

The effects of conscious processing on golf putting proficiency and kinematics

John Toner & Aidan Moran

Abstract

Researchers have suggested that skill performance deteriorates when people try to exert conscious control over automatic actions. Unfortunately, little is known about the effects of different *types* of conscious processing on skilled performance by expert athletes. We conducted two experiments to address this issue. Experiment 1 investigated the influence of a specific form of conscious control (making technical adjustments to a stroke) on the putting skills of expert golfers. The expert golfers maintained putting proficiency (i.e. number of putts holed) when making technical adjustments. However, this form of conscious processing altered the timing and consistency of golfers' putting strokes. Experiment 2 compared the influence of technical adjustments and conscious monitoring (paying attention to the execution of the stroke) on expert golfers' putting skills. Technical adjustments had no disruptive influence on expert golfers' putting proficiency but did reduce the consistency of their strokes. However, conscious monitoring was found to impair putting proficiency. The implications of the work for theory and future work are discussed.

Keywords: Conscious control, explicit monitoring, expertise, kinematics,

Introduction

When describing their peak performances, many elite athletes indicate that they devote little or no conscious attention to the mechanics of their movement (Jackson, Martin, & Eklund, 2008 Jackson, S. A., Martin, A. J. and Eklund, R. C. 2008. Long and short measures of flow: The construct validity of the FSS-2, DFS-2, and new brief counterparts. *Journal of Sport and Exercise Psychology*, 30: 561–587.). In contrast, when expert athletes suffer performance anxiety (e.g. as happens in “choking”; for reviews, see Gucciardi & Dimmock, 2008 Gucciardi, D. F. and Dimmock, J. A. 2008. Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources?. *Psychology of Sport and Exercise*, 9: 45–59. ; Hill, Hanton, Matthews, & Fleming, 2010 Hill, D. M., Hanton, S., Matthews, N. and Fleming, S. 2010. Choking in sport: A review. *International Review of Sport and Exercise Psychology*, 3: 24–39.), they may increase the amount of conscious attention that they devote to their movements, thereby interrupting automated skills and impairing subsequent performance (Jackson & Beilock, 2008). According to Beilock and Carr's (2001 Beilock, S. and Carr, T. 2001. On the fragility of skilled performance: What governs choking under pressure?. *Journal of Experimental Psychology: General*, 130: 701–725.) explicit monitoring hypothesis, consciously attending to step-by-step skilled behaviour impairs expert performance significantly as high-level execution is thought to be governed by proceduralized knowledge that is run without conscious attention to task components. This prediction was corroborated by Beilock and colleagues (Beilock, Carr, MacMahon, & Starkes, 2002 Beilock, S. L., Carr, T. H., MacMahon, C. and Starkes, J. L. 2002. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, 8: 6–16.) in a study of the influence of skill-focused attention on the putting performance of experienced golfers (i.e. handicaps less than 8). When players attended to a specific aspect of their technique (namely, the exact moment that the clubhead finished its follow-through), performance was impaired relative to a dual-task condition in which they putted while performing a secondary task (an auditory tone-monitoring activity).

According to Masters' (1992) theory of “reinvestment” (see recent review by Masters & Maxwell, 2008 Masters, R. S. W. and Maxwell, J.

2008. The theory of reinvestment. *International Review of Sport and Exercise Psychology*, 1: 160–183.), performance breakdown is likely to occur when expert performers “reinvest” or manipulate conscious rule-based knowledge in an effort to control their movements during motor output. Masters and Maxwell (2008 Masters, R. S. W. and Maxwell, J. 2008. The theory of reinvestment. *International Review of Sport and Exercise Psychology*, 1: 160–183.) identified performance-related pressure as the key trigger for reinvestment, which is held to exert its debilitating influence on performance by increasing people's self-consciousness of their movement. This heightened self-consciousness may activate “conscious, explicit, rule based knowledge ... to control the mechanics of one's movements during motor output” (Masters & Maxwell, 2004, p. 208).

Although Masters and Maxwell (2004) suggested that changes in actual motor performance were an *unintended* consequence of conscious control, there is evidence that expert performers sometimes *consciously* change the mechanics of their movement when experiencing performance-related pressure. Such attempted conscious control seems to disrupt certain *kinematic* characteristics of performance. For example, Collins and colleagues (Collins, Jones, Fairweather, Doolan, & Priestly, 2001) measured kinematic aspects of weightlifters' performance during training and competition. They also questioned these athletes about their conscious use of any movement change strategy. The elite weightlifters consciously modified their movement as a result of competitive pressure and such modifications led some participants to display a more inconsistent action. However, Collins et al. (2001 Collins, D., Jones, B., Fairweather, M., Doolan, S. and Priestley, N. 2001. Examining associated changes in movement patterns. *International Journal of Sport Psychology*, 31: 223–242.) also reported that despite displaying more variable movements, participants were successful at the weightlifting tasks attempted. This finding suggests that although reinvestment may change experts' movement patterns, it may not always diminish their overall task performance.

Additional evidence that performance-related pressure may induce performers to deliberately manipulate their actions comes from a study by Nicholls and colleagues (Nicholls, Holt, Polman, & James, 2005 Nicholls, A. R., Holt, N. L., Polman, R. C. J. and James, D. W. G. 2005. Stress and coping among international adolescent golfers. *Journal of Applied Sport Psychology*, 17: 330–340.). These authors identified the

use of “technical adjustments” as one of the strategies used by a sample of elite adolescent golfers to deal with stress. Such adjustments included modifications to “swing plane, stance, grip and technique” (p. 336). However, although Nicholls et al. (2005 Nicholls, A. R., Holt, N. L., Polman, R. C. J. and James, D. W. G. 2005. Stress and coping among international adolescent golfers. *Journal of Applied Sport Psychology*, 17: 330–340.) showed that elite golfers make technical adjustments during competitive performance, researchers have yet to determine the precise mechanism by which this particular form of conscious control may influence performance proficiency (e.g. number of putts holed) and/or movement quality (e.g. kinematic aspects of skilled movements).

How does conscious processing influence the execution of automated movement? Although not dealing specifically with the use of technical adjustments, Fitts and colleagues (Fitts, Bahrick, Noble, & Briggs, 1961 Fitts, P., Bahrick, H., Noble, M. and Briggs, G. 1961. *Skilled performance*, New York: Wiley.) proposed the progression-regression hypothesis to describe how conscious control results in a “dechunking” of automated movement. This hypothesis suggests that “dechunking” causes proceduralized control structures that normally operate without interruptions to be broken down into a sequence of smaller, independent movements in a manner representative of performance during novice learning (Beilock & Gray, 2007; Fitts & Posner, 1967 Fitts, P. M. and Posner, M. I. 1967. *Human performance*, Belmont, CA: Brooks/Cole.). Evidence supporting this hypothesis comes from studies that show that conscious processing can disrupt the timing and variability of expert movement. For example, Mullen and Hardy (2000 Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.) found that the backswing and downswing times of golfers (whose handicap ranged from 12 to 18) increased in an experimental condition in which their attention was directed to the mechanics of their putting strokes relative to a condition in which they received no instructions. Furthermore, Gray (2004 Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54.) found that expert baseball players who monitored their action not only increased movement variability but also experienced disruption to the sequencing and relative timing of the different stages of their swings compared with performance in normal conditions.

