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Comparing movement imagery and action observation as techniques to increase imagery ability

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ABSTRACT

Objectives: This study compared the effectiveness of an imagery intervention with an action observation intervention on the effectiveness of improving the ability to image different content and characteristics. These two intervention techniques were also compared to a control condition.
Design: Experimental study, random assignment to one of three groups and repeated assessments.
Method: Participants (N = 51; 59% female; *M*age = 19.37, *SD* = 1.33) were randomly assigned to one of three intervention groups: 1) imagery, 2) observation, 3) control. Imagery ability was assessed using the Movement Imagery Questionnaire-3 (MIQ-3) and Sport Imagery Ability Questionnaire (SIAQ) before and after the 4-week intervention. Groups consisted of either imaging a series of finger exercises (imagery group), observing videos of the same exercises (observation group), or performing the stroop task (control group). The intervention was conducted once a week in the lab, and imagery and observation interventions were also performed in participants' own time between visits.
Results: Participants in the imagery and observation groups experienced a significant increase in their SIAQ skill, strategy, and mastery imagery ability from baseline to post intervention ($ps < .05$); the control group experienced no change in their imagery ability of these subscales. All groups experienced an increase in their MIQ-3 external visual imagery from baseline to post intervention. 82% of the observation group experienced spontaneous imagery during observation of the movements.
Conclusions: Imagery and observation are similarly effective intervention strategies in improving movement based imagery ability. Observation of actions appears to elicit spontaneous imagery in most people.

Imagery can effectively enhance performance either through directly priming movement patterns, or indirectly through altering constructs and dispositions associated with more successful performance (e.g., enhancing confidence, regulating anxiety) (Cumming & Williams, 2012; Martin, Mortitz, & Hall, 1999). Consequently, imagery is a fundamental technique used in sport, exercise, dance, and rehabilitation (Cumming & Williams, 2012; Martin, Moritz, & Hall, 1999). Therefore, it is important to understand factors and establish procedures that lead to more effective imagery.

Imagery ability, defined as "an individual's capability of forming vivid, controllable images and retaining them for sufficient time to effect the desired imagery rehearsal" (Morris, Spittle, & Watt, 2005, p. 60), is one factor proposed to influence the success of imagery use (Hall, 1998). In support, Robin et al. (2007) found that following an imagery and physical practice intervention to improve tennis service return accuracy, greater improvements were experienced by better imagers compared with poorer imagers. Moreover, at times imagery is only beneficial when used by individuals demonstrating sufficient imagery ability (McKenzie & Howe, 1997; Williams, Cooley, & Cumming, 2013).

When examining imagery ability, it is important to consider that it is a multidimensional construct (Morris et al., 2005). Consequently, various techniques have been established to assess imagery ability such as self-report questionnaires, interviews, mental chronometry, neuroimaging, and physiological techniques (for a review on these different techniques see Collet, Guillot, Lebon, MacIntyre, & Moran, 2011). The most frequently employed technique to assess imagery ability is through the use of questionnaires which typically assess either ease of imaging or imagery vividness (Roberts Callow, Hardy, Markland, & Bringer, 2008; Williams & Cumming, 2011; Williams et al., 2012). However, these ease and vividness ratings are likely to be influenced by the specific content being imaged as well as the different characteristics of the imagery (Cumming & Williams, 2012, 2013). Cumming and Williams (2013) explain that imagery content reflects what an individual is imaging. Specific to sport, Hall (1998) suggested that, "Just

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because athletes might be able to easily and vividly imagine themselves performing a skill (e.g., "throwing a ball"), [it] does not mean they can just as easily and vividly imagine receiving a medal or being in control of difficult situations" (p. 171). In support of differences in imagery ability due to the content being imaged, Williams and Cumming (2011) revealed athletes were able to image positive feelings and emotions (i.e., affect imagery) significantly more easily than images of performing skills, which were in turn significantly easier to image than strategies, goals, and persisting and performing well in difficult situations (i.e., mastery imagery; Williams & Cumming, 2011).

Alongside variations in the ability to image different content, individuals can also vary in their ability to image using different characteristics (Roberts, Callow, Hardy, Markland, & Bringer, 2008; Williams et al., 2012). While imagery content refers to what the individual is imaging (e.g., throwing a ball), imagery characteristics refer to how the imagery of the particular content is experienced and includes by is not limited to imagery modalities and the visual perspective of the image (Cumming & Williams, 2012; 2013). For example, an individual may image performing a tennis serve (content) from an internal visual imagery perspective (characteristic). The two most commonly employed imagery modalities are visual and kinesthetic imagery. Visual imagery involves seeing the image and can be experienced from an external visual imagery (EVI; 3rd person) perspective or an internal visual imagery (IVI; 1st person) perspective (Morris et al., 2005). Kinesthetic imagery (KI) is the feelings and sensations associated with an image. As mentioned, the ability to image using different imagery characteristics can vary, with differences often displayed between visual and kinesthetic imagery ability (Williams, Guillot, Di Rienzo, & Cumming, 2015). Therefore, when examining imagery ability, it is important to establish the ability to image different content (e.g., movement vs. motivational images) as well as the extent to which individuals can image content using different characteristics (e.g., EVI, IVI, KI).

