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Conscious Processing and Rowing: A field Study

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Abstract

Objectives: The theory of reinvestment has been used to explain underperformance of motor skills in sport. Our study had three objectives. First, we examined the influence of conscious processing on rowing performance in competitive races. Second, we investigated conscious processing as a function of rowing experience. Finally, we explored whether extreme conscious processing predicted catastrophic skill failure during competitive rowing. Design: *Cross-sectional field study*: Participants were observed during a competitive race before completing a multi-measure questionnaire.

Method: Participants were recruited from one of five rowing events held in the English midlands. Rowers (N = 147) were observed racing and then completed measures of movement-specific reinvestment, perceived performance, and demographics. Actual performance was calculated from their race finishing position.

Results: Post-hoc data analysis revealed that Movement Self-Consciousness (MSC) but not Conscious Motor Processing (CMP) was associated with actual race performance. CMP was positively associated with perceived technical performance, whereas MSC was negatively associated with perceived tactical performance. Two rowers who were observed to crab (i.e., choke) during their race reported extreme levels of CMP. Finally, the relationship between conscious processing and performance was not moderated by rowing experience.

Conclusion: Our findings provide broad support for the theory of reinvestment in the rowing context. Poor race outcome was only associated with MSC, suggesting that the pressures of competition, such as social evaluation, impact field performance. Catastrophic performance failure during competition (i.e., crabbing) was linked to extremely high CMP, which may be due to excessive conscious control that CMP evokes, therefore disrupting automatic processes.

Conscious processing and rowing: A field study

Competitive sport creates performance pressure (Baumeister, 1984), especially when there is an emphasis on winning (Elendu & Dennis, 2017). Athletes occasionally succumb to this pressure and "choke", which describes a significant sudden drop from the athlete's typical performance level (Baumeister, 1984; Beilock & Gray, 2012; Mesagno & Hill, 2013). Choking is not always a clear cut or an isolated incident; it can reoccur and may negatively impact an athlete's commitment and career (Hill et al., 2019). For instance, Sally Robbins, a former Australian Olympic rower, stopped rowing during the Olympics and Worlds, costing her crew a medal and arguably her career. Some reports state that it was due to exhaustion, however, this is an antecedent to choking (Hill & Shaw, 2013). Therefore, Sally Robbins may have been exhausted prior to stopping rowing but it is this type of physiological fatigue that can result in an athlete internally focusing on their motor mechanics causing performance to breakdown (Hill & Shaw, 2013). With a view to understanding this phenomenon, the current study was designed to examine the role of trait-like conscious processing during competitive rowing and to determine its association with choking.

Dispositional reinvestment

Predicting performance is a popular topic, particularly during competition, when performing optimally is key. Personality traits are a major area of interest due to their stability across contexts (Aidman & Schofield, 2004; Laborde et al., 2016). Recently researchers have discovered a number of personality-trait-like individual differences (PTLID), these are traits that do not belong in the main conceptualisation of personality (i.e., big five) but influence our stress response within the performance environment (Mosley & Laborde, 2015; Laborde & Allen, 2016). Subsequently, traits may be able to determine whether an athlete will choke or not, one of which is reinvestment (Masters & Maxwell, 2008).

Reinvestment was first established as a possible theoretical mechanism to choking under pressure (Masters, 1992; Masters & Maxwell, 2008). The theory proposed that, under pressure, automated skills can be deautomatized (Deikman, 1966) whereby an individual recalls technical know-how (declarative knowledge) of the skill from procedural long-term memory and reinvests (i.e., recalls) that knowledge back into the short-term working memory. This results in the performer having conscious access to their movements which they then try to control using the reinvested declarative knowledge (Masters & Maxwell, 2008). Consciously controlling one's movement execution causes it to revert to an earlier, more cognitive stage of control, which is characterised by inconsistency, instability and inaccuracy (Fitts & Posner, 1967; Masters & Maxwell, 2008).

