Action observation and imagery training improve the ease with which athletes can generate imagery

Abstract

Imagery can improve sport performance, although its efficacy is mediated by the ease with which athletes can generate images. Establishing techniques that improve this imagery ability factor is desirable to enhance the effectiveness of imagery interventions. Twenty-seven club-level female golfers were assigned to imagery, action observation, or physical practice training groups (*n*=nine). Changes in image generation ease were assessed using the Revised Movement Imagery Questionnaire over an eight-week period. Imagery and action observation training were both effective in improving aspects of imagery ability. Action observation can provide sport psychologists with an effective tool for improving visual imagery ability in athletes.

Keywords: imagery ability, action observation, golf

Action observation and imagery training improve the ease with which athletes can generate imagery

Imagery is the process of using multiple senses to create a representation of an action in the mind, typically in the absence of overt physical movement (Jeannerod, 1994; Vealey & Greenleaf, 2010). As imagery involves the creation of a symbolic representation from memory, it can be seen as primarily a top-down, knowledge-driven process (Holmes & Calmels, 2008). A growing body of research suggests that imagery can be an effective technique for improving aspects of motor performance, particularly when used with motor tasks that involve considerable cognitive elements (e.g., Driskell, Cooper, & Moran, 1994; Feltz & Landers, 1983). As such, imagery is used regularly by athletes with the aim of improving their performance (Cumming & Williams, 2012; Weinberg, 2008). Advances in neuroscience research have provided mechanisms to explain these performance gains through imagery (for a review see Holmes & Calmels, 2008). Neuroimaging experiments have indicated that, under certain conditions, similar neural activity can be observed between imagery and physical motor execution (e.g., Decety, 1996; Decety & Grezes, 1999). This "shared" neural activity between the two processes has been termed "functional equivalence" (Holmes & Collins, 2001; Jeannerod, 1994). Based on this evidence, imagery is thought to activate parts of the motor system, as well as other cortical and sub-cortical regions, and strengthen the neural pathways involved in the specific physical movement, resulting in improved performance (Wakefield, Smith, Moran, & Holmes, 2013).

Imagery ability is a collection of skills including ease of image generation, image vividness, image controllability, and image maintenance (Cumming & Williams, 2012; Morris, Spittle, & Watt, 2005). Although imagery can be a beneficial technique for improving sport performance, its efficacy is influenced by the ease with which athletes can create and control images of their own performance (Martin, Moritz, & Hall, 1999; Weinberg, 2008). Indeed, researchers (e.g., Hall, Buckolz, & Fishburne, 1992; Robin et al., 2007) have suggested that the imagery ability characteristics of the athlete are probably the most important factors that influence the effectiveness of imagery interventions. For example, Robin et al. (2007) reported that whilst imagery was generally an effective technique for improving tennis serve return accuracy, the effectiveness of the intervention was meditated by the ease with which participants could perform imagery. In this experiment, those classified as good imagers based on their responses to the Movement Imagery Questionnaire, which measures ease of imagery generation, improved their service return performance to a greater extent than those classified as poor imagers. Imagery, therefore, appears to be more effective in improving performance when used by athletes who are able to generate clear images, compared to when used by athletes with poor imagery ability (Goss, Hall, Buckolz, & Fishburne, 1986; Hall et al., 1992; Robin et al., 2007; Weinberg, 2008).

Fortunately, characteristics of imagery ability are modifiable and can be enhanced through training, allowing athletes to improve their imagery proficiency (Cumming & Williams, 2012). Given the possible performance enhancing effect of imagery training (e.g., Driskell et al., 1994), establishing techniques that can improve characteristics of imagery ability in poor imagers would be desirable in order to improve the efficacy of imagery interventions for such athletes. Rodgers, Hall and Buckolz (1991) reported that figure skaters improved aspects of imagery ability through regular imagery practice. This finding has been replicated in a number of different sporting contexts, including golf (Hammond, Gregg, Hrycaiko, Mactavish, & Leslie-Toogood, 2012; Williams, Cooley, & Cumming, 2013), softball (Calmels, Holmes, Berthoumieux, & Singer, 2004), and synchronized skating (Cumming & Ste-Marie, 2001). However, poor imagers struggle to generate clear images and therefore imagery training may not be the optimum technique for improving imagery ability in these individuals. The identification of additional techniques for improving imagery ability would, therefore, be beneficial (Cumming & Williams, 2012).