Although imagery ability varies amongst individuals, like a physical skill, imagery can be honed and refined (Cumming & Williams, 2012). Performing imagery (i.e., imagery practice) can improve the capacity to image the specific content being practiced (Calmels, Holmes, Berthoumieux, & Singer, 2004; Cumming & Ste-Marie, 2001; Williams et al., 2013). However, imagery practice relies on individuals being able to create and control an accurate representation of the movement that is then further improved and refined. In populations where generating an image may be difficult, other methods such as action observation may be more beneficial by providing important perceptual information (Holmes & Calmels, 2008; Ram, Riggs, Skaling, Landers, & McCullagh, 2007).

Observation is proposed to facilitate imagery by providing the individual with a clear and vivid instruction of what (i.e., the specific content) they are required to image (Lang, 1979). In support, gymnasts and dancers have reported observing others to enhance the quality of their own images (Hars & Calmels, 2007; Nordin & Cumming, 2005). Furthermore, Williams, Cumming, and Edwards (2011) found that observing Movement Imagery Questionnaire-3 (MIQ-3; Williams et al., 2012) actions lead to greater ease of imaging these specific movements from both visual and kinesthetic modalities.

Both observing and imaging actions share certain neural representation (Lorey et al., 2013) and elicit similar brain and corticospinal activity to that experienced when executing the movement (Clark, Tremblay, & Ste-Marie, 2004; Gallese & Goldman, 1998). This overlap in brain activity is proposed to facilitate learning and performance of skills through imitation (Jeannerod, 2001). Both imagery practice and action observation are thought to lead to functional changes in task representation in long term memory which in turn leads to better task performance (Kim, Frank, & Schack, 2017). The neural and behavioral changes elicited through imagery and observation may also serve to enhance the ability to image movements and actions in that individuals may find it easier to retrieve this information from long-term memory and thus find it easier to image this content.

Interestingly, research also suggests that both imagery, and action observation can facilitate improvements in the ability to image movements different to those observed or imaged during the intervention. For example, a 16-week figure skating imagery training program lead to figure skaters improving their ability to image basic movements (Rodgers, Hall, & Buckolz, 1991). Using observation, Rymal and Ste-Marie (2009) found that an action observation intervention of a competitive dive could increase divers' vividness when imaging the Vividness of Movement Imagery Questionnaire (Isaac, Marks, & Russell, 1986) movements (e.g., kicking a ball, running). However, a small sample size and lack of a control group limit the conclusions drawn. Imagery practice and observation can also improve imagery ability differently depending on the characteristics or modalities being employed. Improvements in visual imagery ability as a result of imagery practice tend to occur sooner than improvements in kinesthetic imagery ability (Cumming et al., 2001; Williams et al., 2013). Similarly, external observation has previously only improved ease of imaging when performed from an external visual imagery perspective (Williams et al., 2011).

More recently, Wright, McCormick, Birks, Loporto, and Holmes (2015) examined the effects of both action observation and imagery practice to see whether they could improve the ability to image different content to that of the intervention, and whether any improvement depended on the imagery characteristics being employed. Compared to a control group who did not improve, both action observation and imagery practice groups similarly improved their ability to image movements using a visual modality. For the ability to image the same movements using KI, imagery practice elicited a significant improvement while a similar trend (although not significant) was apparent in the action observation group (Wright et al., 2015).

Despite the promising findings of action observation increasing the ability to image content beyond that being observed, the action observation used by both Rymal and Ste-Marie (2009) and Wright et al. (2015) were personalized videos of the participants themselves. While this was to create personally meaningful and more effective interventions (Holmes & Collins, 2001), Wright et al. (2015) acknowledged that this approach may have impacted the effectiveness of the intervention. Furthermore, despite visual and kinesthetic imagery being the two most commonly used modalities of imagery, previous work comparing imagery and action observation in improving the ability to image visual and kinesthetic imagery has been limited to not separately assessing and comparing the effects of both interventions on EVI and IVI ability (Wright et al., 2015). It is therefore important to examine the effectiveness of action observation on increasing imagery ability through the use of generic models performing the actions, to see whether this non-personalized observation is similarly effective, and separately examine the effectiveness of these techniques on improving the ability to image scenarios varying in content and characteristics.

In sum, imagery practice and action observation appear able to increase imagery ability. However, research, particularly when using generic action observation, has yet to sufficiently examine and compare: 1) whether imagery practice and action observation intervention techniques can improve the ability to image content different that being observed or imaged during the intervention, and 2) whether any such improvements vary for different characteristics of the imagery (i.e., do any imagery ability improvements vary depending on the imagery modalities and perspectives being employed). With these limitations in mind, the present study aimed to comprehensively investigate and compare the effects of movement imagery practice and generic action observation in improving imagery ability. Three groups were compared: 1) imagery practice intervention group, 2) action observation intervention group, 3) control group. The Movement Imagery Questionnaire-3 (MIQ-3; Williams et al., 2012) assessed the ability image movement using EVI, IVI, and KI, while the Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, 2011) assessed the ability to image different cognitive and motivational imagery content. The ability to image these different content and characteristics were assessed at baseline, and after the four week interventions. The imagery practice and action observation interventions involved imaging or observing a series of basic hand exercises respectively. Hand exercises were selected as the intervention content to ensure that the content being imaged and observed was a different type of movement to those being assessed by the MIQ-3 and SIAQ which assess simple gross and more complex movements respectively.

