1. **Title of PhD Project**
   Psychological and biomechanical characteristics of expertise in golf performance

2. **Supervisor(s) Details**
   Dr Mark Campbell & Dr Ian Kenny

3. **Aims of the Research**
   The aim of this research project
   The aim of this project is to investigate the key performance indicators of expertise in golf performance through analysis of (1) visuo-cognitive abilities, measured via eye tracking systems and (2) kinematic and biomechanical parameters, measured via ultrasound and dopplar radar equipment.

4. **Short Justification/Rationale/Background to the Project**
   It has long been established that pupillary responses provide a valid and reliable window on the 'intensity' of mental activity or cognitive effort (Hess & Polt, 1964; Kahneman & Beatty, 1966). As these responses are routinely and non-invasively measured during eye-tracking, they constitute a promising tool for the study of the cognitive mechanisms underlying skilled performance. Specifically, larger pupil diameter during equiluminance reflects increased attentional resource allocation. In eye-tracking research, the "quiet eye" (QE) has been consistently shown to be a key predictor of perceptual-motor expertise (Mann, Williams, Ward & Janelle 2007; Vickers, 2009). Unfortunately, despite an abundance of QE research, there has been a dearth of theorising on the specific purpose of QE or the mechanisms that underlie this distinctive pattern of gaze behaviour. Therefore, the current study aims to tackle this gap in the literature by measuring the allocation of attentional resources during golf putting and driving using pupilommetry. Additionally, as balance is a key principle in the golf swing, and swinging with good balance promotes a more fluid motion and more consistent ball contact it is a notable area to study in conjunction with gaze and visuo-cognitive ability. Postural stability and the maintenance of adequate balance throughout the golf swing are important characteristics of golf performance and the current study aims to measure the development and maintenance of these skills

5. **Study Design**
   A within-subjects and between subjects, repeated measures design will be used.

6. **Participants & Procedures/Methods**
   Participants will comprise of 3 groups of differing abilities of golfer. Group 1 elite/ professional. Group 2 sub-elite/ skilled and Group 3 novice/ low skill.
   The experiment involves a golf putting task consisting of two blocks of ten putts from a distance of 1.83m and 3.66m feet. The order of completing the two blocks of putting will be randomised for participants. Testing will be conducted in an indoor laboratory setting on a 2 x 5 m piece of high quality astroturf artificial grass. The golf club used by participants will be their own putter and this club was between 32" and 36" in length, and the ball is a regulation golf ball (diameter = 42.67 mm, mass = 45.93g). A golf hole with a diameter of 108mm (representing a regulation golf hole) was located on the artifical grass at the allocated distances. Putting performance was measured as a miss or a make, with particpants scoring 1 for the ball rolling into the hole and 0 for a ball that missed the hole.

For gaze analyses, a light-weight eye-tracking glasses (Tobii Glasses, Tobii Technology, Danderyd, Sweden) system was utilised. Scene-related eye positions were stored using an additional scene camera located in the right upper corner of the eye-tracking glasses at a frequency of 30 Hz, an accuracy of .25-1.0˚, and a resolution of .15˚. Eye-tracking data was recorded on a recording assistant handheld device stored on the belt of the participant and linked to the glasses by means of a thin discrete cable. This set-up allowed participants to move freely. The calibration involves a 9-point calibration, conducted manually by the experimenter with the participant standing following an IR (Infrared) marker held by the experimenter to establish concordance with the system and the scene camera to accurately represent the particiapants field of vision. During data collection, the status of the calibration and tracking status will be displayed on the recording assistant device. This tracking status will be monitored to ensure accurate live monitoring and fine calibration of the participants gaze was ensured throughout the testing period. Later, offline analysis consisted of synchonizing the video (motor data) and gaze data to ensure accurate frame by frame precision to map out the onset of QE and various other stages in the golf putt (pre putt routine, backswing, ball impact and follow-through. Pupil size will be recorded from the right eye of participants by the Tobii glasses system at a sampling frequency of 30Hz.

Procedure

Before beginning, participants will be given basic information about the experiment and complete a questionnaire that gathered their age and level of experience in golf. Height and weight will be also ascertained at this time. The experiment will be divided into two blocks of ten golf putts from the two pre-determined distances. Experimental blocks were preceded by a practice period (10 putts) in which the participants will be asked to practice hitting the upcoming putt to familiarise themselves with the task and set-up and to gauge the speed and roll of the putting surface. Between the blocks, a calibration check will be completed and recalibration will becompleted if needed. After finishing the two blocks, the eye-tracker will be removed.

In line with past definitions for targeting tasks (Vickers, 2007), the QE will be defined as the final fixation duration towards a relevant target prior to the initiation of the backswing of the golf putt. Instructions given to each participant were that they were to try and hole all their upcoming shots.

7. Data Collection and Analysis

The data will be analysed using appropriate descriptive (e.g. comparison of means with established baseline norms) and parametric statistics (e.g. ANOVA to assess interaction effects between variables and duration) using SPSS for Windows v22.0.