Title: Examining Movement Specific Reinvestment and Performance in Demanding Contexts

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Introduction

The Theory of Reinvestment (Masters & Maxwell, 2008; Masters, Polman, & Hammond, 1993), Constrained Action Hypothesis (Wulf, McNevin, & Shea, 2001) and Explicit Monitoring Theory (Beilock & Carr, 2001) have been developed to explain the role of conscious processing in motor learning and performance. With respect to skilled performance, these theories propose that directing attention to movements can impair performance. The Theory of Reinvestment, which is the main focus of this paper, proposes that certain contingencies (e.g., psychological pressure, movement errors) can cause individuals to use task relevant knowledge acquired earlier in learning to attempt to consciously monitor and control automated movements, which can lead to impaired performance (Masters & Maxwell, 2008). For example, when preparing for an important putt a skilled golfer might attempt to consciously control the correct force with which to hit the ball, an aspect that may be better controlled automatically.

An individual's propensity for reinvestment can be quantified using the Reinvestment Scale (RS) (Masters et al., 1993) or a more recent scale that specifically relates to movement, the Movement Specific Reinvestment Scale (MSRS) (Masters, Eves, & Maxwell, 2005). Both scales have been shown to identify individuals who are more likely to reinvest (Chell, Graydon, Crowley, & Child, 2003; Jackson, Ashford, & Norsworthy, 2006; Jackson, Kinrade, Hicks, & Wills, 2013; Malhotra, Poolton, Wilson, Ngo, & Masters, 2012; Masters et al., 1993; Maxwell, Masters, & Poolton, 2006). Moreover, the scores on the RS have been shown to positively correlate with amount of task relevant knowledge accumulated and negatively correlate with performance under pressure (Maxwell et al., 2006; Poolton, Maxwell, & Masters, 2004).

Development of the MSRS revealed two factors, suggesting that movement specific reinvestment represents two different dimensions of conscious processing. Conscious motor processing reflects a tendency to consciously control the mechanics of movements, whereas movement self-consciousness reflects a tendency to monitor 'style' of movement (Masters et al., 2005). It has been proposed that movement self-consciousness describes conscious monitoring (conscious attention is directed to movements without an intention to control movements) and conscious motor processing describes conscious control (Malhotra, Poolton, Wilson, Omuro, & Masters, 2015). Jackson et al. (2006) made a conceptual distinction between two modes of conscious processing during movement, in which conscious monitoring of movement can occur independently from conscious control of movement. For example, under normal circumstances a golfer might monitor a certain aspect of movement (e.g., pay attention to the putter face angle), but following a missed putt she/he might attempt to control this aspect of the movement during subsequent putts (e.g., consciously attempt to keep the putter face angle square to the ball). Jackson et al. (2006) suggested that the degree to which either behavior occurs is dependent on the performance context and/or task complexity.

Previous work by Malhotra and colleagues suggests that the demanding nature of a motor task is likely to determine when conscious monitoring and control occur. Malhotra, Poolton, Wilson, Fan, and Masters (2014), for example, found that movement self-consciousness was positively associated with completion times of a relatively less demanding laparoscopic task[1] during practice. On a more demanding laparoscopic task[2] (cross-handed laparoscopy), however, conscious motor processing was positively associated with completion times. Additionally, Malhotra et al. (2015) found that when task demands were higher, in early-practice, both movement self-consciousness and conscious motor processing were positively associated with performance. However, later in practice when the task was presumably less demanding, movement self-consciousness was positively associated with performance. Analysis of the underlying kinematic mechanisms suggested that individuals with higher scores on both dimensions of movement specific reinvestment displayed lower variability of impact velocity and putter face angle, which culminated in better performance. It was argued that a higher propensity for movement self-consciousness potentially conferred superior ability to utilize exteroceptive and kinesthetic feedback to assess the discrepancy between actual and desired levels of performance (Schmidt, 2008), whereas, a higher propensity for conscious motor processing conferred superior ability to adapt movements to achieve success.

One factor that could determine whether movement self-consciousness will positively (Malhotra et al., 2015) or negatively (Malhotra et al., 2014) impact performance is the situational context. Participants in the Malhotra et al. (2014) study were medical students who may have placed high importance on looking like a surgeon when performing the laparoscopic task, and thus performed slower

[1] Laparoscopy is a minimally invasive surgical procedure that requires the insertion of surgical instruments through small incisions in the relevant area of the patient's body (Hunter & Sackier, 1993).

[2] Performance of the cross-handed laparoscopic surgery task was perceived as more mentally and physically demanding (measured using the SURG-TLX scale; Wilson et al. (2011) than the standard laparoscopic surgery task.

under high task demands. Conversely, participants who performed novel tasks in the Malhotra et al. (2015) study might have perceived the learning process as motivational, rather than demanding, which would explain the positive impact of movement self-consciousness on performance.