Video-based action observation is one technique that may prove effective in improving imagery ability. With action observation the athlete does not have to generate a simulated representation of the movement as the key perceptual information is provided in the form of an external video stimulus (Ram, Riggs, Skaling, Landers, & McCullagh, 2007). As such, observation can be seen primarily as a bottom-up, percept-driven process (Holmes & Calmels, 2008). Issues related to imagery ability (i.e., image clarity, image control, and image maintenance) are controlled for during action observation through the video editing process (Holmes & Calmels, 2008). Video-based action observation may, therefore, be an effective method of improving imagery ability characteristics, whereby repeated exposures to a video model may facilitate ease of image generation (Rymal & Ste-Marie, 2009). Interestingly, the discovery of mirror neurons in humans (i.e., neurons that are active both when a movement is executed and observed; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996) has revealed that action observation also activates the motor system in a similar manner to physical movement. As such, it seems likely that the mechanism by which imagery is thought to facilitate performance may also contribute to the effectiveness of action observation. In support of this contention, several researchers (e.g., Clark, Tremblay, & Ste-Marie, 2003; Munzert, Zentgraft, Stark, & Vaitl, 2008) have reported common brain areas active during imagery and observation of human movements, including areas of the primary motor cortex, premotor cortex, supplementary motor area, basal ganglia and cerebellum. Given the common neural substrates proposed to be shared between imagery, action observation and action execution, it would seem likely that action observation training may improve an athlete's ability to perform imagery although little research has yet investigated this possibility (Cumming & Williams, 2012).

Qualitative research into observation and imagery use by elite gymnasts and professional dancers has indicated that participants find action observation to be effective in improving the ease with which they can perform imagery (Hars & Calmels, 2007; Nordin & Cumming, 2005). In these studies, participants reported that observation of models increased their imagery use and imagery ability which led to perceived improvements in performance. Similarly, Williams, Cumming and Edwards (2011) investigated whether prior observation or execution of movement, referred to as 'priming', would facilitate ease of image generation. Williams et al. demonstrated that when participants engaged in video-based action observation immediately prior to completing the Adapted Movement Imagery Questionnaire, participants' ease of imagery generation scores were enhanced compared to when the questionnaire was completed without prior action observation. The authors suggested that action observation may prime the imagery experience and facilitate imagery generation through activating and strengthening the shared neural areas. Similar support for a priming effect between action observation and physical performance has been reported by other researchers (e.g., Brass, Bekkering, & Prinz, 2001). However, the effects of repeated action observation on ease of image generation in sport specific contexts are less well understood. Rymal and Ste-Marie (2009) investigated this issue by comparing the effect of action observation training on the ease of image of generation and imagery vividness in competitive, junior divers. Seven participants completed pre-test self-report questionnaires to assess their imagery abilities. Participants observed edited video footage of their own diving performance four times per week as part of competition preparation for a period of between two and three weeks. Upon completion of the intervention period, participants completed post-test imagery self-report measures and changes from pre- to post-test were compared. The results indicated that imagery vividness improved as a result of the self-action observation training, but ease of image generation did not.

