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The effects of smart phone video analysis on focus of attention and performance in practice and competition

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ABSTRACT

Objectives: Research has consistently found that focus of attention (FOA) affects motor learning and performance. However, much of the previous work has used artificially manipulated FOA of novice participants performing laboratory tasks. There is a paucity of work that has tested transfer to more complex competition environments. We aimed to investigate the effects of smart phone video analysis, which commonly occurs in natural practice settings in golf, on skilled player's FOA and performance in both practice and competition.

Design: This study employed a mixed experimental design. The between participants factor was the use of video analysis (practice with video vs practice only) and the repeated measures factor was time point (pre-intervention vs post-intervention).

Method: Altogether, 19 skilled golfers (handicap: $M = 5.79$, $SD = 5.80$) took part in a four-week practice intervention with ($n = 10$) or without ($n = 9$) the use of smart phone video analysis. Driving range performance and competition performance were measured pre- and post-intervention. Practice diaries provided measures of FOA during the intervention period.

Results: The practice with video group displayed a significantly more internal FOA throughout the intervention period than the practice only group. This resulted in a significant time by group interaction for driving range performance that showed an increase in performance for the practice only group and a decrease for the practice with video group. However, the performance effects did not transfer to competition scores.

Conclusions: Findings enhance our understanding of the effects of video analysis on FOA and question whether FOA effects transfer from on range practice to on course performance.

1. Introduction

An individual's focus of attention (FOA) is a critical variable in performing or learning any complex motor skill (Wulf, Orr, & Chauvel, 2017). FOA has generally been defined in the literature as internal or external. An internal FOA is defined as attention that is directed towards bodily movements, while an external FOA is defined as attention that is directed towards the effect of the movement (Wulf, Hoess, & Prinz, 1998). The effects of FOA on the learning and performance of motor skills has been an intensely investigated topic in the motor learning literature over the last 20 years. Wulf (2013) conducted a 15-year review of the literature in sport and highlighted the consistent effects that differing attentional focus styles can have on learning and performance. Much of this investigation, while utilising sports tasks, has often focused on simple skills and deliberate manipulations of FOA. This has led to a paucity of work that has investigated how attention is directed in real world practice environments and whether findings transfer to complex competition environments where the consequences of a less-than-optimal FOA could be significant.

Internal FOA during practice has been consistently shown to inhibit learning and performance in motor skills. Conversely, an external focus has been consistently shown to facilitate these processes (Wulf, 2013). External FOA has also been explored in multidimensional terms, with research demonstrating that the further the focus is away from the body the greater the benefits (McNevin, Shea, & Wulf, 2003). In order to explain these consistent findings, Wulf, McNevin, and Shea (2001) proposed the constrained action hypothesis (CAH). The CAH suggests that individuals who focus internally (i.e., on body movements) during skill execution are consciously trying to control the processes that regulate their movements. This is suggested to disrupt the automatic processes that would normally regulate movement, resulting in a decline in performance and learning. In contrast, individuals who focus externally (i.e., on the flight of the ball) during skill execution take advantage of the unconscious and reflective control over movements.

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This promotes an automatic movement, which facilitates both performance and learning. This has recently been extended in the integrated OPTIMAL theory of motor learning, which suggests that an external focus also promotes underlying mechanisms of motor performance such as the effectiveness, efficiency, form, and automaticity of the movement (Wulf & Lewthwaite, 2016).

These findings have been repeatedly replicated within golf specific tasks (Bell & Hardy, 2009; Wulf, Lauterbach, & Toole, 1999; Wulf & Su, 2007). For example, Wulf and Su (2007) manipulated the focus of participants during a practice period of a golf pitching task. Participants were instructed to focus on either the "swing motion of their arms" (internal focus group) or the "pendulum-like motion of the club" (external focus group). A control group completed the task with no instructions. During the practice period there was no significant difference between group performances, however the external group performed significantly better than the internal and control groups on a retention test. Perkins-Ceccato, Passmore, and Lee (2003) explored whether the effects of FOA on golf performance differ depending on skill level. In contrast to previous literature, findings showed that low-skilled golfers performed more consistently on a golf pitching task when given internal FOA instructions than when given external FOA instructions. Whereas, the high-skilled golfers performed more consistently when given external FOA instructions. Bell and Hardy (2009) extended these findings by exploring an external FOA in multi-dimensional terms. It is suggested that an external FOA can be split into focus that is near to the body (proximal FOA) or far from the body (distal FOA). For example, in research on skilled golfers by Bell and Hardy (2009), a proximal external FOA is defined as focus that is directed to the club, while a distal external FOA is defined as focus that is directed to the target. Results showed that a distal external FOA is more beneficial than a proximal external FOA for skilled golfers' performance. However, despite investigating skilled samples these studies directly manipulated FOA and focused solely on performance outcomes not learning.