Taken together, these findings suggest that movement self-consciousness can be evoked in both more and less demanding performance contexts, whereas, conscious motor processing is more likely to be evoked in situations that raise performance demands. There is very limited research, however, that has examined how the dimensions of movement specific reinvestment interact to influence performance under particularly demanding contexts like psychological pressure. For example, Huffman, Horslen, Carpenter, and Adkin (2009) examined the role of both dimensions in a pressure context. Inducing postural threat by asking individuals to stand on a raised platform evoked movement self-consciousness (concern for posture) and conscious motor processing (conscious control of posture), which resulted in changes in posture (i.e., leaning further away from the edge of the platform). Therefore, it might be expected that under pressure a high propensity to consciously monitor and control relatively well-practiced movements can disrupt performance by interfering with normally automated motor processes.

The main aim of the current research was to further our understanding of how both dimensions of movement specific reinvestment influence skilled motor performance under demanding conditions. The two experiments presented in this paper examined the differential roles of movement self-consciousness and conscious motor processing in a golf-putting task under pressure (Experiment 1) and in a quiet standing task under relatively low and high attention demands (Experiment 2).

Experiment 1

In Experiment 1, we asked trained participants to perform a golf-putting task under a more demanding high-anxiety condition (i.e., financial incentive) and a less demanding low-anxiety condition. It has been suggested that overall performance outcome measures (e.g., hit or miss) might be too crude to reveal changes associated with conscious processing (Pijpers, Oudejans, Holsheimer, & Bakker, 2003) so kinematic measures were assessed alongside putting proficiency to gain a better understanding of the mechanisms that underpin each dimension of movement specific reinvestment. Movement variability was used as a kinematic measure to examine if a predisposition for movement self-consciousness and/or conscious motor processing leads to more or less consistent putting characteristics. Given that putting success on a flat surface is primarily determined by magnitude of force and putting direction, variability (*SD*) of impact velocity and putter face angle at impact (determines 80% of direction of putting stroke; Karlsen, Smith, & Nilsson, 2008) were chosen as the main kinematic measures (Malhotra et al., 2015; Pelz, 2000; Sim & Kim, 2010).[3]

Overall, psychological pressure induced by the high-anxiety condition was expected to heighten levels of perceived anxiety and result in impaired performance. However, both Processing Efficiency Theory (PET) (Eysenck &

[3] Although recent research has discussed whether movement variability is functional or dysfunctional for performance (Bradshaw et al., 2009; Land & Tenenbaum, 2012; Lohse, Sherwood, & Healy, 2010), this is an issue that is beyond the scope of the current paper.

Calvo, 1992) and Attentional Control Theory (ACT, Eysenck, Derakshan, Santos, & Calvo, 2007) propose that anxiety might also serve a motivational role, increasing the allocation of on-task supplementary processing resources (i.e., effort) that maintain performance effectiveness. While it is not entirely clear what these theories meant by 'effort' (Edwards, Kingston, Hardy, & Gould, 2002; Hardy, Mullen, & Jones, 1996), allocation of additional processing resources to a task does not necessarily guarantee that performance is maintained under pressure; increased effort may lead to conscious motor processing as predicted by the Theory of Reinvestment, in which case performance should be disrupted (Cooke, Kavussanu, McIntyre, & Ring, 2010; Edwards, Kingston, Hardy, & Gould, 2002; Wilson, Smith, & Holmes, 2007). In order to understand the relationship between effort, movement specific reinvestment and performance under pressure, we also incorporated a measure of perceived effort in this study.

Consistent with Malhotra et al. (2015), we expected that the less demanding, low-anxiety condition would evoke movement self-consciousness rather than conscious motor processing. Specifically, it was predicted that movement self-consciousness would be positively associated with putting proficiency. However, the high-anxiety condition was expected to evoke both movement self-consciousness and conscious motor processing (Huffman et al., 2009). In particular, propensity to consciously monitor (movement self-consciousness) and control (conscious motor processing) movements was expected to disrupt relatively automated movements.

Kinematic measures were assessed on an exploratory basis and thus no a priori predictions were made with regard to these measures. A high propensity for consciously controlling movements (i.e. conscious motor processing) might lead to 'constraining' (reduced variability) of the motor system (McNevin, Shea, & Wulf, 2003), such that high scorers on this dimension might display reduced variability of movements. Alternatively, if a high propensity for conscious motor processing leads to conscious control of movements (i.e., making adjustments to movements to achieve optimal performance), we might expect high scorers on this dimension to display greater variability of movements. Given our limited understanding of the mechanisms that underpin movement self-consciousness, it was difficult to make concrete predictions with respect to its relation to kinematic mechanisms.

