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Combined EEG and eye-tracking in sports skills training and performance analysis

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The use of mobile EEG brainwave monitoring and eye-tracking recorded synchronously during the training of sports skills offers significant opportunities but creates challenges.

Opportunities:

- Measuring neurocognitive activity and visual focus in real time which can be used to provide immediate feedback to the coach, in 'real world' settings, for optimising training protocols for the individual athlete.
- Use of sound output ('sonification') in proportion to EEG regions of interest as a neurofeedback mechanism for athlete self-training.
- Application of visualisation protocols and 'EEG-driven' PC games where game feedback based on state of mind is used to optimise mental state prior to performance.
- Examining the relationship between eye movement and neuro activity (e.g. saccades and gamma waves) and in athlete coaching interventions such as sports visual scanning strategies, Eye Movement Desensitisation & Reprocessing (EMDR) therapy, focussed relaxation, etc.

Challenges:

- The recording of EEG during gross motor behaviour is subject to non-brain artefacts in the raw (time-domain) EEG, due to the much larger (than EEG) electrical voltages arising from muscle and eye movements. Practical approaches and signal processing (frequency domain spectrum) techniques to address these problems will be discussed.
- The synchronisation of data recorded on different types of equipment (e.g. EEG, eye-tracker, video, sound, EMG, etc.) with different 'clocks' and diverse data formats is difficult – both in terms of time-stamping the original recordings across all the systems and playing them back synchronously for subsequent performance analysis. Progress on creating real-time data export methods which allow synchronous data recording and playback will be reported.

Examples of studies carried out in archery, golf, motorsport, football and skiing will be discussed, with a focus on archery where:

- Measurements were taken from intermediate, county level, near elite and elite archers.
- Archery was chosen to demonstrate the real-time and in-situ quantification of neural activity compared with target-based measures of performance that archery provides, over a range of time-spans and skills.
- Results demonstrate that there are significant and measurable changes in EEG patterns during a shot with evidence suggesting that the patterns vary as a function of skill level, but not simply as a function of score.

Significance of each of these studies for goal-directed learning and performance enhancement are discussed.