Nevertheless, Masters et al. (1993) noticed that not every individual performs poorly under pressure and proposed that this variation in performance may be because individuals exhibit a greater or lesser disposition to reinvest (Masters, 1992). Consequently, they developed the Reinvestment Scale to quantify this trait-like individual difference. However, the scale's validity was criticised for being a collection of existing scales that captured a number of different personality characteristics that may predict reinvestment but not actually measure the reinvestment process (Jackson et al., 2006). In order to address these criticisms and the lack of face validity of the original scale two new scales were developed to focus on motor and decision-making skill breakdown under pressure; namely the Movement Specific (Masters et al., 2005) and Decision Specific (Kinrade et al., 2010) Reinvestment Scales. The Movement-Specific Reinvestment Scale (MSRS) (Masters et al., 2005) measures the act of manipulating conscious declarative knowledge to control one's motor mechanics, which consequently disrupts the performers automaticity (Masters & Maxwell, 2008). The scale captures two types of conscious processing related to movement, namely, Conscious Motor

Processing (CMP) and Movement Self-Consciousness (MSC). The CMP subscale measures the extent to which an individual tries to consciously control their movements, whereas the MSC subscale measures an individual's concern with their own movement style and making a good impression on others (Malhotra, Poolton, Wilson, Omuro, et al., 2015).

The majority of the literature has explored movement-specific conscious processing within a range of pressure manipulations, including time pressures (Malhotra et al., 2012), evaluative contexts (videotaping, audiences) (Klämpfl, Lobinger & Raab, 2013), monetary incentives (Mosley et al., 2017) and simulated competitions. There have been very few studies that have taken advantage of real-life competition, which naturally inflicts pressure on the athlete (Baumeister & Showers, 1986), and measured movement-specific conscious processing in actual match/race performance. Nevertheless, this has consequently led to mixed results concerning whether movement-specific conscious processing, as reflected by the MSRS, disrupts performance (see Table S1, Supplementary Material). Some laboratory studies have reported that individuals with high MSRS scores exhibit poor performance under pressure compared to those with low scores (e.g., Malhotra et al., 2012; Orn, 2017). For example, Orn (2017) reported that participants with higher MSRS scores had poorer basketball free throw performance and greater kinematic variability compared to those with lower MSRS scores. In contrast, other laboratory-based studies found no association between MSRS scores and performance on a variety of tasks, including dart throwing (Mosley et al., 2017) and golf putting (Malhotra, Poolton, Wilson, Uiga, et al., 2015). Mixed findings have also been reported in non-experimental field-based studies. For instance, MSRS scores discriminated between yip-afflicted (chokers) and non yip-afflicted expert baseball players in a non-experimental causal-comparative study (Gutierrez, 2018), whereas in two observational field-based studies, scores were not associated with the number of successful basketball freethrows (Geukes et al., 2017) or netball passing accuracy (Jackson et al., 2013) during competition.

The mixed findings may be due to a number of methodological factors (see Table S1, Supplementary Material). First, participants need to have sufficient declarative knowledge accumulated to be able to reinvest (Masters & Maxwell, 2008). Mosley et al.'s (2017) dart throwing and Malhotra, Poolton, Wilson, Uiga, et al.'s (2015) golf-putting studies tested complete novices who did not have sufficient declarative knowledge to reinvest under pressure. This underscores the importance of sport experience in relation to conscious processing. Second, most MSRS research has been laboratory-based, and, therefore, the pressure manipulation may not have been potent enough to activate the performers' disposition to reinvest (Hodges & Williams, 2012; Malhotra, Poolton, Wilson, Uiga, et al., 2015; Mosley et al., 2017). Lastly, although field-based studies have been conducted, the majority have used self-reports of choking incidents (Gutierrez, 2018) or likelihood to choke (Iwatsuki et al., 2018), which may have suffered from self-serving bias. Furthermore, the field-studies that have used real performance data have focused on one specific skill or part of the game rather than the whole performance (Geukes et al., 2017; Jackson et al., 2013). Although they may be important skills, such as free-throw performance in basketball, the athletes may have still reinvested or choked in other aspects of the game which have not been recorded (Geukes et al., 2017; Jackson et al., 2013). Additionally, the scale may not be suited to the type and nature of the skill investigated. For instance, Jackson et al. (2013) examined netball passing accuracy, which is predominantly a tactical and decision-making task rather than strictly a motor task. This may explain why the DSRS predicted and the MSRS failed to predict passing performance under pressure. Finally, most MSRS research has been laboratory-based, and, therefore, the pressure manipulation may not have been potent enough to activate the performers' disposition to reinvest (Hodges & Williams, 2012; Malhotra, Poolton, Wilson, Uiga, et al., 2015; Mosley et al., 2017).