Methods[4]

Participants

Thirty undergraduates (16 males, 14 females; age: *M* = 20.48, *SD* = 1.38 years) from [redacted] volunteered to participate in this study. All participants were novice golfers with no official golf handicap. Ethical approval for the study was provided by the Institutional Review Board and written informed consent was obtained from all participants.

Apparatus

Participants used a standard golf putter (length 89 cm) to putt golf balls to a standard size hole (10.80 cm) from a distance of 2 m. The experiment was conducted on an artificial indoor putting green with a hole located 0.72 m from the end of the putting green. Kinematics of the putter were acquired using a three dimensional ultrasound SAM PuttLab system (SAM PuttLab, Science Motion GmbH, Munich, Germany, www.scienceandmotion.de;Land, Tenenbaum, Ward,

[4] Portions of the data (learning trials) were used in a previous study (Malhotra et al., 2015)

& Marquardt, 2013; Toner & Moran, 2011), which has an overall sampling frequency of 210 Hz.

Psychological Measures

Participants completed the Movement Specific Reinvestment Scale (MSRS) before attending the training session. The MSRS comprises two subscales (5 items each) that assess conscious motor processing and movement self-consciousness. The movement self-consciousness (MS-C) subscale includes items, such as, “I am concerned about my style of moving” and the conscious motor processing (CMP) subscale includes items, such as, “I am aware of the way my body works when I am carrying out a movement”. Each item is rated on a 6 point Likert scale (1 = strongly disagree to 6 = strongly agree) such that the scores range from 5-30 points for each subscale. The MSRS has acceptable test-retest reliability and internal consistency: MS-C (r = .67, Cronbach’s α = 0.78) and CMP (r = .76, Cronbach’s α = 0.71).

Effort

The NASA Task Load Index (NASA-TLX) is a multi-dimensional scale that has been used to measure workload in human factors research (Hart & Staveland, 1988). It comprises six bi-polar dimensions that measure mental demands, physical demands, temporal demands, own performance, effort and frustration. In this experiment we only report scores from the effort dimension (i.e., how hard did you have to work to accomplish your level of performance?) Responses to the effort scale are made on a 20 point Likert scale anchored between very low and very high.

State Anxiety

State Anxiety was measured using the short version of the State Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992). This scale has acceptable internal consistency (Cronbach's α = 0.82). The six item Likert scale (1= Not at all to 4 = Very much so) requires participants to respond to items like "I feel calm" and "I feel tense". Scores range from 6-24 points.

Kinematic Measures

The SAM PuttLab system was used to measure between-putt variability (*SD*) of putter face angle at impact and impact velocity for the low-anxiety and high-anxiety conditions.

Performance Outcome Measures

Putting proficiency was measured on the basis of number of putts successfully holed in the low-anxiety and high-anxiety conditions.

Procedure

Participants completed the MSRS before attending two training sessions held on separate days. Participants were offered a financial incentive of [redacted]$1 per successful putt with an opportunity to earn a maximum of [redacted]$300, in order to keep the levels of motivation high throughout learning and as a precursor to our anxiety manipulation. On Day 1, participants completed 10 putts to familiarize themselves with the task after which they putted 20 blocks of 10 putts each. On Day 2, participants completed 10 blocks of 10 putts each. After completion of training, participants were informed about the amount of money they earned and then they were provided a 15 min rest and invited back for a testing phase. In the testing phase participants performed 10 putts each in a low-anxiety and a high-anxiety condition. In the low-anxiety condition participants were simply asked to try their best. In the high-anxiety condition participants were informed that it was crucial that they putted as accurately as possible as each missed putt would result in a loss of 10 percent of their earnings and missing all the putts would result in a loss of their entire earnings. The high-anxiety condition always followed the low-anxiety condition (not counterbalanced) because it was expected that participants would be unmotivated during performance in the low-anxiety condition if it followed a condition linked to a financial incentive.

Participants were required to complete the STAI scale after receiving the instructions and before making the putts in each of the anxiety-provoking conditions. Upon completion of the 10 putts participants were asked to complete the NASA-TLX scale.

Data Analysis

A multivariate analysis of variance (MANOVA) was conducted to assess the impact of anxiety conditions (low-anxiety and high-anxiety) on psychological (STAI and effort), putting proficiency (number of putts successfully holed) and kinematic (*SD* impact velocity and *SD* putter face angle at impact) measures, followed by separate univariate ANOVA’s for each variable.