Based on the neural overlap between movement imagery and action observation (Clark et al., 2004; Gallese & Goldman, 1998), it was hypothesized that both intervention techniques would increase the ability to image movements using EVI, IVI, and KI. Therefore, it was proposed that imagery and observation groups would experience a significant increase in MIQ-3 EVI, IVI, and KI scores from pre to post intervention. Due to the skill and strategy subscales of the SIAQ assessing ease of imaging movements (i.e., movement imagery ability), it was also hypothesized that both imagery practice and action observation groups would experienced a significant increase in skill and strategy imagery ability from pre to post intervention. It was hypothesized that the control group would experience no changes in imagery ability of movements when using EVI, IVI, KI, or in skill, and strategy imagery. It was also hypothesized that there would be no change in the ability to image goal, affect, and mastery imagery content for any of the three groups.

1. Methods

1.1. Participants

Fifty-one healthy right handed participants (male = 21, female = 30; *M*age = 19.37 (*SD* = 1.33)) with no known neurological or muscular injuries or impairments, and no color blindness took part in the study. Prior to data collection ethical approval was obtained from the university ethics committee and all participants provided written informed consent before being randomly assigned to one of three intervention groups; (a) imagery practice (N = 16; male = 7, female = 9), (b) action observation (N = 18; male = 7, female = 11), and (c) control (N = 17; male = 7, female = 10).

1.2. Procedures

Completion of the study included 5 separate lab visits over a 5 week period (each visit 6–8 days apart). The first and final visit lasted no longer than 1 h, and the other visits lasted no longer than 20 min. Please see Figure 1 for an overview of the procedures.

Visit 1. Participants were provided with an overview of the study and reminded that their participation was voluntary and that they were free to withdraw at any point. Participants then provided their consent, demographic information, and completed the MIQ-3 and SIAQ to assess baseline imagery ability. Participants then completed the intervention condition they were assigned to (i.e., imagery practice, action observation, or control – details of which are provided below). Participants in the imagery practice and action observation groups were asked to try and complete their intervention once a day before the next lab visit and were provided with a weekly diary to record each time they completed an intervention bout.

Visits 2, 3, and 4. Participants in the imagery practice and action observation conditions first returned their weekly diaries and completed the intervention weekly evaluation form with regards to the intervention activities they had completed since the previous visit. Next, participants in the imagery and observation groups were introduced to a new combination of movements and completed their intervention condition (i.e., imaged the movements if in the imagery group and observed the movements if in the observation groups). The control group completed the Stroop task. Finally, participants in the imagery practice and action observation groups were given a new diary and reminded to complete their intervention once a day before the next lab visit.

Visit 5. Participants in the imagery practice and action observation conditions first returned the weekly diaries and completed the intervention weekly evaluation form. Next all participants completed the MIQ-3 and SIAQ to assess imagery ability following the intervention. Finally, participants in the action observation intervention group completed the post-intervention imagery assessment. Upon completion of the study all participants were thanked for their participation.

1.3. Interventions

Imagery practice. Each week participants were asked to image a series of exercises of the fifth digit of the left hand. In total eight exercises were used to evoke movements such as finger adduction, abduction, flexion, and extension, and a combination of different exercises to image were prescribed each week to ensure variety and prevent boredom. Each week five of the eight possible movements were imaged during each intervention session. Participants imaged 10 repetitions of each movement before progressing to the next movement. When performing the imagery, participants were instructed to position their hand in the movement's starting position and image the movement as clearly and vividly as possible from their preferred visual perspective whilst also incorporating the different sensations that would be experienced if physically performing the movements. Participants were also told to keep their hand still during the imagery. Participants performed each imagery intervention session once in the lab at the start of the week, and were encouraged to try and perform the imagery once each day in their own time before the next weekly lab visit. During each weekly lab visit, a new set of five movements were given to participants to be imaged the following week under the same instructions. When participants were first introduced to the weekly exercises, they were provided with a video demonstration of the exercises to ensure they understood the movement they were being asked to perform. This was to ensure the imagery group understood the movement they were required to image and only consisted of one repetition for each exercise. During the remaining sessions of the week, participants were provided with a small written description of the movements to remind them of the movements they were required to image.

Action observation. Participants completed the same intervention exercises as the imagery practice group. The difference was that participants in the action observation condition observed a video of the movements being performed rather than explicitly imaged the movements in the absence of a video demonstration. The same movements and the same number of repetitions in the imagery condition were performed in the action observation videos (i.e., participants observed five movements each performed 10 times). Participants positioned their left hand in the start position and then observed the video containing the finger movements for that particular week. There was no mention of performing any imagery in this group.

All observation clips were filmed using an iPhone 5 from a first person perspective with the hand placed on a black surface at an angle of 0° (for a still of an example video please see Figure 2). Clips were filmed using both male and female 22 year old Caucasian models. Participants were gender matched with the videos they observed to ensure greater similarity between the participants and prime (Bussey & Perry, 1982). Each movement clip included the performance of 10 repetitions of the movement and this was matched for speed across both gender videos. The clips to be used in a particular week's video were spliced together using iMovie. The duration of the videos used across the four intervention weeks ranged from 1 m 52s to 2 m 35s. Videos were uploaded to www.youtube.com at the start of each week and participants were provided the link to access the videos to watch each day in their own time.