A limitation of the studies by Mullen and Hardy (2000 Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.) and Gray (2004 Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54.) is that they examined only how conscious monitoring (i.e. attending to a specific aspect of technique) influences automated movement. They did not investigate the influence of either technical adjustments or conscious modifications on performance proficiency or on kinematic aspects of experts' movements. Therefore, to fill this gap in the research literature, in the current study we employed motion analysis technology to examine the influence of excessive conscious control (technical adjustments) on the putting performance of a sample of expert golfers. We also sought to address a persistent methodological problem in previous studies in this field (e.g. Beilock et al., 2002 Beilock, S. L., Carr, T. H., MacMahon, C. and Starkes, J. L. 2002. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, 8: 6–16. ; Gray, 2004 Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54. ; Mullen & Hardy, 2000 Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.) – namely, the questionable ecological validity of the experimental methods that purport to induce conscious processing in participants. For example, Mullen and Hardy (2000 Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.) required participants to repeat aloud a coaching point that had been paraphrased into a verbal cue while they putted. This method has dubious ecological validity because “it would seem rather peculiar to observe an expert golfer verbalizing explicit cues or random letters when putting during a competition” (Gucciardi & Dimmock, 2008 Gucciardi, D. F. and Dimmock, J. A. 2008. Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources?. *Psychology of Sport and Exercise*, 9: 45–59.p. 49). In a similar vein, Gray (2004 Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54.) instructed his baseball participants to indicate

whether their bat was moving up or down when a tone was presented; this secondary task has been criticized for being somewhat “contrived and arbitrary” (Wilson, Chattington, Marple-Horvat, & Smith, 2007; Wilson, M., Chattington, M., Marple-Horvat, D. E. and Smith, N. C. 2007. A comparison of self-focus versus attentional explanations of choking. *Journal of Sport and Exercise Psychology*, 29: 439–456.p. 454). In view of these methodological problems, Wilson et al. (2007; Wilson, M., Chattington, M., Marple-Horvat, D. E. and Smith, N. C. 2007. A comparison of self-focus versus attentional explanations of choking. *Journal of Sport and Exercise Psychology*, 29: 439–456.) recommended that future research in this field should “examine attentional and behavioural changes in performers in more ecologically valid tasks, which require less forced attentional manipulations” (p. 454). It is this latter challenge that inspired the present study.

In summary, the current experiments attempted to circumvent a methodological limitation of previous research on conscious processing in athletes by employing a more ecologically valid task than used to date. Specifically, we requested expert golfers to either attend to or to adjust certain aspects of their technique while kinematic aspects of their performance were being measured by a motion analysis system. This motion analysis system provided an objective method of determining whether or not participants *actually* attended to or adjusted their technique in the instructed manner.

Experiment 1

The aim of Experiment 1 was to examine the influence of conscious processing (in the form of making technical adjustments to a skill) on expert golfers' putting proficiency and key kinematic aspects of their putting strokes (as measured by a motion analysis system). We predicted that expert golfers who made technical adjustments would experience impaired putting proficiency and disruption to the timing and consistency of their putting strokes.

Methods

Participants

A total of 14 male expert golfers participated. Their mean age and handicap were 27.14 years ($s = 11.42$) and 2.6 ($s = 1.9$) respectively. The participants' handicaps ranged from 0 to 6. Ethical approval was

received from the Human Research Ethics Committee of University College, Dublin.

Apparatus

The experiment was conducted on an indoor putting green (1.22 × 3.05 m, Huxley golf green). All participants used their own putters but golf balls were provided by the experimenter. The golfers' putting actions were examined using a three-dimensional kinematic ultrasound system called SAM PuttLab (www.scienceandmotion.com). Briefly, SAM PuttLab records putting stroke positional data, stores it on a computer, reconstructs movement from the data, and then provides an in-depth kinematic analysis of the stroke. SAM PuttLab's accuracy is supported by the system's use of more than 210 data points per second, recorded to determine the position of one's club with a precision of one-tenth of a millimetre for position and one-tenth of a millimetre for alignment (Science and Motion in Golf, 2005). Evidence to support the reliability of the SAM PuttLab system is provided by Karlsen and colleagues (Karlsen, Smith, & Nilsson, 2008; Karlsen, J., Smith, G. and Nilsson, J. 2008. The stroke has only a minor influence on the direction consistency in golf putting among elite players. *Journal of Sports Sciences*, 26: 243–250.).

Procedure

Participants were required to hole golf putts from a distance of 2.5 m from the hole. All participants completed a practice condition involving five putts (as used by Land & Tenenbaum, 2007; Land, W. M. and Tenenbaum, G. 2007. Facilitation of automaticity: Sport-relevant vs. non-relevant secondary tasks. *Journal of Sport and Exercise Psychology*, 29(s178)) and two subsequent counterbalanced conditions each involving 20 putts (as used by Beilock et al., 2002; Beilock, S. L., Carr, T. H., MacMahon, C. and Starkes, J. L. 2002. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, 8: 6–16.). The subsequent two conditions represented a “normal” condition in which participants received no instructions and a conscious control condition in which participants were asked to make a technical adjustment to a flawed aspect of their putting stroke. Furthermore, participants were instructed to hole as many putts as they could. Two

aspects of putting performance were measured. First, a scoring system – similar to the one adopted by Smith and Holmes (2004 Smith, D. and Holmes, P. 2004. The effect of imagery modality on golf putting performance. *Journal of Sport and Exercise Psychology*, 26: 385–395.) – was used as an index of putting proficiency. Five points were awarded to putts that finished in the hole, 3 points to putts that hit the lip of the hole but did not go in (with some control over their pace), 2 points to putts that went past the hole (again, with some control over their pace), and 1 point to putts that finished short of the hole. Second, the SAM PuttLab examined how technical adjustments influenced kinematic aspects (especially timing and consistency) of golfers' putting strokes. Accordingly, six relevant putting stroke parameters – impact timing, impact velocity, backswing time, forwardswing time, consistency, and rhythm – were examined. With respect to the latter two variables, stroke consistency was measured by examining the variability of participants' impact timing, impact velocity, backswing time, and forward swing time. The SAM PuttLab system calculated a consistency score by comparing participants' raw data values on each of the aforementioned putting stroke parameters with the distribution of European Tour golfers' data. In addition, putting stroke rhythm measured the ratio of backswing time to impact time (i.e. from the initiation of the downswing to the point when the ball is struck).