The results of Rymal and Ste-Marie's (2009) experiment indicate that action observation may be effective in improving imagery vividness; however, a number of factors limit this research. First, the authors did not include a control group against which to compare changes in aspects of imagery ability as a result of action observation. Furthermore, the effect of imagery training on imagery ability was not investigated. It therefore remains unknown whether action observation training can be more beneficial in improving characteristics of imagery ability than imagery training. Second, a retention test was not included and so it is unclear how permanent the effects of action observation training on characteristics of imagery ability may be. Third, a small sample of seven, relatively young participants was used. There are known problems with children under the age of 10 completing self-report inventories as well as imagery variations in younger cohorts and, with the criterion for statistical significance set at $p < .10$, the likelihood of making a Type 1 error was increased. Finally, the action observation videos did not take into account participants' observation perspective preference, with all movements filmed from a third-person perspective. In this perspective the action is presented from an allocentric viewpoint (Holmes & Calmels, 2008). The literature suggests that this perspective is most effective for novice athletes, and for skills that depend heavily on form, for example gymnastics (Callow & Hardy, 2004). In contrast, a first person perspective (an action observed or imagined from an egocentric viewpoint) is suggested to be most effective when the basic skill is acquired, and for skills that depend heavily on perception, for example canoe slalom or penalty kicking (White & Hardy, 1995). Athletes are reported to express a preference for one perspective and training using the perspective not preferred by the individual may prove detrimental (Hall, 1997).

The aim of this experiment was to compare the efficacy of action observation and imagery as techniques for improving ease of image generation in competitive golfers. Golf was selected to explore this issue given the prevalence of imagery use in this sport. For example, both elite and novice golfers use imagery extensively prior to performance to rehearse specific skills and enhance motivation (Arvinen-Barrow, Weigand, Thomas, Hemmings, & Walley, 2007; Beauchamp, Bray, & Albinson, 2002), and such use is particularly prevalent in elite golfers (Gregg & Hall, 2006). In addition, there is also considerable literature which indicates that imagery is an effective technique for improving various aspects of golf performance (e.g., Hammond et al., 2012; Smith & Holmes, 2004; Smith, Wright, & Cantwell, 2008). The experiment also aimed to address the limitations associated with Rymal and Ste-Marie's (2009) research. Specifically, the efficacy of action observation training in improving the ease with which athletes could generate imagery was compared against imagery training and physical practice (control) conditions to determine which technique may be more effective. A retention test was included to determine the relative permanence of any changes in imagery ability characteristics resulting from the interventions. We also recruited a larger sample and, as suggested by others (Callow & Roberts, 2010; Williams, Cooley, Newell, et al., 2013), considered the participants' imagery/observation perspective preferences. Based on the findings of Rymal and Ste-Marie and recommendations providing by Cumming and Williams (2012), it was hypothesized that both action observation and imagery training would facilitate the ease with which the athletes could generate imagery to a greater extent than physical practice.

Method

Participants

Twenty-seven female participants aged between 18-67 years (*M* = 36.67, *SD* = 15.71) took part in the experiment. All were experienced golfers who had played club level golf on a regular basis for a minimum of five years (*M* = 16.07, *SD* = 9.37). All participants had a moderate-to-high pre-test imagery ability, and 52% of participants reported that they had previous experience of using imagery when playing or practicing golf, mainly as part of preshot routines. However, all participants reported that such imagery use was infrequent, untrained, and did not follow a formal structure or imagery script. All participants gave their written informed consent to take part in the experiment, which had been granted ethical approval by the local Ethics Committee at a UK University.

Measures

The ease with which participants could generate visual and kinesthetic images was measured using the Movement Imagery Questionnaire – Revised (MIQ-R; Hall & Martin, 1997). This eight-item questionnaire requires participants to read a description of a generic movement, before physically performing it. Participants are then asked to imagine performing the same movement either visually or kinesthetically. Participants respond to each item on the questionnaire by rating the ease with which they are able to generate each image on a seven point Likert-scale, with responses ranging from one (*very hard to see/feel*) to seven (*very easy to see/feel*). Higher scores on the MIQ-R, therefore, indicate better imagery ability. According to Monsma, Short, Hall, Gregg, and Sullivan (2009), both sub-scales of the MIQ-R demonstrate good internal reliability (Cronbach alpha coefficients of .84 for visual imagery and .88 for kinesthetic imagery) and good test-retest reliability (test-retest reliability coefficients of .80 for visual imagery and .81 for kinesthetic imagery). The MIQ-R demonstrates good reliability in numerous settings and is a valid measure of image generation ease (Williams et al., 2011). In addition, the MIQ-R is the questionnaire used most commonly in the sport psychology literature to assess image generation ease (Cumming & Williams, 2012; Williams et al., 2011) and has been used previously in imagery experiments investigating golf (e.g., Ramsey, Cumming, & Edwards, 2008; Smith et al., 2008).