Control. Participants completed a modified Stroop task (Stroop,

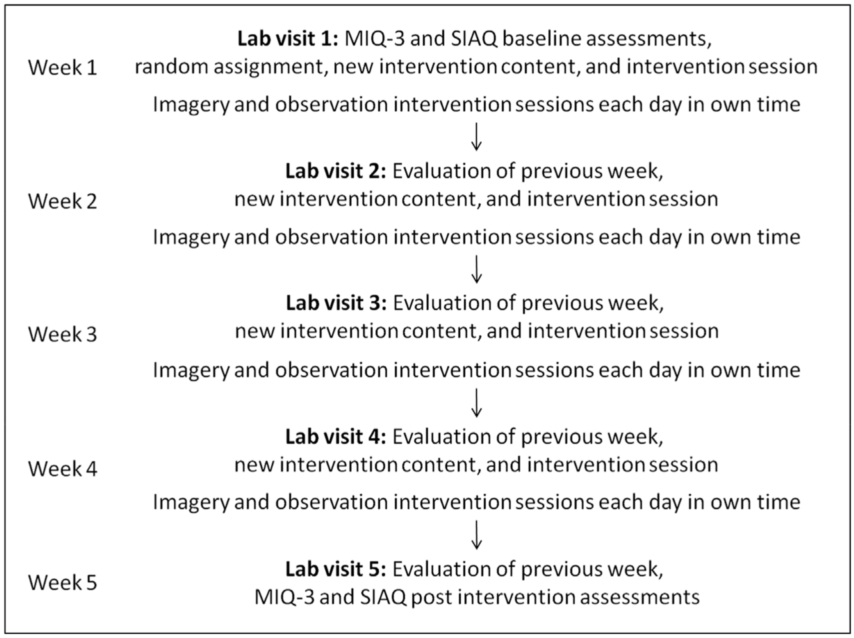

Figure 1. Overview of intervention procedures. Note. MIQ-3 = Movement Imagery Questionnaire-3, SIAQ = Sport Imagery Ability Questionnaire.

Figure 2. Still from a video observed by the action observation intervention group.

1935). This ensured the participants were still processing visual stimuli, and engaging in a cognitive task but one that was not thought to evoke any deliberate or spontaneous imagery. The task presented the word of a color on the centre of the computer screen written in a color (e.g., the word "green" presented in the color blue). Two optional answers were presented at the bottom of the screen. Participants had to identify the color that the word was written in (rather than the color that the word spelt out) and select the appropriate answer. The task was played to participants on a computer and participants were told to select the appropriate answer from the two options as quickly and accurately as possible by selecting the "z" key or " > " key to select the left or right answer respectively. Each trial lasted a maximum of 2.5 s whereby a fixation period of 0.5 s was followed by display of the word for 2 s or until a response was made by the participant (whichever was quickest). There were 120 conditions in total meaning the task lasted no longer than 5 min. Participants performed the modified Stroop during each lab visit.

1.4. Measures

Movement imagery ability modalities. The Movement Imagery Questionnaire-3 (MIQ-3; Williams et al., 2012) assessed the ability to image movement EVI, IVI, and KI. The MIQ-3 consists of 12-items assessing ease of imaging four movements (knee lift, jump, arm movement, and waist bend) from an IVI perspective, an EVI perspective, and a KI modality. Participants read a description of each movement, physically perform the movement, and then image the movement from the perspective or modality described. Participants rate on a 7-point Likert type scale how easily they are able to see or feel each image (*1 = very hard to see/feel, 7 = very easy to see/feel*). Scores derived from the MIQ-3 have previously demonstrated validity and reliability in assessing EVI, IVI, and KI of movements (Williams et al., 2012). In the present study, data demonstrated good internal reliability with Cronbach alpha coefficients being above 0.70 for all subscales both pre- and post-intervention.

Imagery ability of different content. The Sport Imagery Ability Questionnaire (SIAQ; Williams & Cumming, 2011) assessed the ability to image different cognitive and motivational imagery content. Fifteen items assess how easily individuals are able to image content associated with five different types of imagery: movements and actions (skill imagery; e.g., "refining a particular skill"), plans and strategies (strategy imagery; e.g., "alternative plans and strategies"), achieving goals and outcomes (goal imagery; e.g., "myself winning"), positive feelings and emotions (affect imagery; e.g., "the excitement associated with performance"), and coping and persisting in difficult situations (mastery imagery; e.g., "remaining confident in a difficult situation"). Participants rate on a 7-point Likert type scale how easily they are able to image each item in relation to the sport they most frequently play (*1 = very hard to image, 7 = very easy to image*). Scores derived from the SIAQ have previously demonstrated validity and reliability in assessing sport imagery ability of distinctive content (Williams & Cumming, 2011). In the present study, data demonstrated good internal reliability with Cronbach alpha coefficients being above 0.70 for all subscales both pre- and post-intervention except for pre-intervention affect (0.63) and mastery (0.66).

Imagery practice weekly evaluation. Each week participants in the imagery practice group indicated how easily they could image the movements and how clear and vivid their imagery was during the course of the week. Responses to both items were made on 7-point Likert-type scales ranging from 1 (*very hard/no image at all*) to 7 (*very easy/perfectly clear and vivid*).

Action observation weekly evaluation. Each week participants in

Table 1
Session completion and engagement of interventions, ease and vividness of imagery practice intervention, and model similarity of action observation videos.

