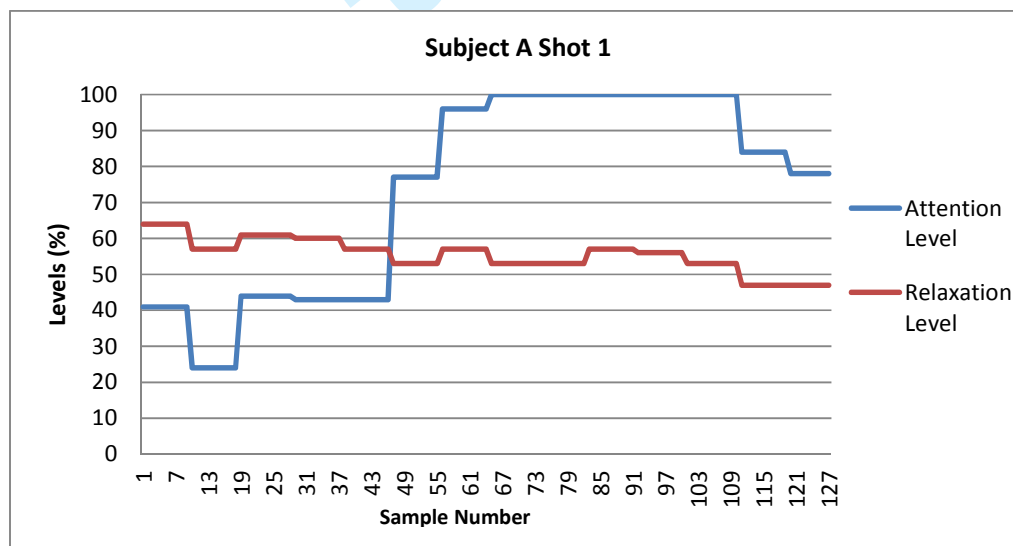


Figure 4 - Attention and relaxation levels of subject A, shot 1

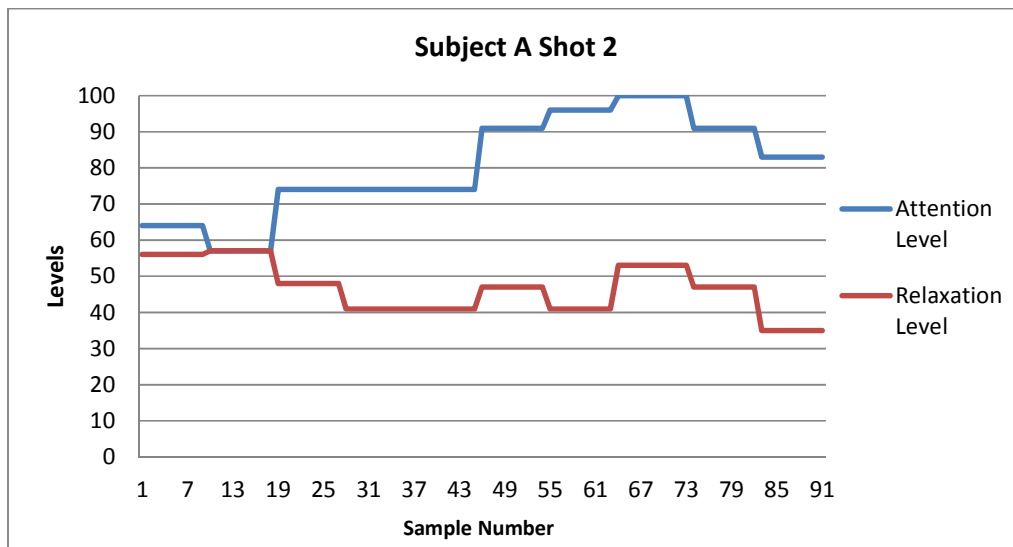


Figure 5 - Attention and relaxation levels of subject A, shot 2

The sample results presented in figures 4 and 5 show the attention and relaxation levels of subject A for 2 archery shots; archer A considered that shot represented by the data in figure 4 was good and shot that produced the data for figure 5 was not so good. The data is presented from the drawing phase of the shot, into the aiming and the release of the arrow. The results show a similar pattern and levels for both shots for subject A with regards to the attention and relaxation plots. During the shot process the attention level raises and peaks at 100% from the full draw - samples 65 to 109 for figure 4 and sample 46-72 for figure 5 until the release of the string. The relaxation levels of subject A decrease slightly during the shot but remain within the 35% to 65% levels for both shots. The other 8 data samples for this archer are remarkably similar, with high repeatability characteristics.

