The effect of attentional focus strategy on physiological and motor performance during a sit-up exercise

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Abstract

The attentional focus of an individual can influence performance and physiological outcomes during strength training exercises. However, prior research has largely investigated this issue with male participants performing a biceps curl exercise and have not investigated the full range of attentional focus strategies. In the present experiment, 24 females did a sit up exercise while adopting an associative or dissociative strategy of attending to cues that were external or internal to result in four conditions: external association, internal association, external dissociation, and internal dissociation. The external association condition produced the lowest electromyographic activity of the abdominal muscles, the lowest heart rate, and the greatest range of movement. The internal dissociation condition produced the lowest level of exercise satisfaction. The results suggest that a focus on the effects of muscle action is the most economical and least strenuous way to exercise with sit ups and similar forms of exercise.

Keywords: attention, exercise, muscle activity, performance

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a sit-up exercise**

An ever increasing body of evidence has shown the benefits of an active lifestyle. Engaging in regular physical activity reduces the risk of several diseases (e.g., cardiovascular disease, type II diabetes, osteoporosis) and contributes to maintaining a healthy weight, healthy bone density, muscle strength, and joint mobility (Donatelle, 2005; US Department of Health and Human Services, 1999; WHO, 2002). Exercises that are specifically aimed at developing muscle strength have benefits across the lifespan (Donatelle, 2005). Strength training is important when bones are developing their peak density in adolescence and to guard against the loss of bone density and muscle mass in old age. In all ages, strength training has continuous energy-burning effects that persist for 24 hours after training. While physical factors, such as exercise duration and intensity are of obvious importance in strength training, psychological factors can also be vital. In Ives and Shelly's (2003) research on functional strength and power training, it was noted that appropriate cognitive states were needed to control the nature of the physiological effort.

Association and dissociation have been identified as two attentional states during exercise (Masters & Olges, 1998). Association involves the athlete focusing on bodily sensations critical to performance, such as muscle tension, breathing, and fatigue (Weinberg, Smith, Jackson, & Gould, 1984). Dissociation occurs when the individual blocks out sensory feedback from the body through performance distraction, for example, by listening to music or talking to others (Morgan, 1978). Association and dissociation are broad strategies; an athlete may associate or dissociate in various ways depending on the nature of the physical exercise, environmental stimuli, or the individual (Connolly & Janelle, 2003).

Stevinson and Biddle (1999) extended the distinction between association and dissociation into a two-dimensional model of task relevance and direction of attention. Task

relevance is divided between the strategies of association and dissociation. Direction of attention is also dichotomous as being either external or internal (see also Wulf, 2007). An external focus is when the performer's attention is directed towards stimuli or events outside of the body. An internal focus is induced when a performer's attention is directed towards internal cues and body states. Combining the two dimensions thus yields four modes of attentional focus: (a) external association (e.g., hitting a target, motion of bat through air), (b) internal association (e.g., muscle tension, fatigue), (c) external dissociation (e.g., scenery, other people), and (d) internal dissociation (e.g., daydreams, mental puzzles).

Performance outcomes during strength training exercises might be influenced by the task relevance and direction of attention that the individual adopts. Initial research on this question examined the direction of attention dimension within an associative strategy. Vance, Wulf, Töllner, McNevin, and Mercer (2004) measured electromyographic (EMG) activity while participants performed biceps curls with a weighted dumbbell. The participants attended to the movements of the dumbbell (external association) or on their biceps muscle (internal association). In the first experiment, movements were performed faster and EMG activity was reduced when performers adopted an external focus than an internal focus. In a second experiment, movement time was controlled through the use of a metronome and EMG activity was again reduced under external focus conditions. These findings are in line with the constrained action hypothesis (McNevin, Shea, & Wulf, 2003; Wulf, McNevin, Shea, 2001). An external associative focus promotes the use of more automatic control processes, thereby resulting in more efficient motor unit recruitment and greater economy in movement production. In contrast, an internal associative focus results in the conscious control of movements and the constraining of the motor system that would otherwise be governed by automatic control processes.