Differential effects of CMP and MSC – Trait-Activation

Recently, the two dimensions of MSRS – CMP and MSC – have been found to demonstrate context-dependent influences on performance. For example, in a time-pressured setting, CMP was found to slow laparoscopic task completion but MSC had no effect (Malhotra et al., 2014). In comparison, in a competitive environment, MSC but not CMP, was associated with perceived choking likelihood in athletes from multiple sports (Iwatsuki et al., 2018; Iwatsuki & Wright, 2016). These results may be in line with trait-activation theory, this theory extends from the interactionist perspective whereby the interaction between the person-situation determines the individual's behaviour (Geukes et al., 2013; Tett & Guterman, 2000). The trait-activation theory predicts that only traits that are relevant to the specific contextual cues will be switched on (Geukes et al., 2013). Geukes et al. (2013) explored this perspective in relation to the activation of self-focus and self-presentation traits under private, mixed and public pressure in handball players. Self-focus traits are concerned with an individual's tendency to exhibit inward attention such as private self-consciousness. Whilst, self-presentational traits are those that are concerned with the awareness of being evaluated or observed by others such as public self-consciousness. Geukes et al. (2013) supported trait-activation theory, with public self-consciousness predicting performance under public and mixed pressure, whilst private self-consciousness only predicted performance under private pressure. In relation to the differential results for MSC and CMP described in Malhotra et al. (2014) and Iwatsuki et al. (2018) study, this may be due to the different situational cues in each context. MSC exhibits similar characteristics to a self-presentational trait, as it reflects a consciousness to others evaluating their movement, on the other hand, CMP, is similar to a self-focus trait, as it reflects an internal conscious control of their motor processes. Consequently, Iwatsuki et al. (2018) measures CMP and MSC in relation to the competitive environment that has the presence of audience members and opponents; therefore, it makes sense that this evokes MSC over CMP. Meanwhile, Malhotra et al. (2014) measures these conscious processes in relation to performance in a time-pressured condition with no audience, similar to the private pressure, therefore the activation of CMP over MSC follows.

Meanwhile, when the trait-activation theory is investigated in relation to overall movement reinvestment in basketball players, free-throw performance in actual matches was not associated with MSRS (Geukes et al., 2017). It was concluded that this was due to the basketball matches being public high pressure due to the audience presence and the authors described reinvestment as a self-focus trait. However, as described before, MSC, is concerned with self-presentational concerns, therefore if the MSRS dimensions had been investigated separately rather than averaged into a single MSRS score, MSC may have demonstrated an association with performance. Consequently, the two dimensions of MSRS should be investigated separately.

Differential effects of CMP and MSC – experience dependent

Similarly, CMP and MSC have demonstrated differential influences on performance depending on the skill-level or experience of the performer. Gallicchio et al. (2016) found that putting-specific CMP was lower in expert compared to novice golfers; MSC was not measured. Nevertheless, exhibiting a high propensity for putting-specific CMP, regardless of skill level, was related to poor performance under pressure. Other than this study, no other studies have directly examined the associations between MSC or CMP and sport performance under pressure as a function of experience. However, a training study noted that the two dimensions of conscious processing exerted different effects on golf putting performance early compared to late in learning. Specifically, CMP was negatively and adversely associated with impact velocity in early but not late training, whereas MSC was positively and favourably associated with putting proficiency throughout training (Malhotra, Poolton, Wilson, Omuro, et al., 2015). Evidence in support of this notion was provided by Capio et al. (2018). This non-sport study found that MSC (but not CMP) was associated with years of experience in physiotherapists: MSC decreased with experience. Less experienced physiotherapists may be more self-conscious as they try to find the optimal movement strategy that produces the most effective outcome.

Taken together, these studies reveal that the two MSRS dimensions should be examined separately rather than combined. In brief, these studies suggest that CMP and MSC can have distinct effects on motor performance which may depend on the experience and/or contextual cues (e.g., stage of learning, practice, competition, pressure). No field study has examined CMP and MSC separately on actual performance during the real-life pressure of competition or the roles of CMP and MSC on performance as a function of experience. The current study sought to address the gap in our understanding of these issues.