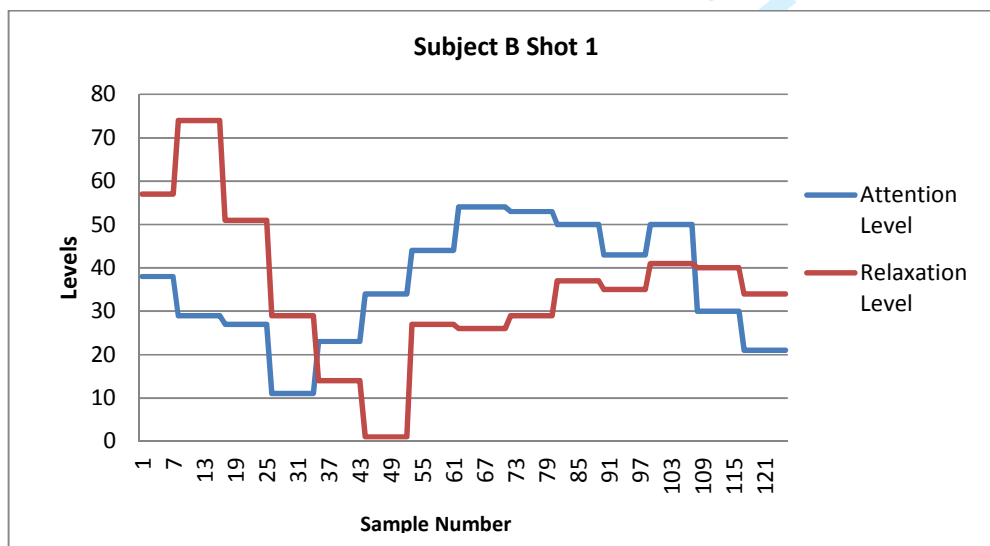


Figure 6 - Attention and relaxation levels for subject B, shot 1

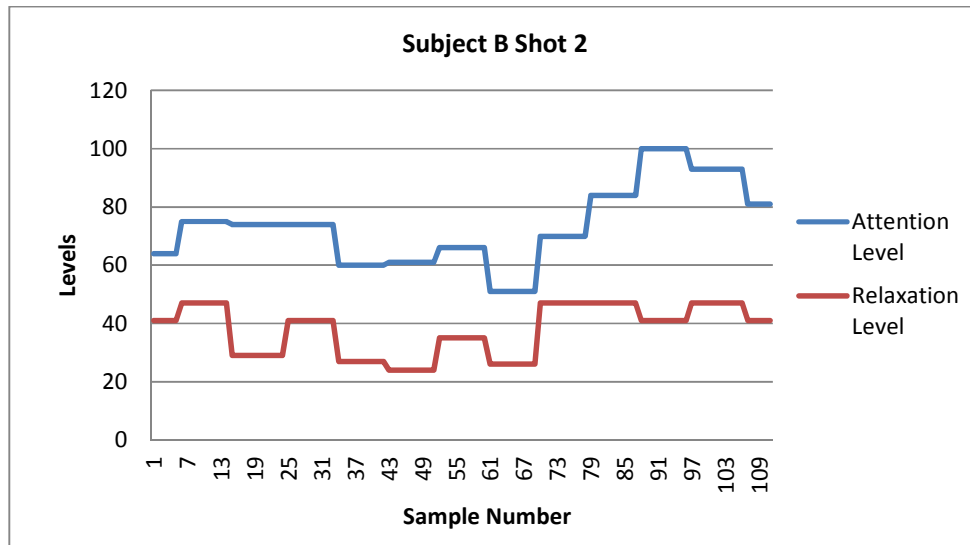


Figure 7 -Attention and relaxation levels for subject B, shot 2

Figures 6 and 7 show the results for subject B over 2 shots; these two shots were chosen as examples as Archer B's shot for the data in figure 6 was less than perfect and the shot made represented by the data in figure 7 was perfect. Whilst the patterns for subject B differ in the overall levels compared to subject A, the data still indicates reasonable repeatability during the shot. The levels for attention increase during the aiming phase of the shot - samples 45 to 106 for figure 5 and 49 to 93 for figure 7.