Despite the wealth of literature supporting the benefits of practicing with an external FOA in sport, there are consistent limitations that need to be considered. Firstly, a large number of studies within the area fail to use a transfer test to understand if the learning effects are sustained in a competition setting. This is due to the majority of the research using a novice sample and therefore exploring the transfer of effects into competition is not necessary. However, this gap in the current FOA literature makes application to applied sports environments challenging (e.g., An, Wulf, & Kim, 2013; Christina & Alpenfels, 2014; Wulf et al., 1999; Wulf & Su, 2007). For example, it is suggested that to fully understand if permanent changes have occurred, the skill needs to be transferred from practice to competition (Williams & Ford, 2009). One reason for this is to see if the learning effects uphold in a high-pressure situation when anxiety is induced (Bernier, Codron, Thienot, & Fournier, 2011). As previous research and theories such as distraction theories (e.g. Eysenck & Calvo, 1992; Wine, 1971) and explicit monitoring theories (e.g. Baumeister, 1984; Masters, 1992) suggest a strong link between anxiety and attentional processes in the phenomenon of choking (Bernier et al., 2011), the need for transfer tests into competition within FOA research is high. As the research discussed does not include transfer tests, the learning effects are not fully understood and therefore applied practitioners and athletes are less likely to implement the changes. Therefore, work is required that includes a transfer into competition to identify if FOA has sustained effects.

A second limitation of previous literature is the lack of ecologically valid evidence to support the CAH. Little research has examined the CAH and FOA in a real sport setting. For example, the majority of research (e.g., Bell & Hardy, 2009; Wulf & Su, 2007) has manipulated the FOA of the participants by instructing them to focus on a single cue (i.e., arm motion) throughout practice. Artificially directing FOA is unlikely to occur in a real golf practice setting, especially without the presence of a coach. Due to the unrepresentative nature of the research conducted, it makes it difficult to generalise to a real practice situation. However, other factors in the practice environment could naturally affect FOA, such as the use of personal devices for video analysis. Furthermore, there are a lack of manipulation checks in these studies to demonstrate the participants are focussing on what they are directed to. As it is suggested that individuals have a natural tendency to focus either internally or externally, for example it is suggested that males tend to focus more externally than internally (Wulf, Wachter, & Wortmann, 2003), manipulation checks are needed to assess if the instructions given by the researcher override these tendencies. To increase the ecological validity of the literature, work is required to explore the sources in the current practice environment that naturally alter the FOA of the athlete.

One suggestion is that the type of instruction and feedback given to an athlete in a practice setting determines the FOA adopted (Wulf & Prinz, 2001). Despite the advantages of an external FOA, most instructions utilised in sport practice tend to promote an internal FOA (Porter, Wu, & Partridge, 2010; Van der Graaff, Hoozemans, Pasteuning, Veeger, & Beek, 2018). For example, Van der Graaff et al. (2018) investigated coaches' instructions and feedback given in a baseball pitching task, in which external targets are readily available. Results showed that the majority of instructions promoted an internal FOA, demonstrating the influence that factors in the practice environment have on the FOA of the athlete. However, Van der Graaff et al. (2018) concluded that there remains a need for research conducted in a field environment that examines the impact of other sources of feedback. Furthermore, such research has only investigated how FOA may be directed by the feedback provided by a coach. However, not all practice, especially in golf, is conducted with the presence of a coach and numerous other sources of feedback are available in the natural practice environment (Schmidt & Lee, 2016).

A further source of feedback that is regularly present in practice environments which may promote an internal FOA is the use of technology. Technological advancements such as heart rate monitors, movement kinematics and video analysis provide the athlete with potentially internally focussed information (Pyke, 2013). Within golf specifically, the advancement of technology has seen a rise in the number of golfers using video analysis to improve their game (Guadagnoli, Holcomb, & Davis, 2002). For example, golfers commonly use the numerous applications available on smart phones to video, analyse and annotate their own swings and even compare their swings to those of professionals. Despite this extensive use, there is little research examining the effects of this on FOA and performance (Guadagnoli et al., 2002; Pauls, Bertram, & Guadagnoli, 2017). A previous study that supports the suggestion that video analysis within golf practice may promote an internal FOA was conducted by Roos and Surujlal (2014). Again, the focus of this study was on the golf coaches rather than golfers who practice independently. However, coaches explained that using video analysis promoted a very technical approach to coaching, resulting in athletes becoming overloaded with technical information about their swing, which often confuses players. However, the use of popular smart phone video in practice scenarios without the presence of a coach is yet to be examined.