Pearson’s product moment correlation coefficients were conducted in order to assess the associations between the MS-C, CMP dimensions and putting proficiency, *SD* impact velocity and *SD* putter face angle at impact. Significant correlations were followed up by separate standard linear multiple-regressions.

The associations were checked for linearity and homoscedacity and a visual examination of standard scatterplots verified that there were no violations of these assumptions. Bivariate correlations of the two predictor variables (r = .580) suggested that they did not have a very strong linear relationship but to ensure that this correlation did not affect the regression analysis, collinearity diagnostics were calculated. The variance inflation factor and tolerance statistics indicated that the assumption of multi-collinearity was not violated. The data were checked for outliers using Cook's distance and none of the cases were found to exert undue influence over the parameters of the model.

Results

The repeated measures MANOVA revealed a significant multivariate effect of condition (low-anxiety/high-anxiety), $F(5, 25) = 7.91$, $p < .001$, $\eta^2_p = .61$. Separate univariate ANOVA's revealed a significant effect of condition on state anxiety, $F(1, 29) = 16$, $p < .001$, $\eta^2_p = .36$, effort, $F(1, 29) = 9.86$, $p = .004$, $\eta^2_p = .25$, and *SD* putter face angle at impact, $F(1, 29) = 12.18$, $p = .002$, $\eta^2_p = .30$, but not on *SD* impact velocity, $F(1, 29) =1.35$, $p = .254$, $\eta^2_p = .05$, or on putting proficiency $F(1,29)= 0.94$, $p = .340$, $\eta^2_p = .03$. State anxiety scores were significantly higher in the high-anxiety (*M* = 14.20, *SD* = 3.74) compared to the low-anxiety (*M* = 11.50, *SD* = 2.42) condition. Perceived effort was higher in the high-anxiety (*M* = 12.87, *SD* = 4.61) compared to the low-anxiety (*M* = 10.97, *SD* = 4.40) condition. *SD* putter face angle at impact was lower in the high-anxiety (*M* = 1.16, *SD* = 0.57) than the low-anxiety condition (*M* = 1.48, *SD* = 0.62).

Descriptive data and Pearson's correlation coefficients between MS-C, CMP and putting proficiency and kinematic measures are presented in Table 1. MS-C was positively correlated with putting proficiency ($p = .016$) and negatively correlated with *SD* impact velocity (p = .041) in the low-anxiety condition but in the high-anxiety condition it was not significantly correlated with putting proficiency (p = .303), *SD* impact velocity (p = .334) or *SD* putter face angle at impact (p = .161). CMP was not significantly associated with putting proficiency, *SD* impact velocity or *SD* putter face angle at impact in the low-anxiety or high-anxiety conditions (p's > .05).

Given that the only significant correlations were between the MS-C dimension of movement specific reinvestment, and putting proficiency and *SD* impact velocity, multiple regressions were only carried out for these variables. Table 2 presents the model statistics, beta coefficients, t statistics and squared semi-partial correlations for the regression analyses predicting putting proficiency and *SD* impact velocity from MS-C and CMP during the low-anxiety condition. The overall multiple regression model for predicting putting proficiency in the low-anxiety condition explained 20.2% of the variance, $F(2, 27) = 3.42$ $p = .047$ (see Table 2a). MS-C made a significant contribution to the model and uniquely explained 17.6 % of variance in putting proficiency, $t(27) = 2.44$, $p = .021$. Higher scores on the MS-C subscale were associated with greater putting proficiency. CMP made no significant contribution to the model, $t(27) = -0.65$, $p = .519$. The overall multiple regression model for predicting *SD* impact velocity in the low-anxiety condition was not significant, $F(2, 27) = 3.01$ $p = .117$ (see Table 2b).

Discussion

In line with previous studies, our experimental manipulation raised levels of perceived anxiety and effort in high-anxiety compared to low-anxiety conditions (Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011; Mullen & Hardy, 2000; Wilson, Chattington, Marple-Horvat, & Smith, 2007). However, anxiety had no effect on putting proficiency. Although these findings are not consistent with our predictions, previous studies have found that anxiety doesn't always impair putting performance (Cooke et al., 2011; Mullen & Hardy, 2000). Additionally, anxiety resulted in participants demonstrating lower variability of putter face angle but anxiety did not affect variability of impact velocity.

Movement self-consciousness was positively associated with putting proficiency under low-anxiety conditions and there was a trend for it to be associated with lower variability of impact velocity. It has been previously suggested that movement self-consciousness may confer a state of heightened awareness in which individuals with a high propensity are better able to utilize feedback to assess current states of performance (Malhotra et al., 2015). Conscious motor processing was not associated with performance under low-anxiety conditions. This is not surprising, given that reinvesting task relevant knowledge in the control of movements (i.e., conscious motor processing) is more likely to occur in situations that raise performance demands (for a list of contingencies that can cause reinvestment, see Masters & Maxwell, 2008), rather than in neutral situations (i.e., the low-anxiety condition in our study).