Rowing and reinvestment

Crew-based rowing is a sport that requires both team and individual effort. Each rower contributes more or less equally to boat speed: inefficient strokes will slow whereas synchronous strokes will quicken the boat (Cuijpers et al., 2017). Although this sport has not yet been investigated in relation to reinvestment, studies have demonstrated the impact of traits (Cumming et al., 2017; Morgan & Johnson, 1978) and attention (Neumann et al., 2020; Parr & Button, 2009; Schücker et al., 2015) on rowing performance. Parr and Button (2009) found that novice rowers taught to adopt an internal focus of attention on their movements improved their efficiency at the “catch”,[1] but not as much as those taught to adopt an external focus on the oar’s blade. Additionally, during a transfer task, when the stroke rate was increased to increase the likelihood of making an error, the external focus group demonstrated better "catch" efficiency than the internal focus group. Furthermore, attentional focus was found to affect rowing efficiency during a submaximal 2000 m test in experienced rowers: internal focus increased oxygen consumption compared to external focus and control (Schücker et al., 2015). In contrast, novice rowers performed better – greater distance and more power output per stroke – if they exhibited internal compared to external focus. These findings suggest that the act of consciously attending to rowing movements may impair performance but this may be influenced by skill level. Nevertheless, this is only circumstantial evidence, as the studies did not directly examine conscious processing. Additionally, the data were not collected during a race, where there are pressures to win and evaluative audiences.

The present research

Few studies have explored the influence of conscious processing on performance under natural competitive pressure. The majority have used athletes' self-report of performance rather than actual performance data or the studies have focused on one specific skill or part of the game rather than the whole performance (Table 1). These two main criticisms may have led to the findings being mixed and their conclusions equivocal (Geukes et al., 2017; Gutierrez, 2018; Iwatsuki et al., 2018; Iwatsuki & Wright, 2016; Jackson et al., 2013). Most studies have examined reinvestment in relation to the performance of discrete skills, such as golf putting, by either novices or experts in a laboratory (Cooke et al., 2011; Malhotra, Poolton, Wilson, Omuro, et al., 2015; Masters, 1992). No study, to our knowledge, has evaluated the influence of experience on conscious processing. This is an important omission given recent evidence suggesting that some conscious processes can be beneficial for novices during learning but detrimental during competitive performance. Thus, the current study sought to fill this gap in our understanding of reinvestment in competition.

The present study had three purposes. Our first study purpose was to examine the association between rowing race performance and both conscious motor processing and movement self-consciousness. In line with the trait-activation theory and that under the competitive context there is a presence of an audience (Geukes et al., 2013; Iwatsuki et al., 2018), we hypothesised that only MSC would be negatively associated with actual and perceived performance.

The second study purpose was to examine the relationship between rowing experience (years) and propensity for movement-specific reinvestment, and whether experience moderated the relationship between reinvestment and performance. In line with Capio et al. (2018) and Gallicchio et al. (2016), who found that more experienced individuals were characterised by lower MSC and CMP scores, we hypothesised that experience would attenuate the relationship between reinvestment and performance.

Our third study purpose, albeit exploratory, investigated whether the MSRS was associated with rowers who choked (i.e., crabbed) during the race. Crabbing is where the blade becomes caught under the water, the oar handle is driven into the rower's chest, and the rower is pushed backwards. A crab will stop, slow or redirect the boat. In line with evidence that consciously attending to the oar detrimentally affects the rowing stroke (Parr & Button, 2009), we hypothesised that rowers who crabbed would have higher than sample norm levels of MSRS scores.

Method

Participants

One hundred and forty-seven rowers (96 females, 51 males), aged between 16 and 57 (M = 25.09, SD = 9.31) years, with mean rowing experience of 4.93 (SD = 6.88, ranging between 1 and 60) years, participated in the study. Rowers had to have at least one year's experience of training and competing, guaranteeing a sufficient accumulation of declarative knowledge (i.e., rules about rowing) to potentially reinvest under pressure (Masters & Maxwell, 2008). Their highest competitive standard was club (n = 105), national (n = 33), and international level (n = 9).

Power calculations using GPower 3.1.5 (Faul et al., 2007) software indicated that with a sample size of 147, the current study was powered at .80 to detect significant ($p < .05$) relationships between reinvestment and performance using Pearson correlation analyses corresponding to a small-to-large ($r = .23$) effect size (Gignac & Szodorai, 2016).