Here we use a novel approach to investigate how the use of smart phone video analysis in the natural practice environment may influence FOA and the effect this has on learning and competition performance. We compare skilled golfers independently practicing with and without personal video analysis and measure FOA and measure learning in the practice environment (driving range), and real competition scores. Based on previous literature, it is hypothesised that the practice with video group will report significantly higher internal FOA than the practice only group. As a result, driving range performance scores will significantly decrease from pre-test to post/retention-test for the practice with video group, while the practice only group will improve over the course of the intervention. Furthermore, the practice with video group's competition performance scores will significantly decrease from baseline to post intervention, while the practice only group will improve.

2. Method

2.1. Participants

Participants were 19 skilled amateur golfers who hold a Council of National Golf Unions (CONGU) handicap and did not currently use video analysis during their golf practice (16 males, 3 females; age: $M = 25.37$, $SD = 7.95$; handicap: $M = 5.79$, $SD = 5.80$). Participants played an average of 10.89 ($SD = 5.81$) competitions in the last year and practice an average of 1.95 ($SD = 0.96$) times a week. To ensure an appropriate sample size, a power analysis was conducted using G*power (Faul, Erdfelder, Lang, & Buchner, 2007). We based our calculations on the main effect sizes reported by An et al. (2013) who investigated the effects of FOA on golf swing mechanics. We used the between-group effect size ($\eta_p^2 = 0.48$), a moderate correlation ($r = 0.3$), and power of 0.8. The total sample size required was $n = 14$. Informed consent was obtained from all participants prior to participation and ethical approval was granted by the local ethics committee.

2.2. Pilot study

A pilot study was conducted with one club level golfer (handicap = 8) completing the procedure. From the pilot study, the target distance and size for the driving range performance task was decided based on shot outcomes. All other procedures were deemed suitable.

2.3. Dependent measures

Driving range performance. Pre- and post/retention performance was measured using a similar procedure to Wulf and Su (2007). Four concentric circles were placed around a target 116 yards away. The inner circle was four yards in diameter, with each circle away increasing by two yards in diameter. Concentric circle sizes were decided based on the performance in the pilot study. Participants played 50 shots with the aim to hit the ball to the centre of the target. Five points were awarded for balls finishing in the inner circle, with one point less being awarded for each circle away. Balls finishing outside the outer circle scored zero points. Scores for all 50 balls were summed to give a performance score (Perkins-Ceccato et al., 2003; Wulf & Su, 2007). Throughout the study participants used their own golf clubs, golf balls provided by the researcher, and played from an artificial surface on the driving range.

Focus of attention. Participants completed a practice diary to measure FOA during the intervention period. The practice diary required both a qualitative and quantitative response from the participants. As the full golf swing is a complex skill and golf practice sessions are often varied, a mixed method approach allowed an in-depth insight into the FOA of the participant throughout the whole session. Hanson, Creswell, Clark, Petska, and Creswell (2005) who suggested that the inclusion of a qualitative element in quantitative research provides a deeper understanding of the phenomenon of interest. The diary was an electronic file that contained an overview of the study, instructions to follow and individual sheets for each of the eight practice sessions. Each sheet asked the participants to answer the question of “What were you thinking about while practicing?” This open question as a measure of FOA was adapted from previous research by Porter et al. (2010), who used a similar open-ended question to understand track and field athletes focus during competition. Additionally, participants answered three questions proposed by Bell and Hardy (2009) as a measure of FOA in golf. On a Likert scale ranging from one (not at all) to five (very much so), participants rated how true the following statements were of their practice session: 1) To what extent were you focussed on the movements of any part of your body (e.g., legs, torso, arms, hands or head) as you executed the shot? 2) To what extent were you focused on the position of the clubface as you executed your shots? 3) To what extent were you focused on the flight of the ball as you executed your shots?

Competition performance. Participants provided their stableford scores from the last five competitions they competed in prior to starting the study. These provided a baseline of the participants’ current competition level. After completing the practice schedule, participants provided their stableford scores from all competitions they competed in within the following three months ($M = 4.26$ scores per participant).