Demanding contexts that emphasize the need to perform well are expected to evoke conscious control of movements (Huffman et al., 2009), but our findings revealed that conscious motor processing was not associated with putting proficiency or movement variability during the high-anxiety conditions. The Theory of Reinvestment (Masters & Maxwell, 2008) argues that anxiety provoking situations have potential to evoke conscious control of movements, which inadvertently leads to '*deautomatization*' of the movement. Thus, the effect of conscious motor processing is more prominent for skills that are at least partially automated (Deikman, 1966; Ford, Williams, & Hodges, 2005). Participants in our study might not have had partially automated movements. However, given that previous studies (Maxwell et al., 2006) have demonstrated the debilitative effects of reinvestment on golf putting performance following a similar number of practice putts this should not be the case. Another possibility is that the anxiety manipulation in this study was not severe enough to evoke conscious motor processing.

Although the performance context might not have been demanding enough to evoke conscious control of movements, it might still be expected to encourage conscious monitoring of movements (Huffman et al., 2009), but our findings suggest otherwise. Movement self-consciousness was not associated with putting proficiency or movement variability under conditions that heightened anxiety. Why did the low-anxiety condition, but not the high-anxiety condition, potentially evoke conscious monitoring?

In the current study, participants experienced increased levels of perceived anxiety and effort yet maintained their level of performance. These findings are in line with Processing Efficiency Theory (PET, Eysenck & Calvo, 1992) and Attentional Control Theory (ACT, Eysenck et al., 2007), which propose that anxiety might also serve a motivational role, increasing the allocation of on-task supplementary processing resources (i.e., effort) to maintain performance. Thus, it is possible that the participants were left with no spare attentional resources for movement self-consciousness. It has been suggested that the act of ‘reinvesting’ can draw upon attentional resources of the working memory system; a limited capacity attention system that temporarily stores and manages information (Buszard, Farrow, Zhu, & Masters, 2013; Lam, Masters, & Maxwell, 2010).

Consequently, Experiment 2 sought to investigate the role of attention demands on movement self-consciousness.

Experiment 2

The findings from Experiment 1 suggested that raised levels of anxiety caused participants to allocate supplementary processing resources (i.e., effort) to the task, leaving them with few attention resources for movement self-consciousness. Experiment 2 was conducted to examine the role of attention demands on movement self-consciousness.

Participants were asked to perform quiet standing on a force platform when attention demands were low (i.e., single-task condition) and when attention demands were high (i.e., dual-task condition). Dual-tasking was expected to make demands of working memory resources that were similar to the demands made by anxiety and effort.

We employed a quiet standing (balance) task for two main reasons. First, the use of a fundamental movement skill, such as balance, ensured that participants would be equally competent at the task, without the need for lab-based training. Second, a closed motor skill in which the goal is the movement itself was likely to evoke movement self-consciousness. The ability to balance is the basis of human movements and has commonly been regarded as one of the most automatic motor skills; however, research has revealed that this fundamental motor skill does indeed demand attention (Lajoie, Teasdale, Bard, & Fleury, 1993).

Consistent with Experiment 1, we expected that movement self-consciousness would be positively associated with performance in the single-task.

Specifically, a high propensity for movement self-consciousness was expected to enable individuals to more effectively monitor their stance to ensure fewer movements. However, the dual-task condition was expected to consume working memory resources (in a similar manner to anxiety) that would normally be available for movement self-consciousness; consequently, we expected that performance in the dual-task condition would not be associated with movement self-consciousness. Performance of a fundamental movement skill in a non-demanding environment was not expected to encourage conscious intervention in the control of movements. Hence, we did not expect conscious motor processing to influence performance in single- or dual-task conditions.

Methods

Participants

Fifty-two healthy undergraduate students (27 males, 25 females; age *M* = 20.94, *SD* = 2.55 years) participated in the study for course credits. Ethical approval for the study was provided by the Institutional Review Board and written informed consent was collected from each participant.

Apparatus

A force platform (Zebris FDM-S 1.5, Medical GmbH, Germany; 55cm x 40cm x 2.1 cm; 50 Hz sampling rate) was used to measure postural stability during quiet standing under single- and dual-task (tone-counting) conditions. The force platform was positioned approximately 1 m away from the wall. LabVIEW Application Builder 2010 (National Instruments Inc.) was used to create an application for the tone-counting task. The high-pitched (1000 Hz) and low-pitched (500 Hz) tones were presented in a randomized order with a frequency of 1 s from speakers connected to a HP Pavilion laptop.