Procedure

Prior to commencing a six-week training program participants completed the MIQ-R questionnaire to provide an indication of their pre-test ease of image generation level. They were also asked to generate, maintain, and manipulate a mental image of themselves performing in a golfing context. The purpose of this was to ensure that all participants were capable of performing imagery in relation to golf. Participants were then assigned to either an action observation (video), imagery (imagery script), or control (physical practice) group for the training program. All three groups (*n*=nine) were matched for age and years of playing experience. Rather than controlling the aspects of golf that participants would focus on in their intervention, all participants were interviewed informally to establish which sub-optimal aspects of their game they specifically wished to improve and focus on during the training program. Participants in the action observation and imagery groups received additional "response training" (Lang, 1979). This involved participants describing in detail their physical performance of their chosen shots to a member of the research team. The researcher then probed the participants' responses to elicit stimulus propositions (descriptions of content and objects in the environment), response propositions (descriptions of each participant's own physical responses to the situation), and meaning propositions (descriptions of the way the participants interpret the situation). These propositions were then incorporated into each participant's action observation video or imagery script, in order to develop an individualized and personally meaningful action observation/imagery intervention. To further personalize each participant's action observation video or imagery script, they were shown nine pictures of a female golfer (one from a first-person visual perspective and eight from various different third-person visual perspectives and viewing angles) and asked to select which perspective and viewing angle they wished their intervention to be based upon. Viewing angle options included rear-view, front-view and several different side-view options.

Imagery training program.

After completing the response training, an individualized imagery script incorporating the participant's self-reported stimulus, response and meaning propositions was created for each participant. Participants were instructed to read the imagery script and then use the information presented to recreate the described content mentally from their preferred perspective and angle. Following PETTLEP imagery guidelines (Holmes & Collins, 2001), participants were also instructed to perform their imagery at the same speed as they would normally perform the movement and in the same environment (i.e., on the golf course or driving range). They were also asked to wear the same attire, adopt the same stance, and hold the appropriate club that they would normally use to perform the movements described in the imagery script. Based on the recommendations of several researchers (e.g., Schuster et al., 2011; Wakefield & Smith, 2009), participants were instructed to read the script and then practice the imagery for 11 min, three days per week, over a six week period.

Action observation training program.

After completing the response training participants were filmed using a Panasonic DMC-FS7 digital camera from their preferred perspective and angle, performing the golf shots they wished to improve upon. Participants then reviewed the recorded shots and selected their best shots to be included in the video. A self-modeling intervention was used as opposed to showing another person as the model, both in order to create a personally meaningful action observation intervention and because self-modeling has been shown to be more effective than other-modeling techniques for improving sport performance (e.g., Clark & Ste-Marie, 2007). Consistent with guidelines for self-modeling interventions (e.g., McCullagh, Law, & Ste-Marie, 2012) only participants' best performances were included in the action observation intervention. This is the most common method of delivering self-modeling interventions in sport settings (Dowrick, 2012). The footage was edited using NCH VideoPad Video Editor Professional 2.11 software to create an individualized action observation DVD. On average, each DVD contained 27 shots and lasted around five min and

30s. To ensure that participants engaged in the action observation intervention in a similar manner to the imagery intervention, aspects of the PETTLEP model were also included in the observation intervention. Participants were instructed to: watch the video whilst wearing golfing attire; hold the same club as depicted in the video; and adopt the observed stance. Participants were instructed to watch the video twice a day, three days per week, over a six-week period.