Results

Manipulation checks

A manipulation check was employed to ensure that all participants made the requested change to their putting strokes in the conscious control condition. In particular, participants 1, 3, 4, and 6 were instructed to reduce the extent to which their putter paths moved to the left of the target at impact (see Table I). In contrast, participants 10, 11, and 14 were instructed to reduce the extent to which they moved their putter paths to the right. Participants 2, 5, 7, 8, and 13 were instructed to lower their putter rise angles, while participants 9 and 12 were asked to increase them. The manipulation check revealed that all participants adjusted their putting strokes in the instructed manner.

Table I.

Putting proficiency and kinematic data

The SAM PuttLab system collected kinematic data for all 14 participants. Each dependent variable (i.e. the index of putting proficiency and six kinematic variables) was subjected separately to a paired samples t -test to examine how technical adjustments influence putting performance. To control for the inflation of Type 1 error rate as a result of multiple t -tests, a Bonferroni conversion on the critical P -value for this set of comparisons was performed, resulting in a P -value of 0.007 (0.05/7).

The act of making technical adjustments had no significant influence on participants' putting proficiency ($t_{13} = 1.44$, $P > 0.007$, $d = 0.35$), their impact velocity ($t_{13} = -1.92$, $P > 0.007$, $d = -0.54$) or on their putting stroke rhythm ($t_{13} = -0.93$, $P > 0.007$, $d = -0.05$). However, technical adjustments *did* significantly influence golfers' backswing times ($t_{13} = -3.80$, $P < 0.007$, $d = -0.33$), forwardswing times ($t_{13} = 5.40$, $P < 0.007$, $d = -0.56$), impact timing ($t_{13} = 4.01$, $P < 0.007$, $d = -0.22$), and the consistency of their putting stroke ($t_{13} = 6.14$, $P < 0.007$, $d = 1.4$). Overall, these results indicate that when expert golfers make technical adjustments to their putting strokes, the overall consistency of their action is impaired and their putting strokes become significantly slower (see Table II).

Table II.

Discussion

We examined the mechanisms by which technical adjustments influence the proficiency and kinematic aspects of the putting stroke of expert golfers. Performers were required to make technical adjustments to their action and the influence of these modifications upon putting proficiency and on various kinematic aspects of their putting strokes was examined. On the basis of previous conscious processing research (e.g. Mullen & Hardy, 2000 Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.), we anticipated that technical adjustments would not only significantly disrupt expert golfers' putting proficiency but would also impair the timing and consistency of their putting strokes. Our findings may be summarized as follows.

First, technical adjustments had no significant influence on expert golfers' putting proficiency. This result is quite surprising as we expected that such a severe form of conscious control (i.e. making technical adjustments to a skilled action) would disrupt a normally automated movement such as an expert golfer's putting stroke. In line with the findings of Collins et al. (2001 Collins, D., Jones, B., Fairweather, M., Doolan, S. and Priestley, N. 2001. Examining associated changes in movement patterns. *International Journal of Sport Psychology*, 31: 223–242.), and in contrast to received wisdom, it would appear that conscious control (in the form of technical adjustments) may not inevitably disrupt task performance.

Second, using motion analysis technology, we found that four key movement parameters of the putting stroke (namely, backswing times, forwardswing times, impact timing, and stroke consistency) were disrupted by attempting to make technical adjustments to the putting stroke. These results are broadly in line with the predictions of the progression-regression hypothesis (Fitts et al., 1961 Fitts, P., Bahrick, H., Noble, M. and Briggs, G. 1961. *Skilled performance*, New York: Wiley.), which, as explained earlier, postulates that conscious control disrupts the timing and variability of automated movements. However, this latter hypothesis did not deal specifically with technical adjustments. Thus, our study provides empirical clues as to precisely which kinematic aspects of the putting stroke are most likely to break down under extreme conscious control (i.e. making technical adjustments to a skill). To explain, technically adjusting one's putting stroke appears to disrupt the overall consistency of the movement. This result supports the findings of MacPherson and colleagues (MacPherson, Collins, & Morriss, 2008 MacPherson, A., Collins, D. and Morriss, C. 2008. Is what you think what you get? Optimizing mental focus for technical performance. *The Sport Psychologist*, 22: 288–303.), who discovered that although an expert javelin thrower who focused on improving arm speed subsequently achieved better performance on that aspect of the action, “attending to one subroutine may have interfered with the consistency of the whole movement” (p. 299). In summary, the results of Experiment 1 indicate that technical adjustments disrupt the timing and consistency of expert golfers' putting strokes, yet, despite such conscious interference, expert golfers are capable of maintaining performance proficiency. However, the precise mechanisms used by these golfers, to achieve proficiency in spite of conscious interference, remain to be elucidated.

There appears to be at least two ways in which performers consciously interfere with automated movements – either by exerting control over or by simply monitoring their actions. Masters' (1992) theory of reinvestment suggests that it is the attempted conscious *control* of one's movements that serves to disrupt skilled performance. In contrast, Beilock and Carr's (2001) Beilock, S. and Carr, T. 2001. On the fragility of skilled performance: What governs choking under pressure?. *Journal of Experimental Psychology: General*, 130: 701–725.) explicit monitoring hypothesis postulates that the disruptive influence comes from the act of attending to or consciously *monitoring* one's movements. Jackson and colleagues (Jackson, Ashford, & Norsworthy, 2006) Jackson, R. C., Ashford, K. J. and Norsworthy, G. 2006. Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, 28: 49–68.) proposed that the terms “conscious control” and “explicit monitoring” are “logically distinct insofar as instructions to monitor and report a particular feature of performance encourage explicit monitoring but do not specifically encourage conscious control” (p. 64). Based on this distinction between “conscious monitoring” and “conscious control”, Jackson et al. (2006) Jackson, R. C., Ashford, K. J. and Norsworthy, G. 2006. Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, 28: 49–68.) speculated that explicit monitoring has a generally disruptive effect on motor control and that additional disruption might occur when performers attempt to consciously control, as well as monitor, their movements. As yet, however, the comparative effects of these different types of conscious processing on skilled performance have not been investigated empirically. Therefore, Experiment 2 was designed to address this unresolved issue.

Experiment 2

In Experiment 2 we employed motion analysis to investigate empirically whether or not a certain form of conscious control (i.e. making technical adjustments) and conscious monitoring (i.e. paying attention to a specific aspect of one's skill) will have differential influences upon the putting proficiency and putting stroke kinematics of expert golfers.