Further evidence of reduced EMG activity under an external associative attentional focus has been obtained in subsequent research. Marchant, Greig, and Scott (2008) also used a biceps curl task, but added a control condition to the internal and external association conditions employed by Vance et al. (2004). In the control condition, participants were not given any instructions on how to focus attention. The external association focus produced lower EMG activity than both the internal association and control conditions to suggest that an external association focus produces a relative reduction in muscle activity. In other experiments in which muscle activity has been measured during a goal-directed activity, lower activity with an external association focus than an internal association focus has been observed in basketball shooting (Zachry, Wulf, Mercer, & Bezodis, 2005) and dart throwing (Lohse, Sherwood, & Healy, 2010). Similar findings have also been observed in a force production task (Lohse, Sherwood, & Healy, 2011).

The effect of attentional focus on muscle activity was recently extended to a comparison between association and dissociation strategies by Neumann and Heng (2011). Participants performed a biceps curl task while listening to a song (dissociative condition), listening to a tone that varied in intensity according to the contraction of the muscle (associative condition), or under no attentional focus instructions (control). The EMG activity was lower in the associative condition than in the dissociative and control conditions. Moreover, the researchers measured heart rate (HR) and also found lower HR in the associative condition than in the other two conditions. The results suggest that the relevance of the attentional focus to the task can also influence physiological outcomes during strength training. However, it is difficult to interpret their results in the context of the prior research that has manipulated the direction of attention using an associative strategy (Vance et al., 2004; Marchant et al., 2008). It is not clear from the instructions and stimuli used by Neumann and Heng (2011) whether the association condition induced an external or internal

attentional focus or a mixture of both. The authors suggested that future research should directly manipulate the direction of attention under both an associative and dissociative strategy according to the two-dimensional model of Stevinson and Biddle (1999).

The present research follows on from the experiment reported by Neumann and Heng (2011) by investigating the effects of both task relevance and direction of attention. To further extend the results of previous studies that have largely used male participants and a biceps curl task (Marchant et al., 2008; Neumann & Heng, 2011; Vance et al., 2004), the present experiment tested female participants performing a sit up exercise. The sit up task does not involve the movement of any equipment, unlike the dumbbell in a biceps curl task. As such, the external association condition required participants to focus on the effects of the muscle action by making smooth movements. This focus is consistent with the constrained action hypothesis in that an external focus of attention is associated with more fluid and smoother movements due to the greater automaticity (Vance et al., 2004). In contrast, the internal association condition required participants to focus on the feeling of their abdominal muscles. The external dissociation and internal dissociation conditions required participants to attend to an irrelevant audiovisual recording and do mental arithmetic, respectively.

Multiple measurements were taken in the present experiment to index the physical and psychological demands associated with the different attentional focus conditions. The measures included EMG activity of the abdominal muscles, HR, movement time, range of movement, ratings of perceived exertion, and exercise satisfaction. It was hypothesized that an interaction between attentional focus strategy and direction would be found. Based on the constrained action hypothesis (McNevin et al., 2003; Wulf et al., 2001), it was expected that an external association focus would yield more efficient performance than an internal association focus (i.e., reduced EMG activity and HR). In contrast, no differences were

expected between the external dissociation and internal dissociation focus conditions due to the similar task irrelevant nature of the attentional focus.

Method

Participants

Twenty-four female first year psychology students from Griffith University volunteered for participation in exchange for partial course credit. One participant experienced back pain during the sit-up task and discontinued her participation. The remaining 23 participants had a mean age of 21.4 years (range = 17 to 43). Of the 23 participants, 11 exercised more than two times per week, 7 participants exercised twice a week, 4 once a week, and 1 participant reported not exercising on a regular basis. Informed consent was obtained before participation in compliance with the University Institutional Ethics Review board.