Control training program.

Participants in the control group discussed their golf game with one of the researchers and identified an area of their game they would like to improve. Participants were asked to engage in physical practice of this aspect of their game for 11 min, three times a week, for six weeks.

All participants completed a training diary to encourage adherence to the training program and to act as a manipulation check ensuring participants completed the training as directed. Participants were contacted weekly and reminded to complete their prescribed training and offered the opportunity to change any aspects of their intervention if they desired (e.g., select a new perspective or viewing angle or focus on different stimulus, response, or meaning propositions). However, no such changes to the intervention were requested by any participants. As all the participants were active club level golfers, the participants in each group continued with their usual training, in addition to completing the training associated with their intervention. This was managed directly for time and volume throughout the experimental period in close liaison with the golfers/golfers' coaches. One of the experimental team was also a professional golfer and was able to work with the coaches to ensure consistency of physical practice within and across groups. Participants completed the MIQ-R questionnaire prior to commencing the training program (pre-test) and upon completion of the six-week training program (post-test). Following the sixth week, participants were instructed to refrain from any form of experimentally assigned training for two weeks, and then complete the MIQ-R for a final time (retention). Upon completion of the training program, all training diaries were inspected. All participants adhered to their prescribed training as directed and refrained from engaging in their imagery or observation training during the retention period. The training diaries also indicated an equal number of reports of spontaneous imagery during the training programs across all groups. The lack of structure and its unsystematic nature would suggest that this was not imagery training as conducted by the experimental group, but more a form of daydreaming and reverie.

Data Analysis

Participants' pre-test questionnaire responses on each sub-scale of the MIQ-R were analyzed using a between groups one-way analysis of variance (ANOVA) to confirm no significant differences in the ease with which the golfers could generate visual or kinesthetic imagery prior to commencing the training program. Participants' responses to the different sub-scales of the MIQ-R questionnaire were analyzed individually. Separate three (Group: action observation, imagery, control) x three (Time: pre-test, post-test, retention) mixed ANOVAs were conducted for the visual and kinesthetic sub-scales of the MIQ-R. Where the assumption of sphericity was violated the degrees of freedom were corrected using the Greenhouse-Geisser method. Post-hoc analyses with the Sidak adjustment were applied where necessary. Where significant changes in imagery ability were obtained in both the imagery and observation training conditions, percentage changes in questionnaire scores between pre- to post-test and pre- to retention-test were calculated. These data were then analyzed using one-way ANOVAs to establish any differences in the changes in imagery ability between the imagery, observation, and control conditions. All significant effects are reported at an alpha value of .05. Effect sizes are reported as partial eta squared (η^2_p).

Results

Pre-Test Data

The one-way ANOVAs conducted for each sub-scale of the imagery questionnaires at pre-test revealed no significant differences in ease of image generation between the groups (p = .18 for visual and p = .16 for kinesthetic). This indicates that the ease of image generation scores were similar between groups prior to commencing the training program.

MIQ-R Visual Sub-scale

The mean scores for visual imagery ease obtained throughout the training program are displayed in Figure 1 and Table 1. The ANOVA showed a significant group by time interaction, $F(4, 48) = 2.77$, $p = .04$, $\eta^2_p = .19$. The post-hoc analysis revealed that for the imagery group there was a significant improvement in ease of visual imagery generation between pre-test and post-test (p = .004), and between pre-test and retention (p = .04). There were no differences in ease of visual image generation ability between post-test and retention (p = .71). For the action observation group, the post-hoc analysis also indicated a significant improvement in ease of visual image generation between pre-test to post-test (p = .004), and between pre-test and retention (p = .05). There were no differences in ease of visual image generation between post-test and retention (p = .53). For the control group, the post-hoc analysis revealed no significant changes in ease of visual image generation at any stage of the training program (all p > .90). These data indicate that both the imagery and action observation groups improved their ease of visual image generation as a result of their respective training. This improvement in visual imagery was maintained at the retention test phase, after participants had withdrawn from their action observation/imagery training for two weeks. The one-way ANOVA on the percentage change data indicated no differences in the extent to which visual imagery ease improved between the imagery and observation groups from both pre- to post-test or pre- to retention-test (both p = .99). Both imagery and observation training, therefore, improved visual imagery ease to a similar extent. The control group, who engaged in physical practice and did not complete any imagery/action observation training, showed no change in ease of visual image generation throughout the experiment.