Measures

Similar to Experiment 1, participants were asked to complete the Movement Specific Reinvestment Scale (MSRS) before attending the study. It has been suggested that the use of multiple postural stability measures can complicate the interpretation of data (Fraizer & Mitra, 2008), so we examined only variability of center of pressure in medio-lateral (*SD*x) and anterior-posterior planes (*SD*y). These measures have been widely used as postural sway measures and have shown effects with regard to quiet standing performance under cognitive dual-task conditions (Riley, Baker, & Schmit, 2003; Riley, Baker, Schmit, & Weaver, 2005) and were automatically calculated by the software program (WinFDM).

The tone-counting task required participants to monitor high- and low-pitched tones and subsequently report the number of high-pitched tones presented during a 1 min period of quiet standing on a force platform. The tone-counting task has been shown to be sufficiently demanding and to hinder the use of working memory in controlling the primary motor task (e.g., Maxwell, Masters, & Eves, 2003; Maxwell, Masters, Kerr, & Weedon, 2001).

Procedure

Participants were required to perform two quiet standing tasks (60 s each) on a force platform. The instructions for the single-task condition were “Stand as still as possible”.[5] Instructions for the dual-task condition were “Stand as still as possible and count the number of high-pitched tones”. The tone-counting task was

[5] We acknowledge that these instructions evoke an internal focus of attention, but the same instructions were given in the dual-task condition as well so we think this is of no consequence.

introduced and practiced before participants performed the balance tasks. If participants' responses varied by greater than +/- 5 tones from the actual number of tones presented, they were asked to perform the task again. None of the participants needed more than two practice trials.

Data analysis

Balance performance under single- and dual-task-conditions was compared using repeated measures MANOVA. Significant results were followed up by separate univariate ANOVAs. Pearson's product moment correlation coefficients were conducted to assess associations between all measures. Separate standard linear multiple regression analyses were conducted to follow up significant correlations between movement self-consciousness (MS-C), conscious motor processing (CMP) and the performance measures. Statistical significance was set at $p < .05$ for all tests. The assumptions of linearity, homoscedacity and multicollinearity were checked for violations. Cook's distance was used to check the data for outliers. None of the cases were found to exert undue influence on the model.

Results

Overall tone-counting proficiency, computed as absolute percentage proficiency between the reported and actual number of high-pitched tones presented (Maxwell et al., 2001), was 97.8 (*SD* = 3.92).

The repeated measures MANOVA of postural sway variables revealed a non-significant multivariate effect of condition, $F(2, 50) = 4.11$, $p = .022$, $\eta^2p = .14$. Follow up univariate analysis revealed that sway variability in the anterior-posterior direction was significantly higher in the dual-task than the single-task condition $F(1,51) = 7.25$, $p = .010$. $\eta^2p = .13$. There was no significant difference for the sway variability in the medio-lateral direction between conditions, $F(1,51) = 2.72$, $p = .105$, $\eta^2p = .05$.

Pearson's correlation coefficients between the performance measures and MS-C and CMP are presented in Table 3. The results show a significant correlation between CMP and MS-C ($r = .56$, $p = .001$). MS-C correlated negatively with single-task sway variability in the medio-lateral direction ($r = -.35$, $p = .012$), but not with dual-task sway variability. No significant correlations were found between MS-C and sway variability in the anterior-posterior direction (*SD*y) and CMP was not significantly correlated with either of the sway variability measures in single-task or dual-task conditions (p's > .05).

Given that the only significant correlations were between the MS-C dimension of movement specific reinvestment and sway variability in the medio-lateral direction in the single-task condition, multiple regression analyses were only carried out for these variables. The model statistics, beta coefficients, *t* statistics and squared semi-partial correlations for the regression analysis predicting sway variability in the medio-lateral direction in the single-task condition are presented in Table 4. The overall multiple regression model for predicting sway variability in the medio-lateral direction in the single-task condition explained 12% of the variance, $F(2, 51) = 3.33$, $p = .044$. MS-C made a significant contribution to the model and uniquely explained 8.8 % of variance, $t(51) = -2.21$, $p = .032$. Higher scores on the MS-C subscale were associated with lower sway variability in the medio-lateral direction. CMP did not significantly contribute to the model, $t(51) = 0.14$, $p = .887$.

Discussion

The main aim of this study was to examine the role of attention demands on movement self-consciousness. The high levels of tone-counting accuracy suggested that participants complied with the dual-task instructions. Consistent with previous research (Shumway-Cook & Woollacott, 2000; VanderVelde, Woollacott, & Shumway-Cook, 2005), quiet standing performance was not affected by the dual-task.