2.4. Procedure

Pre-test and post/retention-test. All participants completed the pre-test prior to the practice schedule to provide a baseline level of performance. The same test was completed as a post/retention-tests between two and four days after conclusion of the practice schedule.

Practice schedule. Following completion of the pre-test, participants were allocated to either the *practice with video* ($n = 10$) group or the *practice only* ($n = 9$) group by stratified randomisation to ensure an even distribution of handicaps between groups (Dempster, 2011). Each participant then completed a 400 trial, four-week, practice schedule that has been suggested to be an appropriate length to identify if learning has occurred (Lawrence, Gottwald, & Kahn, 2012). The practice schedules were conducted over four weeks with two practice sessions completed each week and 50 trials completed in each session. 50 balls per session twice a week was selected as this reflects the normal practice conditions of the participants, ensuring the research is representative of the target population (Brewer & Crano, 2000). After each visit, participants completed the practice diary.

Practice with video analysis group. Participants were instructed to video their swing after every ten shots (five times per session) and take one point of interest from the video before hitting the next ten shots. This was done using the camera on the smart phone device of the participant. Following each session, participants completed the practice diary and sent this and their videos to the lead researcher.

Practice only group. To increase the ecological validity of the research, a practice only group was used opposed to a control group. It is unlikely that the skill level of the participants would not go to the driving range at all over a four-week period, therefore a practice only group was selected. Participants were instructed to complete the practice schedule and not video their swings throughout. The participant diary was completed and sent to the researcher after each visit.

Manipulation Checks. Due to the nature of the study, manipulation checks were important in understanding if the experimental procedure had been successfully implemented (Haslam & McGarty, 2014). Practice diaries sent to the researcher after each session indicated that all participants engaged with the practice schedule. The practice only group were asked if they had videoed their swing throughout the practice schedule and indicated that they had not engaged in video practice throughout the study. The practice with video group sent all of their videos to the lead researcher. All participants were asked to rate on a scale of one (not at all) to 100 (extremely) how committed they were to completing the practice schedule. Participants rated an average of 91% commitment. All participants were also asked to rate on a scale of one (not at all) to 100 (extremely) how much they adhered to the practice instructions outlined in the practice diary. Participants rated an average of 95.6% adherence.

2.5. Data analysis

2.5.1. Driving range performance

Grouping players was based on matching on-range pre-test scores and an independent samples *t*-test was used to ensue no difference in group performance before the intervention. Averages for each group were calculated for pre- and post-tests of on-range and competition performance. Data was deemed normally distributed and two Analyses

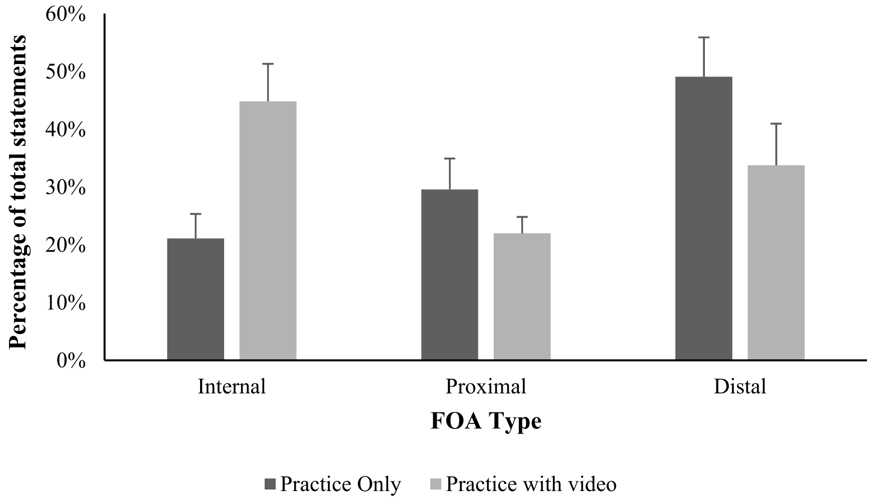

Fig. 1. Percentage of statements recorded in the practice diary referring to an internal, external proximal or external distal FOA of the practice only group and practice with video group with standard error bars.

of Variance (ANOVA) were used to analyse the effect of group (practice only, practice with video), time (pre, post/retention) and group × time interaction for both driving range performance and competition performance. Interactions were investigated further by calculating change scores for individual participants and comparing mean change scores between groups using independent sample t-tests. Violations of sphericity were corrected by adjusting the degrees of freedom using the Greenhouse-Geisser correction when epsilon was less than 0.75 and the Huynh-Feldt correction when greater than 0.75. Partial eta squared ($\eta_p{}^2$) was used as a measure of effect size for all analyses.