MIQ-R Kinesthetic Sub-scale

The mean scores for ease of kinesthetic image generation obtained throughout the training program are displayed in Figure 2 and Table 1. The ANOVA showed a significant group by time interaction, $F(4, 48) = 3.49$, $p = .01$, $\eta^2_p = .23$. The post-hoc analysis revealed that for the imagery group there was a significant improvement in ease of kinesthetic image generation between pre-test and post-test ($p = .005$), and between pre-test and retention ($p = .001$). There were no differences in ease of kinesthetic imagery generation between post-test and retention ($p = .90$). For the action observation group, the post-hoc analysis indicated a trend for an improved ease of kinesthetic image generation between pre-test to post-test, but this did not reach significance ($p = .07$). There were no significant differences in kinesthetic imagery ease between pre-test and retention ($p = .40$) and between post-test and retention ($p = .32$). For the control group, the post-hoc analysis revealed no significant changes in kinesthetic imagery ease at any stage of the training program (all $p > .70$). These data indicate that the imagery group improved their ease of kinesthetic image generation as a result of their training from pre- to post-test, and this improvement was maintained at the retention test phase. Although the action observation group did not significantly improve their kinesthetic imagery ease, there was a trend in this direction. The control group, who engaged in physical practice and did not complete any imagery/action observation training, showed no change in kinesthetic imagery ease throughout the experiment.

Discussion

Athletes can obtain performance improvements by engaging in imagery (Driskell et al., 1994), although the ability of an athlete to generate images influences the extent to which imagery is effective in improving performance (Hall et al., 1992; Robin et al., 2007).

Establishing techniques for improving aspects of imagery is, therefore, important to allow athletes to obtain greater benefits from imagery interventions (Cumming & Williams, 2012). The aim of this experiment was to investigate the efficacy of action observation and imagery training as techniques for improving imagery ability in competitive golfers. To the best of our knowledge, this experiment represents the first attempt to compare changes in imagery generation ease as a result of imagery or action observation training over an extended training and retention period.

The results indicated that both imagery and action observation training over a six-week period produced similar significant improvements in participants' visual imagery generation ease. These improvements remained constant following a two-week retention period. This indicates that both techniques would seem to be equally effective for improving visual imagery generation ease. However, in relation to kinesthetic imagery generation ease, only imagery training produced a significant improvement which remained constant at the retention test phase. There was a trend for improved kinesthetic image generation ease as a result of action observation training, although this effect was not significant. Physical practice alone (control) was not sufficient to produce improvements in the ease with which the golfers could generate visual or kinesthetic images. These findings are consistent, in part, with our hypothesis that both imagery and action observation training would bring about improvements in the ease with which athletes can generate imagery.