The objectives in Experiment 2 were twofold. First, we examined the relative effects of two different types of conscious processing (i.e. technical adjustments and conscious monitoring) on expert golfers'

putting performance. This objective was achieved by exploring expert golfers' performance in three experimental conditions: a condition in which they were instructed to putt as they normally would (normal condition), a condition in which they were instructed to adjust their putting stroke (technical adjustment), and a condition in which they were instructed to monitor a specific aspect of their stroke (conscious monitoring). In the conscious monitoring condition, participants were instructed to monitor their impact spot (clubhead–ball impact), a method that was used previously by Land and Tenenbaum (2007 Land, W. M. and Tenenbaum, G. 2007. Facilitation of automaticity: Sport-relevant vs. non-relevant secondary tasks. *Journal of Sport and Exercise Psychology*, 29(s178)). In Land and Tenenbaum's study, expert golfers performed a putting task under high- and low-pressure situations while carrying out two types of secondary tasks: a traditional secondary task consisting of random letter generation, and a sport-relevant task consisting of monitoring the impact of clubhead on ball. The results supported the authors' hypothesis that monitoring clubhead impact would increase automaticity (and hence increase motion consistency) and “would prevent a return to conscious processing” (p. S178). Land and Tenenbaum's (2007 Land, W. M. and Tenenbaum, G. 2007. Facilitation of automaticity: Sport-relevant vs. non-relevant secondary tasks. *Journal of Sport and Exercise Psychology*, 29(s178)) hypothesis seems to be at odds with Beilock and Carr's (2001 Beilock, S. and Carr, T. 2001. On the fragility of skilled performance: What governs choking under pressure?. *Journal of Experimental Psychology: General*, 130: 701–725.) explicit monitoring hypothesis, however, as the latter postulated that monitoring one's action represents a form of conscious processing that typically *disrupts* expert movement and performance.

As previously noted, Jackson et al. (2006 Jackson, R. C., Ashford, K. J. and Norsworthy, G. 2006. Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, 28: 49–68.) stated that “instructions to monitor and report a particular feature of performance encourage explicit monitoring” (p. 64). Therefore, in contrast to Land and Tenenbaum's (2007 Land, W. M. and Tenenbaum, G. 2007. Facilitation of automaticity: Sport-relevant vs. non-relevant secondary tasks. *Journal of Sport and Exercise Psychology*, 29(s178)) hypothesis, we predicted that requiring skilled golfers to attend to their clubhead impact spot actually involves them in monitoring their clubhead movement before

and at impact – thereby constituting a form of step-by-step conscious monitoring.

The second objective of Experiment 2 was to rectify a possible methodological deficiency of Experiment 1 – the fact that we cannot be sure exactly what participants attended to in the “normal” condition. In Experiment 2 we addressed this issue by employing a “think-aloud” protocol while participants performed in the normal condition (i.e. when left to their own devices). Thus, Experiment 2 used “think-aloud” protocols in an attempt to identify precisely what features of their putting performance expert golfers attend to when asked to adopt their “normal focus”. We hoped that this method would elucidate the extent to which expert golfers focus on technical thoughts (thereby indicating a proclivity to “reinvest”) relating to the execution of the putting stroke.

Methods

Participants

A total of 18 male expert golfers participated. Their mean age and handicap were 29.2 years ($s = 11.46$) and 3.56 ($s = 1.88$) respectively. The participants' handicaps ranged from 0 to 6. Participants also provided informed consent before taking part in this study. Like Experiment 1, ethical approval for the study was received from the Human Research Ethics Committee of University College, Dublin.

Apparatus

The apparatus was the same as used in Experiment 1 with the addition of a dictaphone (Sony tp-s350) to record the “think-aloud” protocol.

Procedure

All participants completed a practice condition involving five putts and three subsequent counterbalanced conditions (a “normal condition”, a technical adjustment condition, and a monitoring condition) each involving 20 putts. The practice condition was conducted to allow participants to familiarize themselves with the green. Each putt was taken from the same spot 2.5 m from the hole.

In each of the three conditions, participants were instructed to hole as many putts as possible. Putting proficiency was measured by using the

same scoring system used in Experiment 1 and by measuring the four kinematic aspects (i.e. consistency, forwardswing times, backswing times, and impact timing) of the putting stroke found to be influenced by technical adjustments.

In the normal condition, all participants performed 20 putts. They were instructed simply to hole as many putts as possible. The “think-aloud” protocol took place after the tenth putt. The dictaphone was switched on and participants were instructed to state aloud any thoughts relating to the task of which they were consciously aware. Participants were instructed to state aloud any task-related thoughts while they were addressing the ball and once the putt had been executed. When participants had finished stating such thoughts, the dictaphone was switched off and participants were instructed to complete the remaining 10 putts in the condition.

The conscious monitoring condition involved instructing participants to monitor their clubhead impact spot for each of the 20 putts in the condition. Participants were instructed to attempt to hole as many putts as possible and to report, after each putt, exactly where on the putter face they thought they had struck the putt (e.g. on the sweet spot, the heel or the toe of the putter face). After every fifth putt participants were reminded to maintain this focus.

Finally, the technical adjustment condition was conducted in the same manner as in Experiment 1.

Results

Manipulation checks

As in Experiment 1, manipulation checks were used. First, we attempted to verify whether the golfers had maintained the specified focus in the conscious monitoring condition. This was achieved by examining the accuracy of participants' impact spot judgements for each putt. Initially, a criterion level was established to identify whether a participant had successfully identified their impact spot on each putt. This criterion level was based on SAM PuttLab's optimal scoring ranges for each movement parameter. In that scoring system, a ball struck 3.5 mm from the centre of the putter face represents a score of 75%, which “indicates a very good performance inside the Tour Pros benchmark range” (SAM PuttLab report). If a participant stated that contact was made at the

sweet spot, then it would have to have been struck no more than 3.5 mm from the centre of the club-face for it to qualify as an accurate judgement. Similarly, if a participant stated that they had hit a putt out of the heel or toe of the club-face, the PuttLab would be required to reveal that the ball had indeed been struck out from these places.

The preceding manipulation check demonstrated that 14 of the 18 participants made at least 16 out of 20 accurate judgements (a success rate of 80%). This result suggests that these participants generally adhered to the instructions in the conscious monitoring condition. However, 4 of the 18 participants made only 5, 5, 7, and 10 accurate responses, respectively. Although these participants may have adhered to the attentional focus instructions that they had received, they appear to have been relatively poor judges of the exact spot on the putter face where they had struck each putt. It is also possible that these participants may have ignored the attentional focus instructions, thereby rendering them incapable of making accurate impact spot judgements. Given the uncertainty surrounding the impact spot judgements of these four participants in the conscious monitoring task, all data were analysed with and without these problem participants, a procedure recommended by Mullen and colleagues (Mullen, Hardy, & Tattersall, 2005; Mullen, R., Hardy, L. and Tattersall, A. 2005. The effects of anxiety on motor performance: A test of the conscious processing hypothesis. *Journal of Sport and Exercise Psychology*, 27: 212–225.). Removal of the problem participants produced a set of results that did not differ from those obtained with the full set. Therefore, data from all the participants are reported here.