	Imagery Practice				Action Observation		
	Number of Sessions (0–6)	Session Engagement (%)	Ease of imaging (1–7)	Vividness of imagery (1–7)	Number of Sessions (0–6)	Session Engagement (%)	Model Similarity (1–7)
Week 1	5.53 (1.30)	70.18 (12.11)	5.21 (1.05)	4.43 (1.09)	5.88 (0.33)	68.59 (19.81)	4.53 (1.18)
Week 2	5.60 (0.74)	85.62 (48.29)	5.43 (1.09)	5.00 (0.88)	5.65 (1.22)	67.88 (20.81)	4.94 (1.30)
Week 3	5.87 (0.52)	77.50 (11.63)	5.36 (1.01)	5.29 (0.73)	5.94 (0.24)	67.20 (21.72)	4.88 (1.11)
Week 4	6.00 (0.00)	78.78 (12.24)	5.50 (1.02)	5.50 (1.02)	5.71 (1.21)	70.29 (20.05)	4.94 (1.43)

the action observation group indicated the extent to which they perceived themselves to be similar to the model performing the exercises observed. Responses were made on a 7-point Likert-type scale ranging from 1 *(not at all similar)* to 7 *(very similar)*.

Imagery and observation diaries. Participants in the imagery practice and action observation groups kept a diary of when they performed their intervention condition. Each time they performed their intervention they recorded the date and time this was done, and indicated as a percentage *(0% = none of the time, 100% = the entire time)* either the extent to which they were fully engaged in the imagery while imaging the movements, or the amount of time they were observing the movements while the video was playing (depending on the intervention group they were assigned to).

Post-intervention imagery assessment. Following the intervention, participants in the action observation group indicated whether they had experienced any deliberate or spontaneous imagery when observing the videos during the intervention (response: yes/no).

1.5. Data reduction and analysis

Data were analyzed using SPSS (version 22). First data were inspected for missing values and outliers. While there were no outliers, three participants dropped out of the study (control: $n = 1$, imagery: $n = 1$, observation: $n = 1$) but provided no reason. As such, their data were excluded from the analysis. This left a final sample of 48 participants (control = 16, imagery = 15, observation = 17).

To examine intervention engagement of the imagery and observation groups, the average number of intervention sessions conducted each week was calculated for each group. A two-way 4 week × two group (imagery, observation) analysis of variance (ANOVA) then examined any differences in intervention engagement between the groups and over the duration of the intervention. A similar 4 week × two group (imagery, observation) ANOVA examined any differences in how engaged participants were when completing their intervention. A one-way repeated measures ANOVA examined differences during the intervention in how similar to the model action observation participants perceived themselves to be.

To analyze how well the imagery practice group could image the specific intervention content, correlations were first run to examine the associations between the imagery group's ease and vividness of imaging the weekly finger exercises. Results revealed that correlations between the two imagery ability dimensions ranged from .68 to .90. Therefore, a bonferroni correction was performed to adjust the critical alpha level to 0.025 for the two separate one-way repeated measures ANOVAs to examine any differences in ease and vividness of the intervention movements throughout the intervention. Next, the frequency counts of those in the observation group that used imagery were calculated before frequency, vividness, and ease of imaging mean scores were generated for those who experienced imagery.

To examine changes in EVI, IVI, and KI movement imagery ability and skill, strategy, goal, affect, and mastery imagery ability during the intervention, eight separate 2 time (baseline, post-intervention) by 3 group (imagery, observation, control) ANOVAs examined any differences between the three groups, or any changes over time.

For ANOVAs involving repeated measures, if Mauchly's test of sphericity was violated, Greenhouse-Geisser correction values were reported (Greenhouse & Geisser, 1959). The probability value threshold for all analyses was set at 0.05 except in the instance of a bonferroni correction in which 0.05 was divided by the number of tests being run. All significant effects were followed up with bonferroni post hoc pairwise comparisons, and partial eta squared (η_p^2) was used as a measure of effect size.

2. Results

2.1. Intervention frequency and engagement

The average number of intervention sessions and engagement in these sessions for each week are presented in Table 1. On average participants performed more than 5 bouts of their intervention each week and were over 65% engaged in this activity. For frequency, the 4 week × 2 group (imagery, observation) ANOVA revealed no significant main effect for week, $F(2.43, 72.76) = 0.75$, $p = .501$, $\eta_p^2 = 0.024$, group, $F(1, 30) = 0.09$, $p = .769$, $\eta_p^2 = 0.003$, and no week by group interaction $F(2.43, 72.76) = 0.78$, $p = .486$, $\eta_p^2 = 0.025$. For engagement, a second 4 week × 2 group (imagery, observation) ANOVA revealed no significant main effect for week, $F(1.14, 34.31) = 1.15$, $p = .299$, $\eta_p^2 = 0.037$, group, $F(1, 30) = 2.11$, $p = .157$, $\eta_p^2 = 0.066$, or week by group interaction $F(1.14, 34.31) = 1.28$, $p = .272$, $\eta_p^2 = 0.041$.

2.2. Observation model similarity

The observation group's self-reported similarity to the model is reported in Table 1. The repeated measures ANOVA revealed no significant differences in ratings across the weeks of the intervention, $F(3, 48) = 1.03$, $p = .387$, $\eta_p^2 = 0.061$. On average participants reported this as being over 4.5 each week.