Apparatus

A BMR Adjustable Situp Bench 1.0 positioned at a horizontal level was used to ensure that the sit up exercise was standardized across participants. A PowerLab 16/s data acquisition system (ADInstruments, Sydney) was used to record the psychophysiological measures with a sampling rate of 1000 Hz (see Neumann & Heng, 2011; Neumann & Thomas, 2009). The PowerLab acquisition system was connected to a ML408 Dual BIO Amp/Stimulator, a ML132 BIO Amp, and MLTS700 electrogoniometer to record electromyographic (EMG) activity, electrocardiogram (ECG) activity, and movements, respectively. Surface-mounted Ag/AgCl EMG electrodes (Noraxon, Scottsdale, AZ) were attached on the chest region (one over the *manubrium* and the second over the *xiphoid* process) to measure ECG (Westbury & Neumann, 2008). Two pairs of electrodes were each placed 100 mm above the umbilicus and 30 mm to the right and left of midline to measure EMG recordings of the left and right upper *rectus abdominus* muscles as well as a grounding

electrode placed on the left hip. The EMG electrode placement allowed the measurement of the isotonic contraction, where the muscle shortens when the trunk is raised, followed by the eccentric contraction, where the muscle lengthens while developing tension. In addition, the electrogoniometer was attached to the participant's upper leg and lower torso of one side to measure the bending of the waist.

Similar to an experiment by Scott, Scott, Bedic, and Dowd (1999), audio-visual stimuli were used to promote the desired attentional focus. Audiovisual recordings were produced for each condition and presented on a desktop computer interfaced with a 15" monitor. A visual cue consisting of three arrows moving across the bottom of the screen at 1 s intervals were also displayed on the monitor throughout the audiovisual recordings to help participants pace their movements. Arrows pointing upwards were used to cue movement to the sitting position and arrows pointing downwards were used to cue movement to a horizontal starting position. In this way, each sit up was paced as 3 s to the sitting position and 3 s to the starting position.

The audiovisual recordings for the external association and internal association conditions were of a fitness trainer using the sit up bench. The trainer was given a script to repeat while performing 12 sit-ups. The fitness trainer induced an external association focus in participants by repeating the phrases "make your movements smooth" and "make your movements flow" so that there was a focus on the effects of the abdominal muscle in producing smooth repetitions. An internal association focus was induced by the fitness trainer repeating the phrases "focus on your stomach muscles", "feel the tension in your stomach muscles", and "feel your stomach muscles working" so that there was a focus on the abdominal muscles contracting. The external dissociation conditions used two separate 72 s clips from a netball match. One clip started with a view of a major semi-final netball match accompanied by narration detailing the competitive season for one of the teams (the New

South Wales Swifts). The second clip consisted of another major semi-final, which also involved the same team, with less than a minute remaining in the game. Game commentary was heard throughout both clips. The internal dissociation condition was produced by requiring participants to do mental arithmetic. To guide the arithmetic calculations for participants, the audiovisual recording showed single digits preceded by addition or subtraction signs at a rate of one every 3 s. The participant had to constantly update the answer in their memory in response to each new digit/arithmetic sign. Three sets of arithmetic strings were produced with one used for practice.

A questionnaire was developed to obtain subjective ratings and for manipulation check purposes. In the subjective rating scales, participants were asked to rate “Your level of exertion on the task” and “Your level of satisfaction with your effort” to measure perceived exertion and exercise satisfaction level, respectively. Participants rated both items on 7-point scale, ranging from 1 = *very low*, 4 = *moderate*, and 7 = *very high*. Two further questions asked “Did you execute the task as you normally would?” and “Did you try your best to follow the instructions provided?” to measure typicality of the task and adherence to the instructions. The two items were rated on a 7-point scale, ranging from 1 = *strongly disagree*, 4 = *neutral*, and 7 = *strongly agree*. In addition to these rating scales, the external dissociation condition contained two items for manipulation check purposes. The items asked “Who were the Swifts arch enemies” (for the first audiovisual recording) and “What was the Swifts score when there was under a minute remaining in the game,” (for the second audiovisual recording). In the internal association condition, participants were asked to record their answer for the arithmetic string.