The second manipulation check was conducted for the technical adjustment condition to ensure that participants had adhered to the conscious control instructions. Six participants were required to adjust the rise angle of their putter, six were requested to adjust their putter paths, and six were instructed to lower their club-face rotation (i.e. the extent to which the putter-face opens) on the backswing. Analysis of the results indicated that all participants adhered to these conscious control instructions.

A third manipulation check was carried out to ensure that participants did not consciously control their putting strokes during the conscious monitoring condition in an attempt to make contact at the sweet spot. When comparing golfers' kinematic results in the normal and the

conscious monitoring condition, there were no differences in their performance as measured by a number of key kinematic variables related to achieving accurate impact spots (e.g. putter path, putter face rotation, and ultimately the impact spot itself). This latter result indicated that participants refrained from using conscious control in the conscious monitoring condition.

The SAM PuttLab system was used to collect kinematic data for all 18 participants. The independent variable was the attentional condition (type of conscious processing) in which participants performed: normal, technical adjustment, and conscious monitoring. The dependent variables were golf putting proficiency (as measured by the scoring system outlined in Experiment 1) and the four putting movement parameters from Experiment 1 that conscious control had been found to influence, namely backswing times, forwardswing times, impact timing, and consistency. A one-way repeated measures multivariate analysis of variance was conducted to examine whether the attentional condition had any influence on participants' putting proficiency and on the four aforementioned movement parameters. Prior to analysis, checks were conducted for normality, linearity, univariate and multivariate outliers, homogeneity of variance–covariance matrices, and multicollinearity. No significant violations of these assumptions were evident.

Using Pillai's trace, there was a significant effect of attentional condition on the five dependent variables ($V = 0.72$, $F_{2,62} = 3.5$, $P < 0.05$, $\eta^2 = 0.38$). Separate univariate analyses of variance on the dependent variables found that attentional condition had no effect on expert golfers' forwardswing times ($F_{2,34} = 2.85$, $P > 0.01$, $\eta^2 = 0.14$), backswing times ($F_{2,34} = 2.26$, $P > 0.01$, $\eta^2 = 0.18$) or on their impact timing ($F_{2,34} = 1.42$, $P > 0.01$, $\eta^2 = 0.08$). However, the univariate analysis revealed a significant effect of attentional condition on expert golfers' putting proficiency ($F_{2,34} = 6.05$, $P < 0.01$, $\eta^2 = 0.26$) and on the consistency of their putting strokes ($F_{2,34} = 6.19$, $P < 0.01$, $\eta^2 = 0.27$). A series of pairwise comparisons (using Bonferroni adjustments) was subsequently conducted to determine precisely how conscious processing influenced expert golfers' putting proficiency and putting stroke consistency. The golfers' putting proficiency was significantly higher in the normal condition than in the conscious monitoring condition ($P = 0.005$). In line with the results from Experiment 1, technical adjustments were found *not* to disrupt putting proficiency compared with performance in the normal condition ($P = 0.52$). In

addition, putting proficiency was similar in the conscious monitoring and technical adjustment condition ($P = 1$). Taken together, these results suggest that expert golfers found conscious monitoring to be disruptive to their overall putting proficiency.

With regard to the influence of conscious processing, conscious monitoring was found to have no greater influence on the consistency of the putting stroke than was evident in the normal condition ($P = 1$). However, expert golfers' putting strokes were significantly less consistent in the technical adjustment condition compared with the normal condition ($P = 0.49$) and compared with the conscious monitoring condition ($P = 0.03$). Clearly, as in the case of Experiment 1, the use of technical adjustments appears to *increase* the variability of expert golfers' putting strokes (see Table III).

Table III.

Think-aloud protocol analysis

All 18 of the “think-aloud” protocol responses were computer-transcribed and printed out for examination. Overall, a total of 24 statements were extracted from the protocols (see Table IV). Such “think-aloud” statements were analysed and a number of themes were identified. These themes were deductively generated with reference to the different types of attentional focus allegedly adopted by expert performers (see Castaneda & Gray, 2007 Castaneda, B. and Gray, R. 2007. Effects of focus of attention on baseball batting performance in players of differing skill levels. *Journal of Sport and Exercise Psychology*, 29: 60–77. ; Wulf, 2007 Wulf, G. 2007. Attentional focus and motor learning: A review of 10 years of research. *E-Journal Bewegung und Training*, 1: 4–14.). For example, Wulf (2007 Wulf, G. 2007. Attentional focus and motor learning: A review of 10 years of research. *E-Journal Bewegung und Training*, 1: 4–14.) distinguished between the adoption of an *internal focus of attention* (i.e. focusing on limb movement) and an *external focus of attention* (i.e. focusing on movement of an implement such as a golf putter-head). Furthermore, Castaneda and Gray (2007 Castaneda, B. and Gray, R. 2007. Effects of focus of attention on baseball batting performance in players of differing skill levels. *Journal of Sport and Exercise Psychology*, 29: 60–77.) suggested that an expert performer may adopt an *environmental focus of attention* (e.g. focusing on movement of a golf ball as it leaves the putter-head).

Table IV.

From the analysis of the protocol statements, three broad themes initially emerged (i.e. internal focus, external focus, environmental focus). However, because a number of statements did not fit these three categories, an additional theme relating to the rhythm or timing of the action was generated. This additionally generated theme meant that a total of four themes emerged from Experiment 2. These themes were labelled as follows: (i) skill-internal, (ii) skill-external, (iii) environmental-external, and (iv) rhythm or timing.

To ensure that the experimenters did not unwittingly assign any statements to the incorrect category, five raters (mean age 25.3 years, $s = 1.8$) were asked to match each statement with the theme to which it appeared to belong most appropriately. This procedure led to the reliable matching of all 24 statements with appropriate themes. Importantly, all of the participants correctly assigned statements to the inductively generated theme (rhythm/timing).