Figures 8 and 9 show the comparison between the Alpha frequency bands for shots 1 and shot 4 for subject A. In addition to the alpha levels measured during the shots, the green trace of the plots shows the distinct phases within the shot starting with the setup; for figure 8, sample 1 to 13, draw, sample 12 to 64, aim, samples 61 to 109, release of the arrow, samples 109 and the follow through of the shot, samples 110 to 126. The markers are plotted on further graphs to illustrate the brain activity for the distinct phases of the shot cycle.

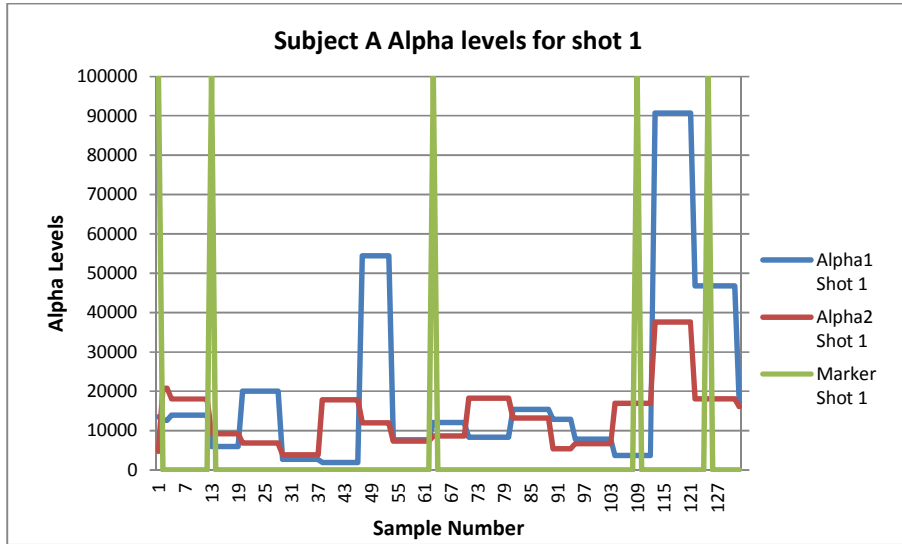


Figure 8 - Alpha levels for subject A, shot 1

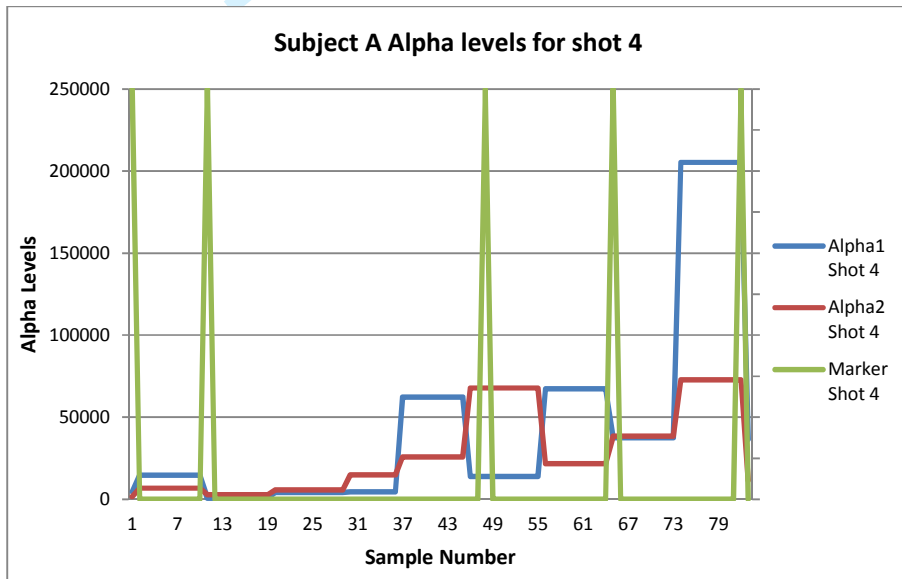


Figure 9 - Alpha levels for subject A, shot 4

The graphs show a distinct pattern for both of the shots with the Alpha 1 levels increasing after the release phase and into the follow through.