Procedure

After providing informed consent, participants were screened for health reasons that may preclude their participation by using a questionnaire adapted from Sports Medicine

Australia Pre-Exercise Screening System (Sports Medicine Australia, 2005). No participants were excluded. Demographic information and exercise history was next obtained. At this point, the requirements of the task were briefly described. Participants were informed that they were required to perform eight sets each consisting of 12 sit-ups. In each set, they should focus their attention as instructed. Preparations for the physiological recordings were next made by attaching the recording electrodes and electrogoniometer. Once participants were comfortable, they were given practice on the sit-up apparatus with the visual arrow cues shown on the monitor on their own to regulate pace and for familiarization. Participants performed the sit-ups with their arms folded and held out in front of their chests to avoid interference with the ECG recordings.

Participants completed two sets of each of the four conditions of external association, internal association, external dissociation, and internal dissociation (i.e., eight sets in total). The order of the four conditions was counterbalanced across participants. Before each condition commenced, participants were given the instructions for that condition. For the external association and internal association conditions, participants were instructed to attend to a fitness trainer who would be performing sit-ups on the same equipment. It was explained that the fitness trainer would ask them to focus on making smooth movements (external association) or the abdominal muscles (internal association). For the external dissociation condition, participants were informed that they would watch a video clip from a netball game and would be asked a question about the clip. For the internal dissociation, an arithmetic string was shown for practice purposes before the actual condition. Participants were asked to mentally solve the addition and subtraction shown on the screen and that at the end of the condition they were required to give the final answer. They were also told that if they lost their spot or lost count they should continue so that a number could still be recorded at the end. After each condition was completed, a 3 minute rest period was provided to allow the

participants to recover. The participants completed the subjective rating scales during this period. The experiment was completed within 1 hour.

Data Scoring and Statistical Analyses

In accordance with Vance et al. (2004), the first and last repetitions in each set were excluded from the analysis of the EMG and electrogoniometer data because they were mechanically different from the other repetitions. Hence, only the second to eleventh repetitions were analyzed. For the EMG data, using a Butterworth low-pass filter ($F_c = 100$ Hz) with custom laboratory software (LabView, National Instruments), DC bias was removed, full-waved rectified, and raw abdominal EMG was filtered using a 30 to 500 Hz pass-band cut-off. The final amount of EMG activity for each repetition was the mean from the onset of the movement up until the offset of the movement down. The onset to offset of the movements for each repetition was calculated from the electrogoniometer recordings. Heart rate was measured using the Chart (ADInstruments, Sydney) software. The ECG signal was initially screened for artifacts. The R-peaks in the signal were identified and were used to calculate HR from the time between the onset of the first repetition until the offset of the last repetition. The recordings from the electrogoniometer were also used to measure movement time and degrees of movement for each of the second to eleventh repetitions.

An α -level of .05 was used for all analyses. Preliminary analyses indicated that repetition and set did not interact with the attentional focus factors. For this reason, subsequent analyses were averaged across all repetitions and both sets. In addition, analyses for the two EMG recording sites did not yield any significant differences as a function of the attentional focus conditions and were averaged prior to statistical analyses. The dependent measures of EMG activity, HR, movement time, degrees of movement, exercise satisfaction, level of exertion, typicality of task execution, and adherence to task instructions were examined with separate 2 (Strategy: association vs. dissociation) $\times$ 2 (Direction: internal vs.

external) repeated measures ANOVAs. Planned analyses using *t*-tests were conducted to compare the external and internal attentional focus directions separately at each strategy (association and dissociation). To examine the relationships between the measures of EMG and HR, bivariate correlations were calculated. In addition, a multiple regression was conducted to determine whether these variables predicted perceived exertion within each attentional focus condition.