Measures

Movement-Specific Reinvestment Scale (MSRS). Conscious processing was measured using the CMP and MSC subscales of the MSRS (Masters et al., 2005). Items from the CMP (e.g., "I am aware of the way my body works when I am carrying out a movement") and MSC (e.g., "I am concerned about what people think about me when I am moving") subscales were rated on a 6-point Likert scale, anchored by 1 (strongly disagree) and 6 (strongly agree). Both subscales have previously exhibited acceptable validity, test-retest reliability, and internal reliability (Masters et al., 2005; Masters & Maxwell, 2008).

Experience. We measured experience by the rower reporting how many years they had been competitively rowing.

Performance. We measured actual and perceived performance. Actual performance reflected the performance of the group of crewmates; however, every single crewmember contributes equally to determining the speed of the boat (Cuijpers et al., 2017). However, because they row as a unit, a fault or inefficient stroke executed by one member will affect the overall boat speed. Perceived performance reflected the performance of the individual rower (see S2, Supplementary Material). First, actual performance was recorded by using information that each participant provided regarding their race, which enabled us to identify their boat's finishing position (e.g., second out of six boats) from the official race results.

This information was used to compute actual performance. A relative ranking system was implemented to standardise the variability across events/races, such as racing formats and the number of boats in each race.2 The ranking system was expressed as a percentage score: the boat that came first received a score of 100%, the boat that finished last received a score of 0%, and boats that finished in between received a score that depended on the position and the number of boats in the race. The percentage for each boat position in the race was calculated using the following formula: score = (100 / (total number of boats in the race − 1) × (total number of boats in the race − finish position of boat in the race)). For example, if a boat came third out of six boats, that boat would receive a percentage score of 60%, as the formula would be: ((100 / (6 − 1) × (6 − 3) = 60)).

Second, perceived performance measured using a rowing-specific perceived performance scale adapted from previous research (e.g., Al-Yaaribi et al., 2016). Participants were asked to rate themselves on a 7-point Likert scale, anchored by 1 ("very poor") and 7 ("excellent"), in terms of their technical (i.e., optimal catches, good body position, clean blade extraction), tactical (i.e., race awareness, responding to cox), physical (i.e., acceleration, power, endurance), psychological (i.e., concentration, resilience, mental toughness) and overall performance. This scale has demonstrated good internal reliability in past research (Al-Yaaribi et al., 2016).

Crabbing. Crabbing was measured via direct observation of each race by a researcher.

Procedure

Ethical approval was first obtained from the university ethics committee. Recruitment of rowers was then initiated through emailing clubs who had registered to compete at the five chosen UK Head3 (5000 m) and Regatta4 races (600–2000 m). The email included details of the study such as a participant information sheet, a study synopsis and whether they or any of their club members competing would like to participate. Follow-up emails were sent nearer to the event.

At each race, the clubs were approached. The questionnaire was explained, and participants were asked to read the questions carefully and answer honestly. Following informed consent, the participant completed the questionnaire. The first page of the questionnaire explained the research aims, that all responses would be confidential, and participants had the right to withdraw at any time. The questionnaire consisted of the MSRS and perceived performance scale. We also asked for basic demographic information (i.e., sex, age, years rowing, rowing experience level) and the individual's competition details. The questionnaire took approximately 20 min to complete. All participants voluntarily completed the questionnaire and in return were entered into a prize draw to win £100 or one of two £50's. Although the questionnaire measures were explained to each participant, each participant was naïve to the purpose of the research.

Data Analysis

Data was analysed post-hoc using SPSS Version 26 (IBM). We examined internal consistency of scale scores by computing the coefficient alpha of the MSRS and perceived performance scale (Cronbach, 1951). Cronbach alpha scores that range between .70 and .80 represent good, whereas scores above .80 represent very good to excellent internal consistency (Taber, 2018). To examine our first study purpose, we conducted Pearson correlations to examine the relationships between MSRS scores, rowing performance, perceived rowing performance and rowing experience (years). Effect sizes were calculated and interpreted as 10, .20 and .30, which corresponded to small, medium, and large effect sizes, respectively (Gignac & Szodorai, 2016). Statistical significance was set at a $p < .05$. To examine our second study purpose, we performed a moderation analyse, using Hayes' (2017) PROCESS macro for SPSS (model 1). This model examined whether experience moderated the relationship between rowing-specific reinvestment (CMP, MSC) and performance. Finally, to explore whether the two rowers who were observed crabbing during their race had extreme MSRS scores compared to the rest of the sample, the mean and 95% confidence intervals for the remaining rowers in the sample (i.e., n = 147–2 = 145) for each MSRS subscale was computed to create group norms. Then each of the two crabbers was evaluated relative to these norms to determine whether their score on each MSRS subscale lay within the confidence intervals for the subsample of 145 rowers.