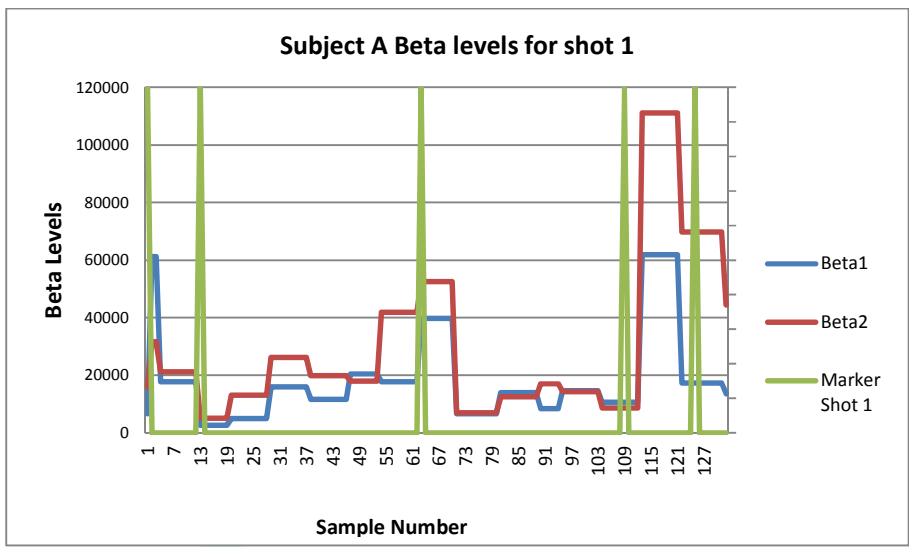


Figure 10 - Beta Levels for subject A, shot 1

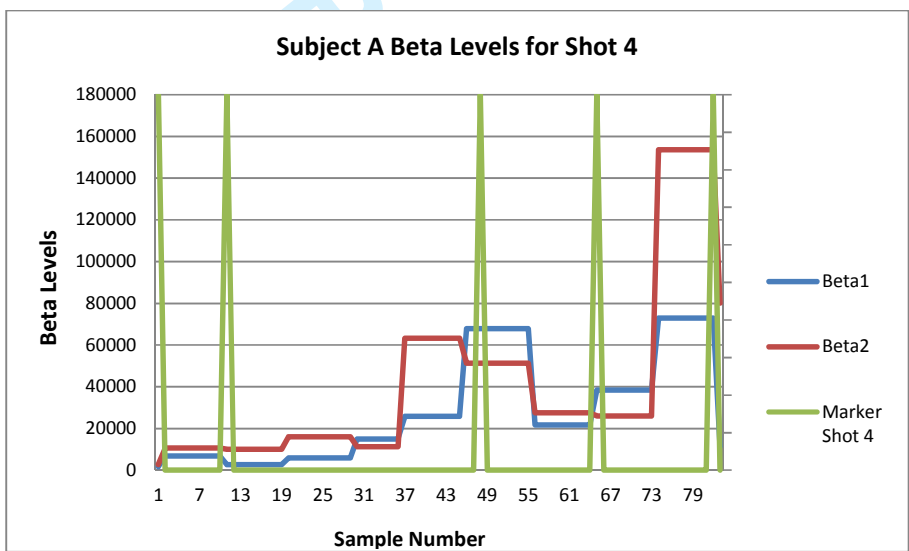


Figure 11 - Beta levels for subject A, shot 4

As with the alpha levels for the selected shots the beta plots are similar showing lower activity during the pre-release shot phases and increasing after the arrow has been released.