Results

Psychophysiological measures

As shown in Figure 1, the mean raw EMG activity was lower in the external association condition than in the internal association condition, whereas this difference tended to be reversed for the dissociative conditions. The ANOVA yielded a main effect for Strategy, $F(1, 22) = 8.77, p = .007, \eta_p^2 = .28$, indicating that EMG activity was overall greater in the associative conditions than in the dissociative conditions. In addition, the Strategy $\times$ Direction interaction was significant, $F(1, 22) = 4.95, p = .037, \eta_p^2 = .18$. Follow up tests confirmed that EMG activity was lower in the external association condition than in the internal association condition, $t(22) = 2.40, p = .025, d = .50$, whereas there was no significant difference between the external dissociation and internal dissociation conditions, $t(22) = 1.01, p = .327, d = .21$.

Insert Figure 1 and 2 about here

The mean HR during each condition is shown in Figure 2. Unlike the raw EMG results, a main effect of Direction was found, $F(1, 22) = 5.41, p = .03, \eta_p^2 = .20$, indicating that HR was lower with an external focus than an internal focus. However, this effect tended to differ between the association and dissociation strategies as indicated by a Strategy $\times$

Direction interaction, $F(1, 22) = 3.82, p = .06, \eta_p^2 = .15$. Paired comparisons confirmed that the lower HR during an external focus than during an internal focus occurred with an association strategy, $t(22) = 5.79, p < .001, d = 1.21$, whereas there was no differences for the dissociation strategy, $t(22) = 0.21, p = .838, d = .04$.

Movement Measures

The mean movement time and degrees of movement for each repetition is shown in Table 1. No significant effects were found for movement time, all $F_s < 3.51, p > .05$. The degrees of movement differed among the conditions, as reflected in a main effect of Strategy, $F(1, 21) = 41.28, p < .05, \eta_p^2 = .65$, a main effect of Direction, $F(1, 21) = 395.82, p < .05, \eta_p^2 = .95$, and a Strategy $\times$ Direction interaction, $F(1, 21) = 217.96, p < .05, \eta_p^2 = .91$. The interaction was due to a larger range of movement in the external association condition than the internal association condition, $t(22) = 25.16, p < .001, d = 5.24$, whereas there was no significant difference between the external dissociation and internal dissociation conditions, $t(22) = 1.70, p = .103, d = 0.35$.

Insert Table 1 about here

Subjective Ratings

The mean ratings for the subjective scales are shown in Table 2. As can be seen, participants rated their level of exertion as moderate, and these ratings did not differ significantly across conditions, all $F_s < 2.39, p > .14$. However ratings of satisfaction level did differ across conditions as shown by a main effect for Strategy, $F(1, 22) = 9.78, p = .005, \eta_p^2 = .31$, a main effect for Direction, $F(1, 22) = 18.56, p < .001, \eta_p^2 = .46$, and a Strategy $\times$ Direction interaction, $F(1, 22) = 12.98, p = .002, \eta_p^2 = .37$. Further analyses indicated that ratings did not differ between the internal and external focus for the association strategy, t

(22) = 0.51, $p = .617$, $d = 0.11$, but that participants gave lower satisfaction ratings with an internal focus than an external focus when using a dissociation strategy, $t(22) = 4.93$, $p < .001$, $d = 1.04$.

The question regarding normal task execution also revealed that the internal dissociation condition was different from the other conditions. The ANOVA revealed significant main effects for Strategy, $F(1, 22) = 9.31$, $p = .006$, $\eta_p^2 = .30$, and Direction, $F(1, 22) = 16.70$, $p < .001$, $\eta_p^2 = .43$, and a Strategy $\times$ Direction interaction, $F(1, 22) = 11.42$, $p = .003$, $\eta_p^2 = .34$. Participants gave lower ratings of normal task execution when focusing internally than when focusing externally with a dissociation strategy, $t(22) = 4.45$, $p < .001$, $d = 0.93$, whereas there were no differences for the direction of attention when an association strategy was used, $t(22) = 0.13$, $p = .900$, $d = 0.03$. The final question of whether participants adhered to the task instructions resulted in mean ratings of 6.26 to 6.54 out of 7 across the conditions and indicated that participants did follow the instructions. The statistical analyses yielded no significant main effects or interactions, all $F_s < 3.64$, $p > .07$.