2.3. Imagery ability of intervention content

Imagery practice group. Means and standard deviations of ease and vividness of the intervention group's images are reported in Table 1. Results of the 4 time (week 1, week 2, week 3, week 4) one-way repeated measures ANOVA for ease indicated no significant difference in imagery ease across the weeks, $F(3, 39) = 0.35$, $p = .788$, $\eta_p^2 = 0.026$. However, the 4 time (week 1, week 2, week 3, week 4) one-way repeated measures ANOVA for vividness identified a significant difference in imagery vividness, $F(3, 39) = 5.98$, $p = .002$, $\eta_p^2 = 0.315$. Post hoc analysis suggested a trend in participants experiencing more clear and vivid imagery during the fourth week of the intervention compared with the first week ($p = .059$), but this was not statistically significant.

Action observation group. In total 14 participants in the observation group reported experiencing imagery while observing the videos compared to 3 participants who did not report experiencing any imagery. A one-way chi-square test revealed a significant difference

Table 2
Movement Imagery Questionnaire-3 and Sport Imagery Ability Questionnaire baseline and post-intervention means and standard deviations.

	Imagery Practice		Action Observation		Control	
	Pre	Post	Pre	Post	Pre	Post
EVI	5.12 (1.07)	5.70 (0.80)	5.19 (1.15)	5.74 (1.01)	5.70 (0.96)	5.61 (1.09)
IVI	5.43 (0.79)	5.67 (0.95)	5.57 (0.79)	5.93 (0.63)	5.47 (1.08)	5.41 (0.95)
KI	4.85 (1.02)	5.42 (1.30)	5.18 (1.14)	5.31 (1.00)	5.16 (0.87)	5.11 (0.81)
Skill	4.76 (0.99)	5.27* (1.05)	4.94 (0.97)	5.49** (0.80)	5.21 (1.05)	5.15 (0.92)
Strategy	4.02 (1.14)	4.78** (1.07)	4.06 (1.19)	4.90** (0.96)	4.90 (0.57)	4.83 (0.77)
Goal	5.16 (1.13)	5.38 (1.34)	5.08 (0.87)	5.43 (1.21)	5.00 (1.35)	5.06 (1.28)
Affect	5.67 (0.80)	5.91 (0.78)	5.80 (0.87)	5.57 (1.20)	5.44 (0.83)	5.71 (0.89)
Mastery	3.93# (0.79)	4.80*** (0.90)	4.86 (1.15)	5.33* (1.07)	4.65 (0.86)	4.71 (1.03)

Note. EVI = external visual imagery, IVI = internal visual imagery, KI = kinesthetic imagery. * = significantly greater than pre-intervention $p < .05$, ** = significantly greater than pre-intervention $p < .01$, *** = significantly greater than pre-intervention $p < .001$, # = significantly lower than the action observation group baseline $p < .05$.

suggesting that people are more likely to spontaneously image than not image during an observation intervention, χ^2 (1) = 7.12, $p = .008$.

2.4. General movement imagery ability

Means and standard deviations of EVI, IVI, and KI are reported in Table 2. Results of the 2 time (baseline, post-intervention) × 3 group (imagery, observation, control) ANOVA for EVI indicated a significant time effect, $F(1, 45) = 5.77$, $p = .021$, $\eta_p^2 = 0.114$, but no main effect for group, $F(2, 45) = 0.33$, $p = .719$, $\eta_p^2 = 0.015$, and no time by group interaction, $F(2, 45) = 2.34$, $p = .108$, $\eta_p^2 = 0.094$. Compared to the first visit, participants reported significantly greater EVI following the intervention. Results of the 2 time (baseline, post-intervention) × 3 group (imagery, observation, control) ANOVAs for IVI and KI revealed no significant main effects for time (IVI: $F[1, 45] = 1.59$, $p = .214$, $\eta_p^2 = 0.034$; KI: $F[1, 45] = 2.05$, $p = .159$, $\eta_p^2 = 0.044$), group (IVI: $F[2, 45] = 0.78$, $p = .466$, $\eta_p^2 = 0.033$; KI: $F[2, 45] = 0.08$, $p = .921$, $\eta_p^2 = 0.004$), and no time by group interaction (IVI: $F[2, 45] = 0.81$, $p = .451$, $\eta_p^2 = 0.035$; KI: $F[2, 45] = 1.39$, $p = .259$, $\eta_p^2 = 0.058$).

2.5. Sport imagery ability

Means and standard deviations of skill, strategy, goal, affect, and mastery imagery ability are reported in Table 2.

The 2 time (baseline, post-intervention) × 3 group (imagery, observation, control) ANOVAs for skill and strategy imagery ability revealed significant main effects for time (skill: $F[1, 45] = 9.24$, $p = .004$, $\eta_p^2 = 0.170$; strategy: $F[1, 45] = 13.68$, $p = .001$, $\eta_p^2 = 0.233$), and significant time by group interactions (skill: $F[2, 45] = 3.29$, $p = .046$, $\eta_p^2 = 0.128$; strategy: $F[2, 45] = 4.38$, $p = .018$, $\eta_p^2 = 0.163$). There were no significant main effects for group (skill: $F[2, 45] = 0.24$, $p = .792$, $\eta_p^2 = 0.010$; strategy: $F[2, 45] = 1.36$, $p = .267$, $\eta_p^2 = 0.057$). Post hoc analysis revealed that although the control group experienced no changes in skill and strategy imagery ability, both the imagery and observation groups improved their skill (imagery: p = .012; observation: p = .005) and strategy (imagery: p = .004; observation: p = .001) imagery ability from before to after the intervention.