Movement self-consciousness was positively associated with quiet standing performance under the single-task condition. Participants with a higher propensity for movement self-consciousness displayed lower sway variability in the medio-lateral direction. The anatomical makeup of the lower limbs results in greater sway variability in the anterior-posterior direction during quiet standing (Mochizuki, Duarte, Amadio, Zatsiorsky, & Latash, 2006) which might have made it easier for participants to monitor sway in the medio-lateral direction. When participants were asked to perform under the attention demanding dual-task condition, however, movement self-consciousness no longer influenced sway variability. These findings support the proposition that the lack of influence of movement self-consciousness under the high-anxiety condition in Experiment 1 was due to the attention demanding nature of anxiety. Conscious motor processing has been shown to influence quiet standing performance in demanding environments (i.e., postural threat) that are likely to encourage conscious control of movements (Huffman et al., 2009), but in non-demanding environments it was not expected to evoke conscious control of movements and our findings revealed that this was the case.

General Discussion

The Theory of Reinvestment is one of the established explanations for why performance decrements occur under pressure. The conceptual advancement of reinvestment (to movement specific reinvestment) has led to the emergence of two dimensions of personality that are expected to influence performance of different tasks and possibly under different circumstances. In Experiment 1, we examined the roles of the two dimensions of movement specific reinvestment in a more demanding high-anxiety condition (i.e., financial incentive) and a less demanding low-anxiety condition. Conscious motor processing did not influence performance under either low-anxiety or high-anxiety conditions. The influence of movement self-consciousness was evident in the low-anxiety but not the high-anxiety condition. Experiment 2 was carried out to examine the role of attention demands on movement self-consciousness.

Consistent with the findings of Malhotra et al. (2015), the results from Experiment 1 revealed that participants with a higher propensity for movement self-consciousness displayed greater putting proficiency in the low-anxiety condition. Although the anxiety manipulation in our study raised levels of perceived anxiety, it did not disrupt putting proficiency. In accordance with PET and ACT (Eysenck, 1992; Eysenck et al., 2007), increased anxiety was accompanied by increased effort and maintained performance which suggests that effort probably depicted allocation of supplementary processing resources to the task. While researchers have suggested that increased effort may at times lead to conscious processing (Edwards et al., 2002; Eysenck et al., 2007), our findings suggest that such a process did not occur in this instance. Other factors, such as the severity of anxiety or motivation, might determine when effort leads to conscious motor processing.

In Experiment 2, participants were asked to perform a quiet standing task while concurrently performing an attention demanding dual-task. Movement self-consciousness positively influenced performance on the quiet standing task in the single-task condition but its influence was diminished in the more demanding dual-task condition. While balance has been considered to be an automatic motor skill, there is some evidence to suggest that it does indeed require some amount of attention (Lajoie et al., 1993). A quiet standing task in which the goal is the movement itself was very likely to result in self-focused attention and possibly evoke movement self-consciousness. Given that the goal of the task was to consciously monitor movements (stand as still as possible) it is not surprising that participants with a higher propensity to consciously monitor their movements (high movement self-conscious participants) performed better. These findings are congruent with the acclimatization hypothesis (Baumeister, 1984), which suggests that individuals should perform better in situations that evoke their normal behaviour. In the dual-task condition, however, participants were no longer able to be movement self-conscious. The performance of a concurrent tone-counting task seemed to reduce the attention capacity available for movement self-consciousness. Previous literature has suggested that reinvestment is an attention demanding process (Buszard et al., 2013; Lam et al., 2010) and this study lends support to this proposition, specifically with regard to movement self-consciousness.

Our study is not without its limitations. The anxiety manipulation in Experiment 1 did not disrupt performance. It is possible that training with a monetary incentive might have evoked a certain level of anxiety that acclimatized performers to anxiety provoking conditions (Baumeister, 1984). However, this seems unlikely as participants reported increased levels of anxiety from low to high anxiety conditions. Researchers have raised concerns about the difficulties associated with evoking anxiety in laboratory settings that is comparable to real world settings (Williams, Vickers, & Rodrigues, 2002). Future work that examines the influence of the two dimensions of movement specific reinvestment on performance needs to be carried out in more ecologically valid settings. Although impact velocity and putter face angle at impact are the most crucial stroke parameters that determine putting success on a flat surface (Pelz, 2000; Sim & Kim, 2010), it is possible that they do not adequately reflect the processes underpinning conscious motor processing and movement self-consciousness. While some studies have been successful in identifying changes in movement patterns that may reflect conscious processing (Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; Pijpers, Oudejans, & Bakker, 2005; Pijpers et al., 2003) others (Mullen & Hardy, 2000) have failed to do so. This remains an issue to be tackled by future studies. With regard to kinematics, another limitation is that the variability measure might have been somewhat confounded by performance as better performance may result in lower variability as a consequence of not requiring to correct movements. Similarly, in Experiment 2 we did not measure muscle activity during the quiet standing task, which might have provided more information about the mechanisms that underpin movement self-consciousness (Weinberg & Hunt, 1976).