The results support previous reports that imagery training can improve aspects of imagery ability (e.g., Calmels et al., 2004; Cumming & Ste-Marie, 2001; Hammond et al., 2012; Rodgers et al., 1991; Williams, Cooley, & Cumming, 2013). Further, the results support the findings of Rymal and Ste-Marie (2009) that action observation training improves the ease with which athletes can generate visual images of themselves performing in a sporting context. The finding that action observation can facilitate the ease with which participants can generate visual images of themselves performing may be reflective of the shared neural circuitry between the two states (Jeannerod, 2001). For example, Munzert et al. (2008) reported considerable overlap in neural motor areas active when participants engaged separately in observation and imagery of a gymnastics routine. Specifically, they reported overlapping activation in areas of the primary motor cortex, premotor cortex, supplementary motor area, cerebellum and basal ganglia between the two conditions. Although in this experiment we did not measure neural activity during imagery and observation, based on the findings of Munzert et al., it is possible that the action observation training activated some of the same motor regions of the brain that are active during the process of imagery. The putative human mirror neuron system (Gallese et al., 1996) may have been the mechanism by which the action observation intervention facilitated the ease with which the golfers could generate visual images of themselves performing golf shots. In addition, it is likely that any possible activation of mirror neuron regions in this experiment would have been enhanced through the use of a self-modeling observation intervention, rather than the use of another person as the model (see Dowrick, 2012 for a review).

The finding that action observation improved the ease with which the golfers could generate visual, but not kinesthetic, images of themselves performing golf shots is not surprising. Holmes and Calmels (2008) suggested that with observation interventions the desired perceptual information is provided to the athletes in the form of an external stimulus and controlled in the video-editing process. As such, action observation videos provide athletes with visual images of a particular movement that can be recalled at a future time during imagery. As the action observation video provides mainly visual stimuli to the observer, it is logical that this type of intervention would facilitate the ease with which participants can generate visual as opposed to kinesthetic images. In addition, it is possible that kinesthetic characteristics of imagery ability are improved through imagery training, as kinesthetic imagery is important in helping the athlete control complex movement imagery with a high degree of temporal accuracy. Conversely, with action observation, highly accurate visual and temporal cues are provided which may reduce the demand for kinesthetic aspects of imagery to support the process. This may explain the lack of a significant improvement in ease of kinesthetic image generation for the action observation group.

Although not significant, there was a trend (p = .07) for an improvement in ease of kinesthetic image generation as a result of the action observation training, despite higher variation in ease of image generation scores within the action observation group (see Table 1). As this effect approached significance, it is possible to speculate that the use of additional verbal instructions alongside the action observation training may allow athletes to improve the ease with which they can generate both visual and kinesthetic imagery. For example, sport psychologists could combine imagery and action observation into a single intervention by instructing athletes to attempt to “feel” themselves performing the movement as they observe it during the video intervention. Although previous sport psychology research has tended to focus on comparing the effectiveness of imagery and action observation against one another (e.g., Gatti et al., 2013; Neuman & Gray, 2013; Ram et al., 2007), the idea that the two techniques should be combined is increasingly advocated in the literature. For example, Holmes and Calmels (2008) suggested that imagery and observation should be seen as complementary, rather than competing interventions. Indeed, engaging in combined imagery and observation has been shown to activate the cortical motor system to a greater extent than observation or imagery alone (e.g., Berends et al., 2013; Macuga & Frey, 2012; Sakamoto, Muraoka, Mizuguchi, & Kanosue, 2009; Villiger et al., 2013; for a review see Vogt, Di Rienzo, Collet, Collins, & Guillot, 2013). There is also limited evidence that combined imagery and observation is effective in improving motor skill performance (e.g., Atienza, Balaguer, & Garcia-Merita, 1998) and perceptions of collective efficacy in sport performers (Shearer, Mellalieu, Shearer, & Roderique-Davies, 2009). As such, instructing athletes to engage in the kinesthetic imagery of a movement whilst simultaneously observing it may activate the motor system to a greater extent than observation or imagery alone. This may in turn be effective in improving the ease with which participants can generate both visual and kinesthetic imagery. Future sport psychology research should investigate this possibility further.