Protocol analysis results

The “think-aloud” protocol showed that 14 participants reported between two and four task-related thoughts, while the other four participants reported only one task-related thought. In total, participants reported a mean of 2.16 ($s = 0.87$) task-related thoughts during performance. With regard to each individual theme, participants reported a mean of 0.5 ($s = 0.85$) skill-internal rules, a mean of 0.61 ($s = 0.5$) skill-external rules, a mean of 0.72 ($s = 0.67$) environmental-external rules, and a mean of 0.33 ($s = 0.59$) rhythm or timing rules. When considering the extent to which performers reinvested conscious attention into the mechanics of their strokes, we may discount environmental-external rules attended to as this focus of attention directed participants' attention *away* from technical elements of the action. Therefore, when taking into account skill-internal, skill-external, and rhythm/timing rules attended to, participants had a mean of 1.44 ($s = 0.52$) thoughts. This result suggests that when left to adopt their normal focus of attention, expert golfers in the current study focused on between one and two technique-related thoughts.

Discussion

The findings from Experiment 2 provide support for our prediction that technical adjustments and explicit monitoring would have different influences on expert golfers' putting stroke proficiency and their putting movement kinematics. Specifically, expert golfers' putting strokes were significantly more consistent in the normal and conscious monitoring conditions than in the technical adjustment condition. However, although the consistency of participants' putting strokes was unaffected by engaging in conscious monitoring, it would appear that when golfers were asked to attend to and report on a particular feature of movement (i.e. the impact spot), their overall putting proficiency was significantly impaired. This finding has important practical implications for golfers who may wish to focus on specific “swing thoughts” during movement. Specifically, the results of Experiment 2 suggest that golfers may need to choose their swing thoughts very carefully because focusing on certain elements of movement, such as the impact spot, could lead to an *impairment* in performance proficiency. In line with the results of Experiment 1, technical adjustments did not significantly impair putting proficiency. Furthermore, although the consistency of golfers' putting strokes differed as a function of conscious processing conditions, technical adjustments and conscious monitoring had no significant influence on the other three kinematic measures (i.e. backswing times, forwardswing times, and impact timing) of the putting stroke. In contrast to Experiment 1, technical adjustments had no significant influence on the timing of expert golfers' putting strokes.

How can we reconcile these apparently contradictory results? When we analyse the relevant mean scores across conditions (see Table III), we see that, despite the absence of statistical differences, participants' forwardswing, backswing, and impact times are noticeably slower in the technical adjustment condition than in the normal condition – a trend in line with that seen in Experiment 1. Thus Experiment 2 lends tentative support to Experiment 1 by suggesting that attempts to adjust *technique* tend to slow down the *timing* of expert golfers' putting strokes.

Turning to the protocol analysis results, it seems that expert golfers pay attention to technical aspects of their movement when left to their own devices. This finding is interesting because although Beilock and Carr (2001 Beilock, S. and Carr, T. 2001. On the fragility of skilled performance: What governs choking under pressure?. *Journal of*

Experimental Psychology: General, 130: 701–725.) and Masters and Maxwell (2008 Masters, R. S. W. and Maxwell, J. 2008. The theory of reinvestment. *International Review of Sport and Exercise Psychology*, 1: 160–183.) claimed that skill-focused attention disrupts the procedural nature of skilled performance, Ericsson (2001 Ericsson, K. A. 2001. “The path to expert golf performance: Insights from the masters on how to improve performance by deliberate practice”. In *Optimising performance in golf*, Edited by: Thomas, P. R. 1–57. Brisbane, QLD: pAustralian Academic Press.) has argued that a defining characteristic of such performance is the fact that experts appear to be able to monitor and control their “on-line” performance. However, a close look at the protocol analysis results (see Table IV) indicates that when left to their own devices, many of the performers were preoccupied with looking at the target to ensure that their clubs were correctly aligned with the hole. In fact, this approach led to participants' best putting performance occurring in the normal condition. In contrast, instructions to consciously monitor “on-line” performance appear to have impaired putting proficiency. This latter finding is more closely in line with the prediction that expert performance is better facilitated by a lack of “on-line” attentional control (as postulated by Beilock et al., 2002 Beilock, S. L., Carr, T. H., MacMahon, C. and Starkes, J. L. 2002. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, 8: 6–16. and Masters, 1992 Masters, R. S. W. 1992. Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology*, 83: 343–358.) than by the monitoring and control of technique during real-time performance (as postulated by Ericsson, 2001 Ericsson, K. A. 2001. “The path to expert golf performance: Insights from the masters on how to improve performance by deliberate practice”. In *Optimising performance in golf*, Edited by: Thomas, P. R. 1–57. Brisbane, QLD: pAustralian Academic Press.).

General discussion

The experiments reported here examined the effects of different types of conscious processing (making “technical adjustments” or consciously manipulating one's movement and “conscious monitoring” or paying attention to the execution of the putting stroke) on two indices of skilled performance by expert golfers – namely, putting proficiency (measured

by a points scoring system) and various kinematic aspects of the putting stroke (measured by the SAM PuttLab motion analysis system). By using a motion analysis system, our experiments have two methodological advantages over previous studies in this field. First, we addressed the validation problem whereby “one cannot ensure that participants actually monitor their movements in accordance with the instruction” (Jackson et al., 2006 Jackson, R. C., Ashford, K. J. and Norsworthy, G. 2006. Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, 28: 49–68.p. 64). The SAM PuttLab motion analysis system enabled us to provide an objective manipulation check on the degree to which participants actually adhered to the attentional instructions that they had received. Second, this system allowed participants to be instructed to engage in conscious processing (either technical adjustments or conscious monitoring) without the need to employ secondary tasks (e.g. auditory tone monitoring) that may reflect “arbitrary and contrived” (Wilson et al., 2007 Wilson, M., Chattington, M., Marple-Horvat, D. E. and Smith, N. C. 2007. A comparison of self-focus versus attentional explanations of choking. *Journal of Sport and Exercise Psychology*, 29: 439–456.p. 454) attentional manipulations.

Experiment 1 found that technical adjustments *did* slow down and disrupt a number of important kinematic features (e.g. backswing times) of golfers' putting strokes. This finding is in line with research (e.g. Gray, 2004 Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54.) that has demonstrated that conscious processing impairs expert performance by disrupting the sequencing and timing of automated movement. However, the disruption to the timing and consistency of the putting stroke appears to have had little influence on expert golfers' putting proficiency.