Results

CMP, MSC and Performance

The first study aim was to examine the relationship between conscious processing and rowing performance. Our hypothesis was partially supported, with the Pearson correlations (Table 1) revealing that MSC was only negatively correlated with a medium-to-large effect size for perceived tactical and small-to-medium effect size actual performance. In contradiction to our hypothesis, CMP was positively correlated with perceived technical performance, with small-to-medium effect sizes but no other performance variables.

CMP, MSC and Experience

The second study aim was to investigate the associations between conscious processing and rowing experience, and whether experience moderated the relationship between reinvestment and performance. Pearson correlations indicated that rowing experience was negatively associated with both CMP and MSC (Table 1). Contrary to our hypothesis, the moderation analysis (Table 2) revealed that CMP, MSC and experience had no main effect on performance. Additionally, experience did not moderate the relationship between either dimension of reinvestment and actual performance.

CMP, MSC and Crabbing

The third study aim was to explore whether athletes who crabbed during the race were characterised by higher than average MSRS scores. In support of our hypothesis, the CMP scores (first rower = 5.40, second rower = 5.20) were greater than the upper confidence interval of the rest of the sample (M = 3.99, 95% CI = 3.83, 4.15). In partial support of our hypothesis, the MSC scores were outside the confidence intervals (M = 3.41, 95% CI = 3.20, 3.61); the first rower's score of 5.20 was above the upper confidence interval, whereas the second rower's score of 2.80 was below the lower confidence interval.

Discussion

Conscious processing of movements has been predominantly measured using instruments, namely, the Reinvestment Scale (Masters et al., 1993) and Movement Specific Reinvestment Scale (Masters et al., 2005), in relation to laboratory-based motor skills, such as golf putting (Malhotra, Poolton, Wilson, Omuro, et al., 2015; Masters et al., 2005), basketball shooting (Orn, 2017), and dart throwing (Mosley et al., 2017; van Ginneken et al., 2017). The current field study examined conscious processing and performance in real-world competitive rowing. We measured performance using perceptions of the rowers themselves and records of rowing race finishing positions. We also investigated the relationship between conscious processing and skill experience, and examined whether experience moderated the reinvestment-performance relationship. Lastly, we explored whether crabbing was related to conscious processing, but because there were only two cases, this question was analysed in an exploratory fashion.

Conscious processing and race performance

In support of our hypothesis, only MSC was negatively associated with actual performance. This finding is similar to previous studies that found only MSC was related to choking (Iwatsuki et al., 2018; Iwatsuki & Wright, 2016). Taken together these findings suggest that MSC plays a more important role than CMP in disrupting performance in competitive field settings. The finding that MSC was linked to poor performance and not CMP, may also compatible with trait-activation theory, as performance was measured in a rowing competition (e.g., a regatta) that constitutes a number of high public pressure elements (e.g., concerns about social evaluation and self-presentation) that are likely to have activated the underlying trait (Geukes et al., 2013). For example, in a regatta, rowers race side-by-side with other crews, and large crowds watch from the side of the river, both of which can increase the rowers' concern about what they look like, in terms of their posture and technique, when rowing.

Consistent with our hypothesis we also found that MSC was negatively associated with perceived tactical performance (Table 1). This finding suggests that reinvestment could be linked to decision-making in sport. Rowers all have tactical decisions to make during races, these are primarily pacing strategies, race plans and deciding whether to respond to the cox. Additionally, certain rowers in the boat also have responsibility for making specific decisions. Specifically, the "stroke" determines the rate and rhythm followed by the rest of the crew during the race, and, in a coxless boat, the "bow" plays a similar role to the "cox" in choosing the racing line, rate changes, and power changes. Previous studies have reported that the MSC subscale of the MSRS is positively related to the Decision-Specific Reinvestment Scale (e.g., Iwatsuki & Wright, 2016; Jackson et al., 2013; Laborde et al., 2014, 2015), suggesting that individuals who are self-conscious about movements are also self-conscious about decision-making. Consciousness during decision-making has shown to lead to poorer and slower tactical decisions, compared to tactical decisions that are made intuitively (i.e., without consciousness) (Raab & Laborde, 2011). Therefore, high movement self-consciousness may have caused rowers to make poorer decisions, which would have impaired their tactical performance.