Insert Table 2 about here

Relationships between the measures

Bivariate correlations calculated separately for each attentional focus condition showed that EMG and HR were not significantly correlated, all $r_s < .29$, $p > .18$. However, multiple regression analyses revealed that EMG and HR significantly predicted ratings of exertion in three of the four conditions. A significant prediction was found in the internal association condition, $R^2 = .40$, adjusted $R^2 = .34$, $F(2, 20) = 6.74$, $p = .006$, with EMG activity contributing significantly to the prediction, $\beta = .43$, $p = .03$, and HR approaching significance, $\beta = .36$, $p = .06$. Similarly, in the internal dissociation condition, a significant

prediction of level of exertion was found, $R^2 = .39$, adjusted $R^2 = .33$, $F(2, 20) = 6.47$, $p = .007$. However, in this condition, HR contributed significantly to the prediction, $\beta = .49$, $p = .01$, whereas EMG approached significance, $\beta = .32$, $p = .08$. A significant prediction of exertion ratings was also found in the external dissociation condition, $R^2 = .29$, adjusted $R^2 = .22$, $F(2, 20) = 4.13$, $p = .03$, with EMG, $\beta = .49$, $p = .02$, but not HR, $\beta = .14$, $p = .47$, contributing significantly to the prediction. In contrast to the three other conditions, no significant prediction of ratings of exertion was found in the external association condition, $R^2 = .11$, adjusted $R^2 = .02$, $F(2, 20) = 1.21$, $p = .32$, using EMG activity, $\beta = .18$, $p = .41$, and HR, $\beta = .23$, $p = .32$.

Manipulation check

Finally, the participant's answers to the questions in the dissociative strategy conditions were examined. For the questions in the external dissociation condition, 19 participants answered the question for set 1 correctly and 20 participants answered the question for set 2 correctly. The results for the two arithmetic number strings in the internal dissociation conditions showed that five participants gave the correct answer for set 1 and four participants gave the correct answer for set 2. As the subjective rating scales gave support for the participants trying to do the task as asked, the low number of participants that correctly solved the task may have reflected that participants made calculation errors.

Discussion

In the present experiment, focusing attention on specific cues or stimuli influenced performance and subjective states during a sit up task. Most significantly, and consistent with the hypotheses, an interaction between the attentional focus strategy (association or dissociation) and direction of attention (external or internal) was observed. When participants attended to the movement effects of the abdominal muscles (external association), it resulted in less muscle activity than when attention was focused on the muscles themselves (internal

association). In addition, physiological effort (heart rate) was lower but the range of movement was greater in the external association condition than in the internal association and both dissociation conditions. The internal dissociation condition was rated as the least satisfying and the least typical way that participants might perform the task. Taken together, the results suggest that an external association focus promotes the efficient recruitment of muscle fibers to perform a strength training exercise task.

The constrained action hypothesis (McNevin et al., 2003; Wulf et al., 2001) suggests that an external association and internal association focus has different effects on the motor system. In the context of a strength training task, adopting an internal association focus results in individuals attempting to consciously control their movements, which disrupts the normal automatic control processes involved in making the movements. The effects of this disruption can be observed at the neuromuscular level through the measurement of EMG (Vance et al., 2004), but can be observed in other performance outcomes as shown in the present experiment. In contrast, more automatic movements result when individuals adopt an external focus during exercise. At the neuromuscular level, the benefit of an external association focus is observed as a more effective recruitment of motor units and overall lower EMG activity. The present results are consistent with this hypothesis. Moreover, the inclusion of dissociation conditions in the present experiment confirms the notion of conscious control and automaticity as being important in the reduction of EMG activity. As shown in Figure 1, EMG activity was similar between the external association and both dissociation conditions. By definition, a dissociation strategy results in attention being drawn away from the conscious control of the body during exercise. The similar EMG activity thus suggests that an external associative focus reduces control of the muscle contractions and promotes automaticity.