While previous research has shown that conscious control of movements can potentially impair skilled performance (Beilock, Carr, MacMahon, & Starkes, 2002; Gray, 2004; Masters et al., 1993; Maxwell et al., 2006), our results show that a high propensity for conscious monitoring of movements (not necessarily control) might be beneficial. Movement self-consciousness appears to be a desirable trait that is positively associated with performance on a variety of tasks; however, this only holds true in non-attention demanding contexts. Previous studies have implied that the propensity for movement self-consciousness is not immutable (Wong, Masters, Maxwell, & Abernethy, 2008), suggesting that it can be trained. A possible way to train movement self-consciousness could be through ‘associative training’ (Shusterman, 2011; Toner & Moran, 2014) in which a performer is made aware of the proprioceptive feelings associated with different movements. Future work is required to empirically verify the effectiveness of associative training in sport contexts.

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Table 1.
Descriptive data and correlation coefficients among all measures

		M	*SD*	1	2	3	4	5	6	7	8	9	10
1.	MS-C	20.10	3.85										
2.	CMP	20.47	4.02	.58**	-								
	Low-Anxiety												
3.	Putting Proficiency	6.27	2.53	.44*	.16	-							
4.	*SD* Impact velocity	89.90	42.82	-.38*	-.15	-.19	-						
5.	*SD* Putter face angle at impact	1.48	0.62	-.29	-.30	-.38*	.17	-					
	High-Anxiety												
6.	Putting Proficiency	6.70	2.02	.19	-.07	.44*	-.10	-.31	-				
7.	*SD* Impact velocity	82.07	38.04	-.18	-.11	-.21	.59**	.29	-.30	-			
8.	*SD* Putter face angle at impact	1.16	0.57	-.26	-.26	-.26	.25	.65**	-.26	.39*	-		

***$p < .001$, **$p < .01$, * $p < .05$
MS-C, movement self-consciousness; CMP, conscious motor processing

Table 2.
Multiple regression analysis predicting (a) putting proficiency and (b) *SD* impact velocity from MS-C and CMP during the low-anxiety condition

		Variables	β	t	sr^2_{unique}	
		Low-Anxiety				
a.	Putting Proficiency	MS-C	0.34	2.44^{*}	.18	
		CMP	-0.09	-0.65	.01	
			Intercept = 1.24			
						$R^2 = .202$
						$R^2_{adj} = .143$
						$R = .450^{*}$
b.	*SD* Impact Velocity	MS-C	-4.81	-1.99	.13	
		CMP	1.07	0.46	.01	
			Intercept = 164.61			
						$R^2 = .147$
						$R^2_{adj} = .084$
						$R = .383$

***$p < .001$, **$p < .01$, * $p < .05$
MS-C, movement self-consciousness; CMP, conscious motor processing

Table 3.
Descriptive data and correlation coefficients among all postural stability measures

	M	*SD*	1	2	3	4	5	6
1. MS-C	20.02	4.52						
2. CMP	20.52	4.16	.56**	-				
3. *SD* of M/L sway, mm (ST)	21.28	13.32	-.35*	-.18	-			
4. *SD* of M/L sway, mm (DT)	19.28	12.71	-.21	-.17	.78**	-		
5. *SD* of A/P sway, mm (ST)	30.50	17.09	.04	-.01	.09	.14	-	
6. *SD* of A/P sway, mm (DT)	35.59	17.17	-.06	-.10	.15	.08	.68**	-

***$p < .001$, **$p < .01$, * $p < .05$
MS-C, movement self-consciousness; CMP, conscious motor processing
M/L, medio-lateral; A/P, anterior-posterior
ST, single-task; DT, dual-task

Table 4.
Multiple regression analysis predicting *SD* of M/L sway from MS-C and CMP in the (a) single-task and (b) dual-task conditions

Variables	β	*t*	sr^2_{unique}	
SD of M/L sway (ST)				
MS-C	-0.36	-2.21*	.09	
CMP	0.02	0.14	.00	
	Intercept = 40.90			$R^2 = 0.12$
				$R^2adj = 0.08$
				R = 0.35*

***p < .001, **p < .01, * p < .05
MS-C, movement self-consciousness; CMP, conscious motor processing
M/L, medio-lateral
ST, single-task