Goal and affect imagery 2 time (baseline, post-intervention) × 3 group (imagery, observation, control) ANOVAs revealed no significant main effects for time (goal: $F[1, 45] = 2.97$, $p = .092$, $\eta_p^2 = 0.062$; affect: $F[1, 45] = 0.48$, $p = .494$, $\eta_p^2 = 0.010$), group (goal: $F[2, 45] = 0.22$, $p = .802$, $\eta_p^2 = 0.010$; affect: $F[2, 45] = 0.30$, $p = .745$, $\eta_p^2 = 0.013$), and no time by group interactions (goal: $F[2, 45] = 0.48$, $p = .623$, $\eta_p^2 = 0.021$; affect: $F[2, 45] = 1.53$, $p = .228$, $\eta_p^2 = 0.064$).

Results of the 2 time (baseline, post-intervention) × 3 group (imagery, observation, control) ANOVA for mastery imagery ability indicated a significant main effect for time, $F(1, 45) = 15.18$, $p < .001$, $\eta_p^2 = 0.252$, and a significant time by group interaction, $F(2, 45) = 3.65$, $p = .034$, $\eta_p^2 = 0.140$. There was no significant main effect for group, $F(2, 45) = 2.73$, $p = .076$, $\eta_p^2 = 0.108$. Post hoc analysis demonstrated that the imagery and observation groups improved their mastery imagery ability from before the intervention to after the intervention (imagery: $p < .001$; observation: $p = .024$). Additionally, while the imagery group displayed lower levels of mastery imagery ability compared to the observation group prior to the intervention ($p = .026$), this difference did not exist following the intervention ($p = .427$). There were no differences in the control group's mastery imagery ability over the duration of the intervention or when compared to other groups.

3. Discussion

The present study compared the effects of movement imagery practice and generic action observation as techniques to improve the ability to image different content using different imagery characteristics. It was hypothesized that both interventions would increase imagery ability of content of movements and actions (i.e., all three MIQ-3 subscales, and the skill and strategy subscales of the SIAQ), whereas the control group would experience no changes. Weekly diary and evaluation results demonstrated that both groups engaged in their intervention technique sufficiently and to similar extents suggesting results of the study are reflective of the intervention strategies rather than differences in intervention engagement and dosage. The action observation condition perceived the generic model to be adequately similar to themselves, and the imagery practice group imaged the intervention content to a sufficient standard suggested the interventions were successfully received by participants.

Surprisingly and contrary to our hypothesis, there were no changes in IVI and KI subscales of the MIQ-3 from pre-to post-intervention for any of the groups. Additionally, the MIQ-3 EVI subscale increased for all three groups across the intervention. Consequently, the imagery practice and action observation seemingly failed to increase the ability to image EVI, IVI, or KI of basic movements. This could have been due to MIQ-3 instructions requiring participants to physically perform each movement prior to imaging. Williams et al. (2011) demonstrated that prior movement can lead to significantly higher MIQ-3 scores in all three subscales which may have bolstered IVI and KI ability prior to the intervention, subsequently reducing the effect that action observation and movement imagery practice had on the ability to image this content using these modalities.

The increase in EVI experienced by all three groups may have been due to participants finding it more difficult to image the required movements from an EVI perspective. As such, completing the questionnaire a second time may have served as the imagery practice required to increase scores. However, examining the mean scores of the groups suggests that the significant time effect may have been driven by the imagery practice and action observation groups as these are the only two groups to experience increased EVI scores from pre-to post-intervention. An *a priori* power analysis was calculated based on results of the previous work (Wright et al., 2015) to determine the sample size needed for the current study. However, the effect sizes in the present study were somewhat smaller than those in found by Wright et al. (2015). Consequently, while it is important to note that the time by group interaction was non-significant, this finding may have been slightly underpowered and a possible Type II error.

As hypothesized, participants in the movement imagery practice and action observation groups increased their skill and strategy imagery ability, while the control group experienced no changes. These findings support the notion that imagery practice and action observation of basic movements can lead to improvements in individuals' ability to image sport related movement content. This study also builds on existing work by demonstrating that action observation to increase movement imagery ability does not have to include personalized models (Rymal & Ste-Marie, 2009; Wright et al., 2015).

It may seem surprising that participants in both intervention groups experienced significant increases in skill and strategy imagery ability but not IVI and KI ability. This could be due to participants seemingly displaying lower skill and strategy mean scores prior to the intervention. It would therefore be interesting to examine the extent to which movement imagery practice and action observation techniques are able to increase the ability to image IVI and KI in participants with lower baseline IVI and KI ability scores.