The external association focus also had an effect on HR. Heart rate was lower during the external association condition than in the internal association condition. Heart rate in the external association condition was also lower than both the dissociation conditions. This latter difference suggests that the external association condition influenced more than the conscious control of the movements. Further, the fact that the external association condition differed from the dissociation conditions in HR and not EMG suggests that attending to movement effects influenced aspects of performance other than the conscious control of the abdominal muscles. For example, it may have altered respiration rate and depth, postural adjustments and balance, or general bodily tension, all of which could influence HR and motor performance without necessarily having a direct influence on abdominal EMG activity. Further research that uses additional physiological and motor measures may assist in determining how a focus on movement effects can influence performance through mechanisms other than those directly involved in the motor action.

Although differences between the conditions were observed in the physiological measures, it should be noted that there were no significant differences in the subjective rating scale for physical exertion. The relatively low intensity and short number of repetitions of the sit up task may be the reason for this null finding. The small, but significant reduction of about 4 bpm that was observed in HR during the external association condition may not have been large enough to cause a change in the participant's perceptions of exertion. This explanation suggests that increasing the intensity of the task will have a larger effect of perceived exertion ratings.

Attentional focus instructions can also influence movements during a strength training exercise. Vance et al. (2004) reported that an external association focus resulted in faster repetitions with a smaller range of movement than an internal association focus during a biceps curl task. Neumann and Heng (2011) found that an association focus resulted in

slower movements than dissociation and control conditions and that the range of movement for novices was greater in a control condition than in an association or dissociation condition. Marchant et al. (2008) controlled movements through the use of a isokinetic dynamometer. In the present experiment, pacing of the sit ups was controlled through the use of visual cues (see also Vance et al., 2004 Experiment 2 in which a metronome was used). Although no significant differences across conditions in movement time were observed in the present experiment, the external association condition resulted in a larger range of movement than the other conditions. This result may be consistent with the notion of a greater automaticity being induced by an external association focus. More automatic control of movements would be expected to result in a more pronounced movements and thus greater degrees of movement.

Some prior research has not found a benefit of an external focus of attention over an internal focus (e.g., Lawrence, Gottwald, Hardy, & Khan, 2011; Poolton, Maxwell, Masters, & Raab, 2006). Using overly complex instructions for simple motor tasks (e.g., golf putting; Poolton et al., 2006) has been cited as one reason for these contradictory results (Wulf, 2007). The present experiment employed simple instructions in the sit up task and this may have facilitated seeing benefits of an external focus of attention. In other research, no benefit of an external focus was found for a gymnast routine (Lawrence et al., 2001). One explanation for this result was that an external focus of attention will benefit tasks in which movement effects involve external stimuli (e.g., the ball in golf putting or dumbbell in biceps curls) but not when movement effects have no obvious influence on the environment (e.g., gymnastics; Lawrence et al., 2011). The present sit up task is an example of the latter type of task, yet the benefits of an external attentional focus were still observed. It would thus appear that, under the right instructions or task requirements, that an external focus of attention can enhance performance during simple motor movements seen during exercise.

The relationships between the physiological measures of EMG and HR and subjective ratings of exertion were also examined in the present study. No significant correlation between EMG and HR were observed in any of the attentional focus conditions. This finding appears contrary to prior reports of a relationship between isometric muscle contraction and heart rate (e.g., Gálvez, Alonso, Sangrador, & Navarro, 2000). However, such a relationship may not hold for the relatively low intensity muscle contractions required to complete the sit up exercise. For example, Mitchell, Reeves, Rogers, Secher, and Victor (1989) reported that isometric contractions sustained for 2 minutes at only 15% of the maximal force did not produce an increase in heart rate. Nevertheless, regression analyses indicated that ratings of exertion were significantly predicted by EMG activity and HR during the internal association, internal dissociation, and external dissociation conditions. These findings are consistent with the observed relationship between HR and ratings of perceived exertion (Borg, 1982) and validate their relationship with the type of sit up exercise used in the present experiment. It is perhaps noteworthy that no relationship existed between the physiological measures and perceived exertion during the external association condition. This is the same condition that produced the most efficient recruitment of muscle fibers during the sit up exercise. Given that there were no significant differences between the conditions in ratings of perceived exertion, the results suggest that the neuromuscular benefits of the external attentional focus did not sufficiently reach focus awareness to have an influence on perceptions of exercise intensity.