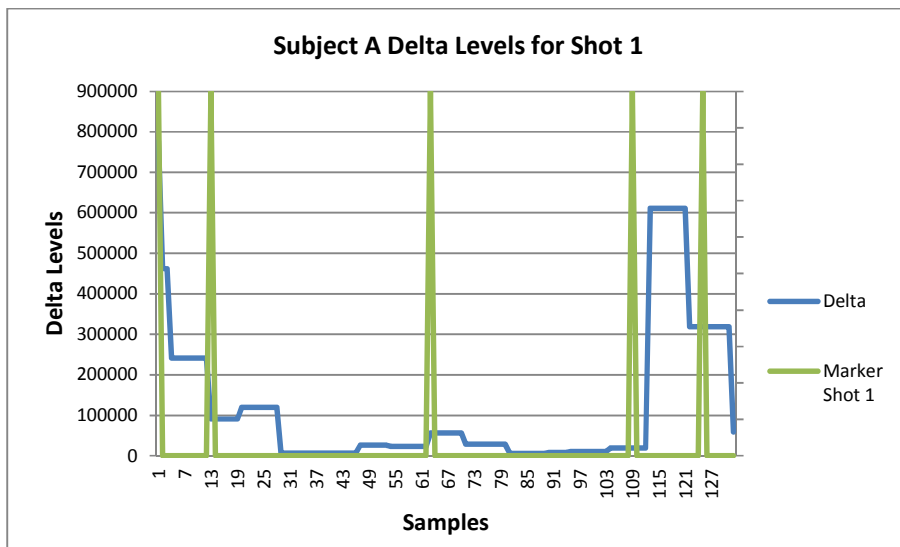


Figure 12 - Delta levels for subject A, shot 1

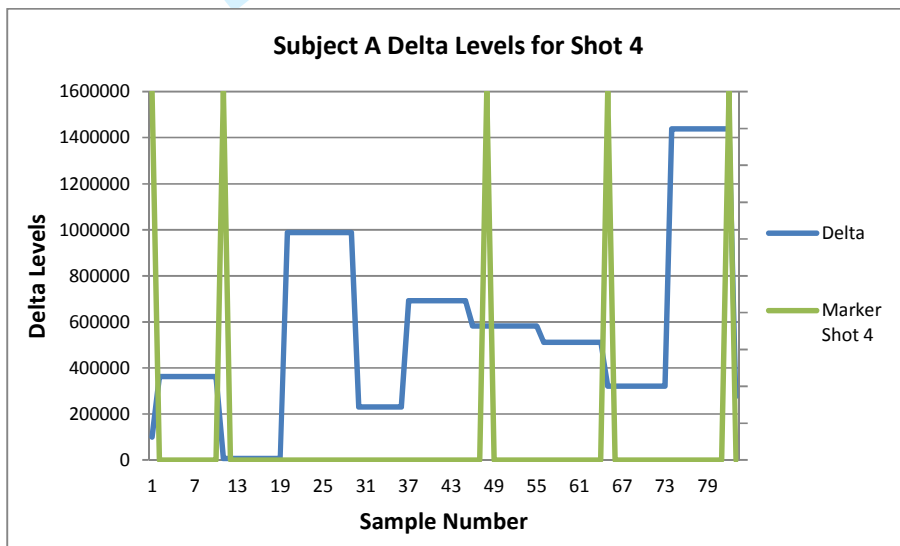


Figure 13 - Delta levels for subject A, shot 4

Figures 12 and 13 show the delta activity for subject A for shots 1 and 4, as with the alpha and beta plots the delta activity distinctly increases after the release of the arrow for both shots although within shot 4 there is more delta activity during the draw and aim phase when compared to shot 1.