This experiment has produced some interesting results in relation to improving ease of image generation. However, due to the applied nature of the experiment, there are a number of important issues to address. First, personalizing imagery/observation interventions is recommended in the sport psychology literature (e.g., Callow & Roberts, 2010; Holmes & Collins, 2001; Wakefield et al., 2013). As such, participants were able to select both the perspective/viewing angle and the aspect of their golf performance upon which they wished their intervention to based. Although this approach is beneficial in an applied sense, the lack of homogeneity in the content of imagery/observation interventions within groups may have introduced additional variables that could have mediated the extent to which ease of image generation improved in certain participants. For example, it is possible that improvements in ease of image generation may have differed between participants who selected first- or third-person perspectives for their interventions, or between participants who focused on different aspects of golf such as putting, driving or chipping. Future research could address these issues by comparing directly the effects of training using different imagery/observation perspectives on imagery ability characteristics in a more controlled laboratory setting.

Second, research indicates that both imagery and action observation are effective in improving sport performance (e.g., Ram et al., 2007; Robin et al., 2007). It is therefore possible that the golfers who took part in either the imagery or action observation conditions, may have improved aspects of their golf performance as a result of their specific intervention. However, as participants were permitted to select which aspects of their game they wished to focus on in their imagery or observation intervention, not all participants' interventions focused on the same aspects of golf. As such, it was not possible in the current experiment to measure performance improvements within and between groups as a result of these interventions, and future research should explore this issue. In addition, it is important to acknowledge that this was one of the first experiments to investigate the extent to which imagery ability characteristics can be improved by different interventions. Although the results indicate that ease of image generation can be improved by imagery or action observation training, the time scale over which such changes occur or remain intact are currently unknown. Future research should therefore seek to replicate this experiment whilst measuring changes in imagery ability characteristics more regularly throughout the training program and over an extended retention period in order to establish both the time-course and permanence of the reported effects.

Imagery ability comprises multiple components, including ease of image generation, image vividness, image maintenance and image controllability (Cumming & Williams, 2012; Morris et al., 2005). The findings reported in this experiment that both imagery and action observation were effective in improving the ease with which participants can generate imagery are encouraging. Future research should investigate the extent to which imagery and action observation interventions can improve other imagery ability characteristics. In addition, future research may wish to investigate the use of imagery and observation intervention in individuals classified as poor imagers. Such individuals typically score lower than 16 on either sub-scale of the MIQ-R (e.g., Smith, Wright, Allsopp, & Westhead, 2007; Smith et al., 2008). In this experiment, the golfers all had a moderate-to-high pre-test imagery ability and this may be due to their previous experience of performing golf-related imagery in an unstructured manner. It is possible that the improvement in visual imagery generation ease of the golfers in this experiment was mediated by their existing imagery competence. The nature of video-based action observation ensures that athletes do not have to generate images themselves and issues related to imagery ability (such as image clarity, control, and maintenance; Holmes & Calmels, 2008) are controlled. Given these benefits of action observation over imagery, it is possible that action observation training may be particularly effective in improving ease of image generation if used with participants classified as poor imagers.

Since observation of actions was shown to improve imagery generation ease the findings of this experiment suggest that coaches and practitioners should consider using video-based psychological practice as part of their athletes' regular training. Video is readily available and practical through discrete technological devices including smartphones, tablets and cameras, making imagery facilitated action observation a viable training aid for most sport performers. In our applied work, we have used this approach through smartphone and tablet applications, in some cases removing the structured imagery training via imagery scripts altogether. In these cases, our athletes' imagery volume and quality has increased as a result of the observation intervention, in line with the findings of this experiment and recent qualitative research (e.g., Hars & Calmels, 2007; Nordin & Cumming, 2005). We would therefore advocate this approach as an effective and time efficient approach to mental skills training.

In conclusion, the results of this experiment demonstrate that the ease with which athletes can generate imagery can be improved through both imagery and action observation training. Particularly interesting is the finding that action observation can produce improvements in the ease with which athletes can generate visual images of themselves performing. Given that imagery can be an effective technique for improving sport performance, the discovery of an effective technique for improving ease of image generation is invaluable. Sport psychologists should consider using action observation methods to facilitate ease of image generation in their athletes. This may be particularly effective if implemented with athletes classified as poor imagers, and if combined with instructions to engage in kinesthetic imagery whilst observing the observation video, although these ideas remain to be tested.

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