2.5.2. Focus of attention

Self-reported attentional focus ratings. An average internal (i.e., focus on bodily movements), proximal (i.e., focus on club face), and distal (i.e., focus on target) focus score was calculated for each participant from attentional focus ratings. The average internal FOA score was calculated by finding the mean rating given to each of the three questions on the Bell and Hardy (2009) rating scale over the practice period. Mean were calculated for each group. Independent t-tests were used to determine if there was a significant difference between each of the three attentional focus scores of the practice only group and the practice with video group. Cohen's *d* was used as a measure of effect-size. The alpha level (*p*) for statistical significance was set at 0.05 for all tests.

Self-reported attentional focus statements. Deductive content analysis was conducted on the practice details recorded in the practice diaries. Firstly, the researcher read through the data several times so ensure the data was fully understood (Polit & Beck, 2004). Statements containing a mixed attentional focus were split into clauses and each clause was coded individually. Secondly, a categorisation matrix was developed based on previous research definitions of FOA styles. Clauses were coded as invoking an internal FOA when they contained information regarding the movements of the body parts during the execution of the skill (van Vilet & Wulf, 2006). Examples of such clauses in the practice diaries were: "turning my hips through" and "hand position at the top". Clauses that were directed at an external factor close to the body were coded as invoking a proximal focus of attention (Bell & Hardy, 2009). Examples of such clauses in the practice diaries were: "club face was square" and "consistent strike". Finally, clauses were coded as invoking a distal focus of attention when they contained a focus on an external factor that was further away from the body (Wulf, McNevin, Fuchs, Ritter, & Toole, 2000). Examples of such clauses in the practice diaries were: "the flight of the ball" and "the flag". Thirdly, the number of FOA statements made in the practice diary was totalled and the percentage of statements relating an internal, proximal or distal focus was calculated for each participant. To ensure inter-rater reliability, the data was coded by the lead researcher and by an independent researcher to reduce bias (Davey, Gugiu, & Coryn, 2010). Cohen's kappa was run to determine if there was an agreement in coding between the two researchers. Analysis indicated that there was a substantial agreement between the two researchers, $k = 0.737$, $p = .001$ (McHugh, 2012). The data in discrepancy was discussed and both coders came to an agreement. Independent t-tests were used to determine if there was a significant difference between each of the three attentional focus percentages of the practice only group and the practice with video group. Cohen's *d* was used as a measure of effect-size. The alpha level (*p*) for statistical significance was set at 0.05 and Bonferroni corrections were incorporated to correct for multiple comparisons. Exact significance values (*p*) are reported throughout.

3. Results

3.1. Focus of attention

Self-reported attentional focus statements during practice. There was no significant difference between the total number of statements in the practice diary of the practice only group ($M = 28.33$, $SD = 9.73$) and the practice with video group ($M = 29.50$, $SD = 13.16$), $t(17) = .\text{-}0.22$, $p = .415$, $d = 0.10$. However, there was a significant difference between the percentage of statements referring to an internal FOA of the practice only group ($M = 21.12$, $SD = 12.76$) and the practice with video group ($M = 44.83$, $SD = 20.51$), $t(17) = -2.98$, $p = .004$, $d = 1.39$. There was also a significant difference in the number of statements referring to external focus between the practice only ($M = 78.76$, $SD = 12.77$) and the practice with video group ($M = 55.76$, $SD = 20.15$), $t(17) = 2.93$, $p = .009$, $d = 1.36$. There was no significant difference between the percentage of statements referring to a proximal FOA of the practice only group ($M = 29.63$, $SD = 16.05$) and the practice with video group ($M = 22.01$, $SD = 8.96$), $t(17) = 1.30$, $p = .212$, $d = 0.59$. There was no significant difference between the percentage of statements referring to a distal FOA of the practice only group ($M = 49.13$, $SD = 20.45$) and the practice with video group ($M = 33.75$, $SD = 22.83$), $t(17) = 1.54$, $p = .142$, $d = 0.71$. Fig. 1 shows the percentage of statements referring to an internal, proximal or distal FOA for both groups.