4. Discussion

This preliminary study recorded the brainwaves of two experienced archers, whilst undertaking the process of aiming and shooting arrows at a target. Brainwaves have been analysed for repeatability and dominant characteristics within individual EEG activity. Images of the archers were also recorded to establish reference points within the shot cycle for correlating the EEG data sets. The results have shown that there are

1
2
3 repeatable patterns, which emerge in brainwave activity obtained from the EEG device
4 for each subject during the distinct phases of the shot cycle. The patterns also show
5 distinct differences between the 2 subjects over the shot cycle with subject A attaining
6 higher attention levels during the aiming process than subject B. The results of the
7 alpha and beta activity during the shot cycles for subject A also show a repeatable
8 pattern with an increase in activity at these frequency bands when the arrow is
9 released, this is also evident for the delta waves. The delta wave plots also show a
10 difference between the two shots with more activity in the delta frequencies during the
11 draw and aim phase. It must be noted that within this small, preliminary test no
12 correlation calculations were carried out between the results of the EEG plots and the
13 resultant scores of the arrow at the target. This may be the notable difference in levels
14 for subject B between the 2 shots with figure 6 being a less than perfect shot, noted by
15 the lower attention levels and figure 7 being a good shot for the subject, again noted by
16 the higher attention levels found within the results. This proposal may also be applied
17 to subject A with figure 4 attaining a sustained, higher attention level than the plot
18 within figure 5 and for the difference in delta activity of subject A shown within figures
19 12 and 13. It is envisioned that by monitoring the brain waves of a subject during a high
20 volume of shots and noting how the subject "felt" the shot went, an ideal pattern would
21 emerge that corresponded to "good" shots. This pattern can then be used for training
22 purposes, allowing the subject to perform a repeatable pattern to maximise
23 performance. The system could also be expanded to include other biometric monitoring
24 to explore the effect of additional pressure on the archer, such as in a head to head
25 match, and how this influences brain activity.
26
27
28
29
30
31
32
33
34
35

36 This research received no specific grant from any funding agency in the public,
37 commercial, or not-for-profit sectors.
38
39
40

41 5. References

- 42
43
44 [1] Vickers, J. N. (1996): Visual control when aiming at a far target. *Journal of Experimental*
45 *Psychology: Human Perception and Performance*, 22, 342–354.
46 [2] D. Cohen, *The Secret Language of the Mind*. London: Duncan Baird Publishers, 1996.
47 [3] M. Teplan, "Fundamentals of EEG measurement," *Measurement Science Review*, vol.
48 2, pp. 1-11, 2002.
49 [4] E. Hoffmann, "Brain Training Against Stress: Theory, Methods and Results from an
50 Outcome Study," version 4.2, October 2005.
51 [5] Zunairah Hj. Murat, Mohd Nasir Taib, Zodie Mohamed Hanafiah, Sahrim Lias, Ros
52 Shilawani S. Abdul Kadir, Norlida Buniyamin, Aisah Mohamed, (2011): "EEG
53 Brainwaves Synchronization Comparison between Electrical Engineering and Sports
54 Science Students: Pre and Post Horizontal Motion Intervention", *International*
55 *Conference on Food Engineering and Biotechnology, IPCBEE vol.9*, Singapore.
56
57
58
59
60

- 1
2
3 [6] Gavin M. Loze , David Collins & Paul S. Holmes (2001): Pre-shot EEG alpha-power
4 reactivity during expert air-pistol shooting: A comparison of best and worst shots,
5 Journal of Sports Sciences, 19:9, 727-73.
6
7 [7] Maman Paul, Sathiyaseelan Ganaesan, Jaspal S. Sandhu, Joel V. Simon (2012): Effect
8 of Sensory Motor Rhythm Neurofeedback on Psycho-physiological, electro-
9 encephalographic measures and performance of archery players, Ibmosina Journal of
10 Medican and Biomedical Sciences, 4:2, 32-39
11 [8] Peter C.M. Vijin, Bob W. van Dijk, Henk Spekreijse (1991): Visual stimulation reduces
12 EEG activity in man, Brain Research, 550:1, 49-53
13
14 [9] Wolfgang Kilmesch (2012): Alpha-band oscillations, attention and controlled access
15 to stored information, Trends in Cognitive Sciences, 16:12, 606-617
16
17 [10] Jochen Baumeister, Thorsten Barthel, K.R. Geiss, M. Weiss (2008): Influence of
18 phosphatidylserine on cognitive performance and cortical activity after induced
19 stress, Nutritional Neuroscience, 11:3, 103-110
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60