Experiment 2 showed that conscious monitoring had a more disruptive influence on putting proficiency than did the use of technical adjustments. A possible explanation for this latter finding comes from dynamical systems theory (see Davids, Button, & Bennett, 2008 Davids, K., Button, C. and Bennett, S. 2008. *Dynamics of skill acquisition: A constraints-led approach*, Champaign, IL: Human Kinetics.), which emphasizes the important role of functional variability in achieving successful motor performance. Specifically, this theory proposes that degrees of freedom (the number of ways in which limbs can move and

joints rotate) are used as a resource to enhance adaptive movement behaviours during performance (Glazier & Davids, 2009 Glazier, P. S. and Davids, K. 2009. Optimization of performance in top-level athletes: An action-focused coping approach (commentary). *International Journal of Sports Science and Coaching*, 4: 59–62.). Accordingly, the expert golfers in Experiment 2 may have performed more proficiently in the technical adjustment condition than in the conscious monitoring condition because they engaged in compensatory variability when instructed to adjust their putting strokes. In contrast, no such movement variability was observed in the conscious monitoring condition. The act of consciously attending to an aspect of the putting stroke (i.e. impact spot) appears to have been a sufficient distraction to reduce putting proficiency. The results of Experiment 2 provide some evidence that different forms of conscious processing (i.e. conscious monitoring and technical adjustments) may have differential influences on expert movement and performance proficiency in golf putting. However, further research is required to validate this theoretical explanation.

A possible methodological limitation associated with both experiments concerns the nature of the technical adjustment instructions provided for participants. Participants were required to adjust their technique in a manner that improved or “fixed” a flawed aspect of their movement. Such instructions may have led to the disruption of certain kinematic aspects of the putting stroke (e.g. its consistency) but may not have had any significant influence on putting proficiency because the adjustments made could have overridden the disruptive effects of conscious control on performance outcome. In an effort to obviate this possibility, we recommend that researchers address this issue by using a control condition in which participants are given neutral technical adjustment instructions.

A practical implication of the findings from our experiments is that it would appear prudent for skilled performers to avoid consciously attending to their movement during competitive performance. However, as discovered by Nicholls et al. (2005 Nicholls, A. R., Holt, N. L., Polman, R. C. J. and James, D. W. G. 2005. Stress and coping among international adolescent golfers. *Journal of Applied Sport Psychology*, 17: 330–340.), elite amateur golfers occasionally use technical adjustments as a coping strategy in pressurized situations. Unsurprisingly, however, technical adjustments in this latter case failed to improve performance. Nevertheless, evidence that performers may

engage in this excessive form of conscious control raises a number of important questions. For example, do certain performers (e.g. high reinvesters) have a proclivity to use technical adjustments under pressurized conditions (Poolton, Maxwell, & Masters, 2004 Poolton, J., Maxwell, J. and Masters, R. 2004. Rules for reinvestment. *Perceptual and Motor Skills*, 99: 771–774.)? If so, what can be done to prevent such attempted conscious control during performance? In future, researchers could address these questions by examining the degree to which the use of emotion-focused coping strategies (e.g. positive appraisal or acceptance of mistakes) prevents skilled performers from engaging in excessive conscious analysis. Another interesting line of enquiry stems from the suggestion by Gucciardi and Dimmock (2008 Gucciardi, D. F. and Dimmock, J. A. 2008. Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources?. *Psychology of Sport and Exercise*, 9: 45–59.) that certain forms of conscious processing (e.g. the use of global cue words) may actually prevent the regression to conscious control by allowing performers to “focus their attention and trigger their implicit processes stored in memory” (p. 56). Research is urgently required to test this prediction.

Overall, the present results suggest that different types of conscious processing seem to have contrasting influences upon expert performance and movement. More precisely, our findings indicate that for golfers, conscious control (in the form of technical adjustments) may disrupt the timing and consistency of automated movement – despite having no influence on overall putting proficiency. In contrast, the act of conscious monitoring may disrupt performance proficiency but have no influence on automated movement. The protocol analysis in Experiment 2 indicates that expert golfers' putting was most proficient in the normal condition where they focused externally or on rhythmical properties of their movement. This latter finding is in line with recent evidence suggesting that experts' performance and movement are most effective when their attention is directed externally to the effects that such movements have on the environment (e.g. Castaneda & Gray, 2007 Castaneda, B. and Gray, R. 2007. Effects of focus of attention on baseball batting performance in players of differing skill levels. *Journal of Sport and Exercise Psychology*, 29: 60–77.) or to rhythmical “sources of information” (e.g. MacPherson et al., 2008 MacPherson, A., Collins, D. and Morriss, C. 2008. Is what you think what you get? Optimizing mental focus for technical performance. *The Sport*

Psychologist, 22: 288–303.). Unfortunately, it is not clear if specific foci of attention will prevent certain skilled performers (e.g. high reinvesters) from reinvesting their automated movements with conscious attention during competitive performance. Clearly, further research is required to examine this possibility.

References

1. Beilock, S. and Carr, T. 2001. On the fragility of skilled performance: What governs choking under pressure?. *Journal of Experimental Psychology: General*, 130: 701–725.
2. Beilock, S. L., Carr, T. H., MacMahon, C. and Starkes, J. L. 2002. When paying attention becomes counterproductive: Impact of divided versus skill-focused attention on novice and experienced performance of sensorimotor skills. *Journal of Experimental Psychology: Applied*, 8: 6–16.
3. Beilock, S. L. and Gray, R. 2007. “Why do athletes “choke” under pressure?”. In *Handbook of Sport Psychology*(3rd ed, Edited by: Tenenbaum, G. and Eklund, R. C. 425–444. Hoboken, NJ: John Wiley & Sons.
4. Castaneda, B. and Gray, R. 2007. Effects of focus of attention on baseball batting performance in players of differing skill levels. *Journal of Sport and Exercise Psychology*, 29: 60–77.
5. Collins, D., Jones, B., Fairweather, M., Doolan, S. and Priestley, N. 2001. Examining associated changes in movement patterns. *International Journal of Sport Psychology*, 31: 223–242.
6. Davids, K., Button, C. and Bennett, S. 2008. *Dynamics of skill acquisition: A constraints-led approach*, Champaign, IL: Human Kinetics.
7. Ericsson, K. A. 2001. “The path to expert golf performance: Insights from the masters on how to improve performance by deliberate practice”. In *Optimising performance in golf*, Edited by: Thomas, P. R. 1–57. Brisbane, QLD: pAustralian Academic Press.
8. Fitts, P., Bahrick, H., Noble, M. and Briggs, G. 1961. *Skilled performance*, New York: Wiley.
9. Fitts, P. M. and Posner, M. I. 1967. *Human performance*, Belmont, CA: Brooks/Cole.
10. Glazier, P. S. and Davids, K. 2009. Optimization of performance in top-level athletes: An action-focused coping approach (commentary). *International Journal of Sports Science and Coaching*, 4: 59–62.
11. Gray, R. 2004. Attending to the execution of a complex sensorimotor skill: Expertise differences and slumps. *Journal of Experimental Psychology: Applied*, 10: 42–54.
12. Gucciardi, D. F. and Dimmock, J. A. 2008. Choking under pressure in sensorimotor skills: Conscious processing or depleted attentional resources?. *Psychology of Sport and Exercise*, 9: 45–59.