Self-reported attentional focus ratings. There was no significant difference in internal FOA scores for the practice only group (M = 2.93, SD = 1.07) and the practice with video group (M = 3.54, SD = 0.78), but there was moderate to high effect size, $t(17) = -1.43$, p = .085, d = 0.65. There was also no significant difference in proximal FOA scores for the practice only group (M = 2.83, SD = 0.97) and the practice with video group (M = 2.65, SD = 0.69), $t(17)$ = 0.46, p = .323, d = 0.22. There was a non-significant difference in distal FOA scores for the practice only group (M = 3.56, SD = 0.59) and the practice with video group (M = 3.30, SD = 0.80), $t(17)$ = 0.77, p = .225, d = 0.37.

3.2. Performance

Driving range performance. Results at pre-test revealed no significant difference between the practice only group (M = 146.22, SD = 17.23) and the practice with video group (M = 147.80, SD = 16.51), $t(17) = -0.20$, p = .840, d = .009. There was no significant main effect of group for performance test scores, $F(1, 17) = 0.19$, p = .666, $\eta_p^2 = 0.01$, and no significant main effect of time for the performance test scores, $F(1, 17) = 0.19$, p = .747, $\eta_p^2 = 0.01$. However, there was a significant time by group interaction for performance test sores, $F(1, 17) = 5.27$, p = .035, $\eta_p^2 = 0.24$. Fig. 2a shows the nature of the interaction where the practice only group increased performance scores from pre- (M = 146.22, SD = 17.23) to post/retention-test (M = 151.56, SD = 16.33), while the practice with video group showed a decrease in performance score from pre- (M = 147.80, SD = 16.51) to post/retention-test (M = 143.80, SD = 13.69). There was a significant difference in pre-to post-test change scores between the practice only group (5.33 ± 6.22) and the practice with video group (−4.00 ± 10.65; $t(17)$ = 2.29, p = .04, d = 1.07.

Competition performance. Results at baseline revealed no significant difference between the practice only group and the practice with video group, $t(17) = -0.20$, p = .65. There was no significant main effect between groups for competition scores, $F(1, 17) = 0.51$, p = .46, $\eta_p^2 = 0.03$, no significant main effect of time for competition scores, $F(1, 17) = 0.35$, p = .56, $\eta_p^2 = 0.02$ and no significant time by group interaction for competition scores, $F(1, 17) = 0.64$, p = .43, $\eta_p^2 = 0.04$ (Fig. 2b). There was no difference in change scores between the practice only group (0.53 ± 1.99) and the practice with video group (−0.08 ± 1.30; $t(17)$ = 0.803, p = .803, d = .36.