In the present study, the attentional focus conditions required participants to watch a video while performing the exercise. The use of audio visual stimuli followed the method employed by Scott et al. (1999) who examined association and dissociation strategies during a rowing task. However, the requirement to watch a video may be interpreted as being a relatively weak manipulation, at least for some of the attentional focus conditions. The video became a focus of the participant's external environment. As such, some of the participant's

attention was focused on an external stimulus in all conditions. This requirement to attend to an external cue may have thus reduced the distinction with the external and internal conditions. Nevertheless, using a video in all conditions did have the benefit of increasing experimental control. It ensured that similar stimuli (audiovisual) and experimental set up were used for all the different attentional focus conditions. Thus, while some attention was directed to an external environmental stimulus in all conditions, the four conditions were still distinctive in the additional requirements of what else to focus attention on (e.g., by also attending to the abdominal muscles in the internal association condition).

The internal dissociation condition was rated as less satisfying and the most different from normal task execution than the other conditions. These results were supported by anecdotal observations during the experiment in which participants verbalised their dislike for doing the arithmetic strings in the internal dissociation condition. While this mental task may draw attention away from the sit ups, it is also a less common task than merely watching a video (external dissociation condition) or concentrating on the exercise itself (both association conditions). The novelty of the task, in addition to the difficulty of being accurate, suggests that it would not be a recommended strategy for individuals to adopt if they want to employ a strategy of dissociation. Further research could explore the use of different internal dissociation modes, such as irrelevant imagery and backwards counting.

The increasing body of evidence over the past decade that has shown the benefits of regular physical activity makes research into the area of exercise psychology a necessary and beneficial practice. Investigations of the effects of attentional focus strategies during strength training exercises will benefit from a psychophysiological approach that can measure direct performance outcomes such as activity of the muscles and the characteristics of the movements. The present experiment suggests that there can be significant benefits from adopting an external association focus in reducing the intensity of the exercise on the muscles

required and the level of heart rate. It is recommended that individuals should exercise at a moderate to high intensity level to best realize significant health benefits (US Department of Health and Human Services, 1999). An external associative focus may therefore be an adaptive strategy to use during strength training exercises like sit ups if it allows the individual to exercise at a higher intensity (e.g., perform more repetitions, perform repetitions faster) with a more economical and less strenuous use of the body.

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Table 2.

Mean movement time and degrees of movement obtained in each strategy and attentional focus direction condition (standard deviations are in parentheses).

Measure	Condition			
	External association	Internal association	External dissociation	Internal dissociation
Movement time (ms)	5166.69 (949.53)	4912.14 (1192.99)	4903.76 (1283.36)	4804.66 (1259.82)
Degrees of movement	249.33 (44.46)	163.16 (32.14)	179.42 (25.59)	173.12 (27.52)

Table 2.

Mean subjective ratings obtained in each strategy and attentional focus direction condition (standard deviations are in parentheses).

Measure	Condition			
	External association	Internal association	External dissociation	Internal dissociation
Level of exertion	4.63 (1.28)	4.67 (1.07)	4.30 (1.48)	4.43 (1.41)
Level of satisfaction	5.13 (0.74)	5.04 (0.92)	5.22 (0.93)	4.09 (1.09)
Normal execution of task	5.39 (1.26)	5.36 (1.37)	5.41 (1.29)	4.28 (1.622)
Adherence to instructions	6.52 (0.75)	6.50 (0.74)	6.54 (0.62)	6.26 (0.99)

Figures

Figure 1. Mean electromyographic (EMG) activity as a function of the strategy (association and dissociation) and direction (external and internal) of the attentional focus. Error bars depict the standard error of the mean.

Figure 2. Mean heart rate (HR) as a function of the strategy (association and dissociation) and direction (external and internal) of the attentional focus. Error bars depict the standard error of the mean.