13. Hill, D. M., Hanton, S., Matthews, N. and Fleming, S. 2010. Choking in sport: A review. *International Review of Sport and Exercise Psychology*, 3: 24–39.
14. Jackson, R. C., Ashford, K. J. and Norsworthy, G. 2006. Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, 28: 49–68.
15. Jackson, R. C. and Beilock, S. L. 2008. “Performance pressure and paralysis by analysis: Research and implications”. In *Developing sport expertise: Researchers and coaches put theory into practice*, Edited by: Farrow, D. and Baker, J. 104–118. London: Routledge.
16. Jackson, S. A., Martin, A. J. and Eklund, R. C. 2008. Long and short measures of flow: The construct validity of the FSS-2, DFS-2, and new brief counterparts. *Journal of Sport and Exercise Psychology*, 30: 561–587.
17. Karlsen, J., Smith, G. and Nilsson, J. 2008. The stroke has only a minor influence on the direction consistency in golf putting among elite players. *Journal of Sports Sciences*, 26: 243–250.
18. Land, W. M. and Tenenbaum, G. 2007. Facilitation of automaticity: Sport-relevant vs. non-relevant secondary tasks. *Journal of Sport and Exercise Psychology*, 29(s178)
19. MacPherson, A., Collins, D. and Morriss, C. 2008. Is what you think what you get? Optimizing mental focus for technical performance. *The Sport Psychologist*, 22: 288–303.
20. Masters, R. S. W. 1992. Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology*, 83: 343–358.
21. Masters, R. S. W. and Maxwell, J. P. 2004. “Implicit motor learning, reinvestment and movement disruption: What you don't know won't hurt you”. In *Skill acquisition in sport: Research, theory and practice*, Edited by: Williams, A. M. and Hodges, N. J. 207–228. London: Routledge.
22. Masters, R. S. W. and Maxwell, J. 2008. The theory of reinvestment. *International Review of Sport and Exercise Psychology*, 1: 160–183.
23. Mullen, R. and Hardy, L. 2000. State anxiety and motor performance: Testing the conscious processing hypothesis. *Journal of Sports Sciences*, 18: 785–799.

24. Mullen, R., Hardy, L. and Tattersall, A. 2005. The effects of anxiety on motor performance: A test of the conscious processing hypothesis. *Journal of Sport and Exercise Psychology*, 27: 212–225.
25. Nicholls, A. R., Holt, N. L., Polman, R. C. J. and James, D. W. G. 2005. Stress and coping among international adolescent golfers. *Journal of Applied Sport Psychology*, 17: 330–340.
26. Poolton, J., Maxwell, J. and Masters, R. 2004. Rules for reinvestment. *Perceptual and Motor Skills*, 99: 771–774.
27. Science and Motion in Golf. 2005. SAM PuttLab analysis system Available at: www.scienceandmotioningolf.com
28. Smith, D. and Holmes, P. 2004. The effect of imagery modality on golf putting performance. *Journal of Sport and Exercise Psychology*, 26: 385–395.
29. Wilson, M., Chattington, M., Marple-Horvat, D. E. and Smith, N. C. 2007. A comparison of self-focus versus attentional explanations of choking. *Journal of Sport and Exercise Psychology*, 29: 439–456.
30. Wulf, G. 2007. Attentional focus and motor learning: A review of 10 years of research. *E-Journal Bewegung und Training*, 1: 4–14.

Table I. Manipulation check for Experiment 1

Parameter adjusted	Normal	Technical adjustment condition
(1) Putter path	5.9° left	4.7° left
(2) Rise angle	6.6°	4.4°
(3) Putter path	5.3° left	4.5° left
(4) Putter path	12.1° left	2.1° left
(5) Rise angle	6.0°	4.5°
(6) Putter path	5.3° left	4.2° left
(7) Rise angle	6.5°	4.3°
(8) Rise angle	5.4°	2.6°
(9) Rise angle	0.0°	1.1°
(10) Putter path	2.7° right	1.7° right
(11) Putter path	2.5° right	1.8° right
(12) Rise angle	0.3°	1.1°
(13) Rise angle	4.3°	2.9°
(14) Putter path	5.5° right	3.5° right

Table II. Mean scores (*s*) for expert golfers' putting proficiency and kinematic measures of their putting strokes

Variable	Normal condition	Technical adjustment condition
Putting proficiency	87.64 (8.51)	83.64 (13.94)
Consistency	75.88 (6.8)	66.6 (6.9)
Backswing time (ms)	641.35 (70)	664.64 (73.02)
Forwardswing time (ms)	858.28 (125)	930.28 (133.38)
Impact timing (ms)	326.25 (50.54)	337.85 (53.09)
Impact velocity (ms)	1174.57 (53.7)	1204.57 (57.46)
Rhythm	1.99 (.19)	2.01 (.19)

Table III. Mean scores (*s*) for expert golfers' putting proficiency and kinematic measures of the putting stroke across attentional conditions in Experiment 2

Variable	Normal condition	Conscious monitoring condition	Technical adjustment condition
Putting proficiency	89.05 (8.78)	80.72 (13.47)	83 (12.78)
Forwardswing times (ms)	876.88 (157.81)	872.55 (136.04)	908.27 (144.84)
Backswing times (ms)	649.96 (87.09)	659.42 (84.88)	664.88 (86.34)
Impact timing (ms)	299.43 (47.6)	301.91 (47.76)	311.63 (56.22)
Consistency	74.66 (9.19)	75.46 (9.57)	68.58 (11.35)

Table IV. Themes and statements generated

Theme	Statement
Skill-internal	(1) Settle over it as I take the stance
	(2) Left hand grip weak
	(3) Grip the putter, make sure it's right
	(4) Get my weight right on my feet
	(5) Pushing my chest out
	(6) Get my hands ahead of the ball 2
	(7) Thinking about the connection of the upper half of my left arm to my body
	(8) Hard right grip and soft with the left hand
Skill-external	(1) Just line up the putter face as I'm standing behind the ball
	(2) Aim the blade square at the hole 3
	(3) Keep it (clubface) square back and through
	(4) Looking down and think the putter face is slightly open
	(5) Just hold it (clubface) off
	(6) I'm thinking make sure the putter doesn't come too far back on the inside
	(7) Just make sure I get the putter head square instead of slightly open
	(8) Face closed, trying to open the face a bit
	(9) Feeling the putter like a pendulum
Environmental-external	(1) Just look at the target 9
	(2) Just about getting your alignment and everything
	(3) Focusing on the number two (on the ball)
	(4) Line it up and make sure you allow enough for the left edge
Rhythm/timing	(1) Back and through 3
	(2) Accelerate through
	(3) Smooth back 3

Note: **Bold** numbers represent number of participants who made these specific statements.