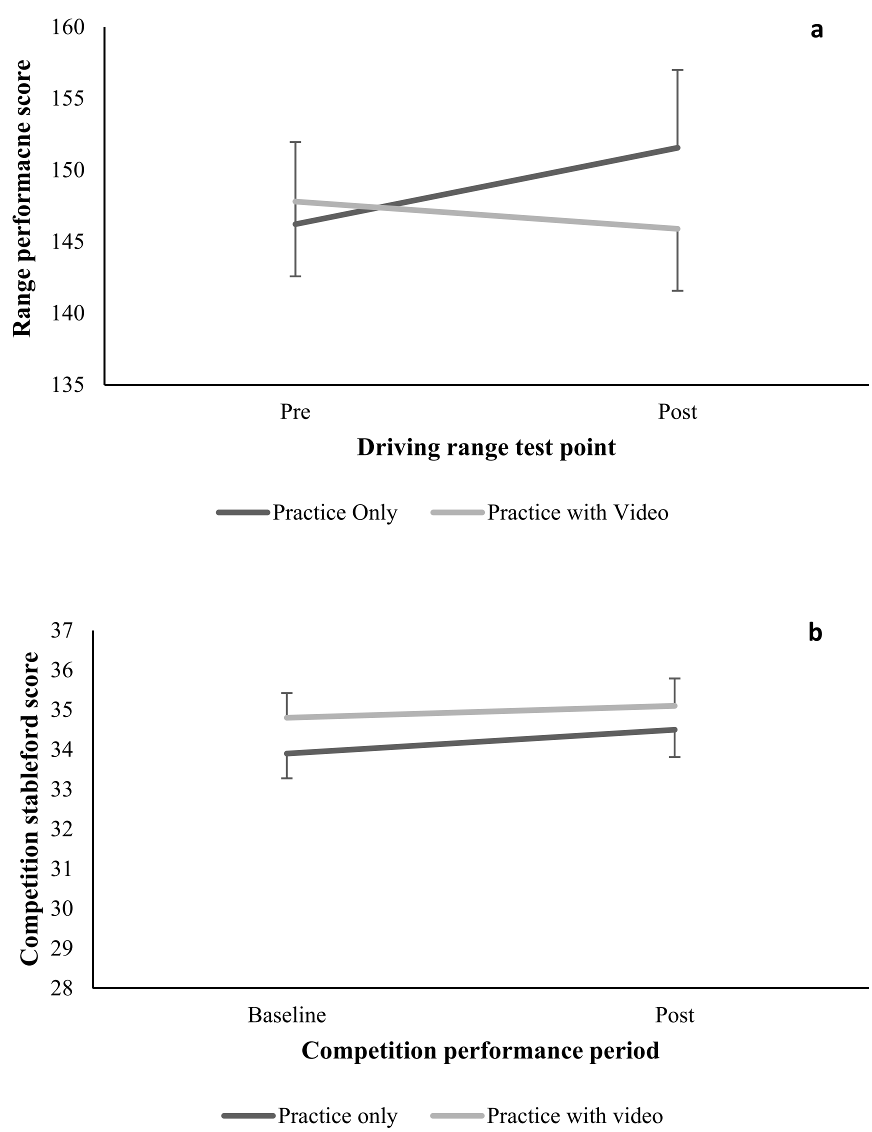

Fig. 2. Performance scores in (a) driving range pre-test and post/retention-test performance and (b) on course competition performance at baseline and post-intervention for the practice only group and the practice with video group with standard error bars.

4. Discussion

This study used a novel approach to investigate how FOA may be influenced by the use of smart phone video analysis in the natural practice environment and the effect this has on learning and performance in practice (driving range) and competition environments. We compared skilled golfers who practiced independently with and without personal video analysis. Results show that the practice with video group reported significantly higher internal FOA statements than the practice only group. However, this finding was not replicated when using questions from Bell and Hardy (2009). There was a significant interaction between group and time where the practice with video group's driving range performance scores decreased from pre-test to post/retention-test in comparison to the practice only group who improved driving range performance scores. However, no changes were observed in competition scores pre-to post-intervention for either group.

In support of our hypotheses, the practice with video group did report a significantly higher percentage of internal FOA statements in the practice dairy than the practice only group. This occurred consistently across practice sessions in which the swing was recorded. Previous work has suggested that videos are primarily used in golf practice so that the golfer can see how their own body is moving during the shot (Park & Lee, 2016). The feedback received from these videos provides knowledge of performance (KP; i.e., feedback on movement patterns) rather than knowledge of results (KR; i.e., feedback on the outcome; Lauber & Keller, 2014). This in turn could lead to the use of declarative rather than procedural memory structures. Moran, Murphy, and Marshall (2012) suggest that feedback in the form of knowledge of results does promote an external FOA. Therefore, it may be inferred that feedback in the form of KP received from video promotes an internal FOA, as it directs the learner towards their bodily movements. This relationship between KP and internal FOA has been acknowledged by previous research (Weeks & Kordus, 1998; Wulf, McConnel, Gartner, & Schwarz, 2002). For example, Wulf et al. (2002) suggests that KP feedback given on a volleyball "tennis" serve induces an internal focus in novice and advanced level volleyball players.

While there was a trend and a medium to large effect size for the self-reported attentional focus ratings using modified questions from Bell and Hardy (2009), this measure did not show significant differences in FOA between groups. The scale was originally developed as a specific measure of FOA during a golf putt so the specificity of questions may have made the measure less sensitive during a full shot. For example, the specific question of "to what extent were you focused on the position of the clubface as you executed your shots?" was an appropriate measure of a proximal FOA for putting. However, in the present study the FOA during the execution of a whole golf shot was being measured. As the whole golf swing is a complex skill with the face of club moving much faster and in a more variable manner, it may be that the participant had an external proximal FOA that did not involve focussing on the position of the clubface. Furthermore, the distal FOA rating used by Bell and Hardy (2009) may not truly reflect a distal FOA as "the target" is not an effect caused by the action. This variation between the two measures of FOA used in the present study highlight the importance of the open-ended question used alongside.