In further support of the hypotheses, the ability to image goal and affect related content did not change over the course of the intervention suggesting that movement based imagery and observation interventions are unlikely to elicit improvements in the ability to image content involving feelings, emotions, and outcomes such as winning. Interestingly, the imagery practice and action observation appeared to increase the ability to image mastery imagery content. While this may be surprising, there are two possible explanations. First, in line with previous research, participants displayed lower mastery imagery ability mean scores compared with goal and affect imagery ability scores (Williams & Cumming, 2011). As such, simply imaging or observing actions, even though they were movement based, may have been beneficial enough to increase participants' ability to image content they found more difficult. Second, the content of the mastery subscale of the SIAQ may be more closely associated with the observation and imagery practice content than initially anticipated. While the items that assess mastery imagery ability are concerned with doing well and persevering in difficult situations, the wording of items (i.e., "Giving 100% effort even when things are not going well", "Staying positive after a setback", "Remaining confident in a difficult situation") likely infer an elements of performance. As such, participants likely image performing movements and actions under difficult situations meaning this movement content is likely to have been improved as a result of the movement based interventions.

Overall the results of the present study suggest that 4-weeks of imagery practice or action observation are similar in their effectiveness in increasing imagery ability. This is not surprising given that similar brain and corticospinal activity is experienced when imaging or observing movements (Clark et al., 2004; Gallese & Goldman, 1998). As such, imagery practice and action observation likely primed and enhanced imagery ability using similar imitation processes to that which primes movement (Jeannerod, 2001). Furthermore, action observation using a generic model was a powerful enough prime to elicit similar improvements in imagery ability to that obtained using imagery practice.

The results of this study support previous work demonstrating imagery or observation interventions of certain content can increase the ability to image content different to that of the intervention (Rodgers et al., 1991; Rymal & Ste-Marie, 2009; Williams et al., 2013; Wright et al., 2015). Despite imagery and observation's transferable benefits to other types of imagery ability, there has been little attention from a theoretical point of view for why this occurs. One argument is that the imaging or observing could facilitate the imagery process in general. Both imagery and observation share certain neural representation (Lorey et al., 2013) and elicit similar brain and corticospinal activity when being performed (Clark et al., 2004; Gallese & Goldman, 1998). As well as this brain activity leading to changes in task representation which is thought leads to better task performance (Kim et al., 2017), it could be suggested that this brain activity during imagery also leads to changes which makes the imagery process (i.e., generate, inspect, transform, maintain; Kosslyn, 1995) more effective and efficient. Therefore, although imagery group participants didn't increase imagery ability of intervention content (i.e., imagery of finger exercises), likely due to a ceiling effect, improvements in the neural processes involved in imagery may have enabled more difficult content to be imaged more easily (i.e., skill, strategy, and mastery imagery ability). Future work should examine the neural mechanisms through which imagery and observation are able to alter imagery ability of different content and characteristics to provide greater insight into why this phenomenon occurs.

Interestingly, all but three action observation participants experienced spontaneous imagery while performing their observation. This finding demonstrates that the two processes were used in conjunction with each other and goes some way to supporting the proposal that imagery and action observation are complimentary processes (Holmes & Calmels, 2008). It could therefore be argued that the majority of action observation group participants underwent an imagery and action observation intervention. Imagery could have been experienced due to participants being instructed to position their left hand in the start position of the videos being observed. While this was done to remain consistent with the imagery group, this positioning may have encouraged participants to actively image during the observation. Alternatively, it may be that observation of actions regularly elicits imagery irrespective of hand positioning. Either way, changes in imagery ability arising from action observation may be facilitated (or even caused) by the imagery experienced. Future research should further examine this as the effect of action observation interventions may be due to accompanying imagery that is experienced.

The majority of observation group participants experiencing imagery also poses the question of whether action observation would be more effective in increasing imagery ability if it was accompanied by more explicit imagery instructions. Action observation combined with imagery is more effective than imagery alone in eliciting changes both neurologically and behaviorally (Eves, Riach, Holmes, & Wright, 2016; Holmes & Calmels, 2008). Therefore, a similar principle may apply for increasing imagery ability. However, three participants reported not experiencing any imagery during the observation. It would be interesting to establish characteristics that determine when spontaneous imagery accompanies action observation, and examine differences in action observation's effectiveness at improving imagery ability as a result of incorporating or not incorporating imagery.

A limitation of the study was that all questionnaires assessed ease of imaging, despite imagery ability being reflected in other dimensions such as vividness and controllability (Morris et al., 2005). However, ease of imaging is thought to reflect the ability to perform the different stages of the imagery process (i.e., the capacity to generate clear and vivid images, but also control and maintain these for the appropriate amount of time; Williams & Cumming, 2011). Despite this, future research should compare the effects of imagery practice and action observation on other dimensions of imagery ability and through the employment of a combination of measures beyond questionnaires (Collet et al., 2011), particularly given that measures do not always correlate (Williams et al., 2015). A second limitation is that it is unknown the extent to which observation's effectiveness was due to the observational process itself, or whether it was due to imagery being conducted at the same time. While it was beyond the scope of the present study, future work should examine the role and impact that imagery plays during action observation interventions.

In conclusion, the present study compared the effects of movement imagery practice and action observation on improving the ability to image different types of imagery content using different characteristics. Imagery practice and action observation had a similar impact on imagery ability; although both failed to increase EVI, IVI, or KI of movements, imagery and action observation significantly increased the ability to image skill, strategy, and mastery content. The majority of action observation participants spontaneously experienced imagery during their intervention suggesting that imagery is likely to be experienced in conjunction with action observation. Findings suggest that researchers and practitioners should consider the technique to use when wanting to bolster imagery ability and that future research should continue to establish which techniques are most effective for enhancing the ability to image particular imagery content and when using certain characteristics.

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