As predicted, results showed a significant interaction between group and time for driving range performance. The practice only group improved from pre-test to post/retention-test whereas the driving range performance of the practice with video group decreased. This supports the predictions of the CAH, the OPTIMAL theory, and a large body of previous empirical literature (e.g., Wulf et al., 1998; Wulf, Shea, & Park, 2001) by showing that the group with increased internal focus showed a decrease proficiency in performance of a motor skill. We have also extended these previous findings by displaying that this effect can occur for skilled performers in natural practice settings due to the use of popular smart phone video analysis for complex gross motor skill.

We had also hypothesised that the practice with video group competition performance scores would significantly decrease from baseline to post intervention. However, no significant difference was found between or within the group competition performance scores at pre- and post-test. This suggests performance effects from the practice environment may not have transferred to competition scores. One possible explanation for this can be linked to the work of Peh, Chow, and Davids (2011) who suggested that when performing a task in which there is a performance outcome, it is natural for performers who are proficient in the skill to switch from focussing on the movements of their body to focussing on the target. Based on this research, it is likely that, although the participants in the practice with video group were mainly directing their attention internally in practice, they may be capable of switching to a different and more optimal FOA in competition. As performance in a transfer test provides an understanding of whether learning has fully occurred (Williams & Ford, 2009), it may be inferred that despite effects shown in the practice environment, there were actually no competitive disadvantages to practicing using video analysis.

The findings presented here have implications for both theory and practice. A strength to the current research is that it builds on the current knowledge base by examining how a practice technique (i.e., video analysis) affects FOA in a real practice environment. The field-based design of this study allowed for the research to be conducted in the natural practice environment of the participants, providing high ecological validity and making the findings more generalisable to the applied world (Pinder, Davids, Renshaw, & Arujo, 2011). Furthermore, Porter et al. (2010) suggests that there is a recognisable gap between empirical evidence derived under laboratory conditions and its applicability to the real practice setting. Specifically, within the FOA literature, Van der Graaff et al. (2018) suggested that there is the need for field experiments to be conducted that investigate how FOA may be invoked in a real sport context. The findings presented here take a step towards bridging this gap by using a novel method that integrated the use of widely used modern technology and exploring how FOA effects extend to competition performance in skilled golfers. Due to the preliminary nature of the present findings, further research is needed to fully understand the impact of FOA on competition performance.

Some limitations of the current study should also be noted. We did not measure the participant's preferred FOA prior to the study to avoid any potential changes in natural FOA before introducing the video manipulation. We cannot therefore show that FOA became more internal from pre-test to video-based practice, however, a change from participant's natural FOA can be inferred from decreases in performance observed. While the effort to measure FOA in a natural practice session is a strength of this study, the method of utilising a practice diary is not without its potential limitations. The participants were not required or expected to understand or know their FOA but instead reported what they worked on during practice; this information was then interpreted as different types of FOA by the researchers. Although we showed strong inter-rated reliability there may be more direct ways to assess FOA in natural practice settings. Stableford scoring is a measure that incorporates the complexity of a golf competition into a single score, which consists of the performer completing all parts of the golf game (e.g., driving, approach shots and putting) in one round. It has been suggested that previous research within the FOA literature has failed to find differences between group performances due to the lack of sensitivity of measures (Kearney, 2015). To increase the sensitivity of the competition measure, future research could provide participants with a statistical recording scorecard to complete throughout their competition rounds (England Golf, 2014). While we did measure competition performance which can be assumed to be a significantly pressurised environment, we were unable take measures of FOA or anxiety during competition. To build on the current work, future research could examine how practicing with video analysis affects skilled golfers' performance when high levels of anxiety are induced (Jackson, Ashford, & Norsworthy, 2006; Liao & Masters, 2002) and aim to measure FOA in the performance environment to confirm if skilled performers are able to switch to a more beneficial FOA in competition.

This study used a novel approach to investigate how FOA may be influenced by the use of technology in the natural practice environment and the effect this has on performance in practice and competition. Findings presented provide the first quantitative support that advancements in technology, such as smart phone video analysis, may be a cause of internal focus for the athlete and the potential issues this causes in practice. However, we have extended previous literature in this area to show that, in skilled performers, changes in FOA in golf practice may not impact the more complex domain of competition performance.

CRediT authorship contribution statement

Beth Yeoman: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing - original draft, Writing - review & editing, Visualization, Project administration. **Phil D.J. Birch:** Conceptualization, Methodology, Resources, Writing - review & editing. **Oliver R. Runswick:** Conceptualization, Methodology, Formal analysis, Writing - review & editing, Visualization, Project administration, Supervision.

Declaration of competing interest

None.

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