On the other hand, contrary to our hypothesis, we found that CMP was positively associated with perceived technical performance, such as blade placement and extraction (Table 1). This finding is inconsistent with reinvestment theory. High CMP, which represents a strong propensity to consciously process or control movement (e.g., Masters et al., 2005), should disrupt performance (Masters & Maxwell, 2008; Toner & Moran, 2011). However, high CMP was associated with greater technical consistency in golf putting in previous research (Malhotra, Poolton, Wilson, Omuro, et al., 2015): individuals with high CMP scores exhibited less variable putter-ball impact velocity and angle. Consistency in rowing is important for crew synchronicity and boat balance. Similarly, there is some evidence that athletes consciously control their movements to restore or refine their technique; this has been reported by elite skiers during air-jumps (e.g., Nyberg, 2015). The abovementioned evidence suggests that conscious motor processing can sometimes benefit performance. Nevertheless, there is scepticism towards these perceived performance measures, as they can be influenced by the rower's racing outcome, as they are more likely to perceive their performance positively if they did well, compared to if they did not.

Conscious processing and rowing experience

Our second aim was to examine the moderating effect of experience on the reinvestment-performance relationship. The correlational data were in line with previous studies (Gallicchio et al., 2016; Zhu et al., 2011) showing that greater experience was associated with lower MSC and CMP scores (Table 1), and suggesting that more experienced rowers were less likely to reinvest. However, opposing this explanation and our hypothesis, experience did not moderate the reinvestment-performance relationship (Table 2). This contradicts recent research showing that the effect of conscious processing on performance depends on experience (Capio et al., 2018; Gallicchio et al., 2016; Zhu et al., 2011). In relation to the current study, the null finding may be due to the sample being homogenous in terms of experience, as the majority of rowers were beginners (1 year), therefore the sample may be insufficient to detect any moderating effect. On the other hand, the lack of moderation could suggest that conscious processing exerts the same influence on performance across the novice-expert continuum. For instance, conscious processing has been found to improve performance for both novices (Malhotra, Poolton, Wilson, Leung, et al., 2015) and experts (Toner & Moran, 2014, 2015) but also have detrimental effects at both skill levels (Masters & Maxwell, 2008), therefore conscious processing may act independently to the athlete's experience level.

Crabbing under pressure

Our final study aim was to explore whether the MSRS was associated with crabbing during competitive racing. The hypothesis that the MSRS scores of crabbers would be higher than the sample norms was partially supported. CMP and MSC scores for both crabbing cases fell outside the norms for our sample. Both rowers had CMP scores that were higher than the sample's norms. Extreme CMP levels may be the signature of an individual who is "constantly consciously surveying each individual component of the movement" (Toner & Moran, 2015, p. 114), and therefore most vulnerable to catastrophically disrupted performance under pressure, such as experienced in actual competitions.

Nevertheless, for MSC, one rower scored higher and one rower scored lower than the norms for the sample. The contrast in MSC scores may be due to individual differences, the rower with low MSC may naturally have less self-presentational concerns compared to the other rower and more worried about the outcome of the race and therefore their technical application to make the boat go faster, hence the high levels of CMP. The present study is the first of the authors knowledge to adopt an individual case analysis approach making direct comparisons to existing literature difficult. Nevertheless, there is other evidence that the relation between MSC and performance is not consistent, with some studies even reporting that high MSC is associated with better performance (Larson & Larson, 2016; Malhotra, Poolton, Wilson, Omuro, et al., 2015). It is evident that this finding also requires replication.

Study implication, limitations and future directions

Findings from this study have performance implications especially in relation to preventing conscious motor processing. Coaches may limit the accumulation of explicit knowledge of the skill during the learning phase through implicit techniques (Masters & Maxwell, 2008). Whilst for more established rowers, coaches could implement interventions such as secondary tasks or mindfulness that may prevent athletes from conscious processing (Birrer et al., 2012; Masters & Maxwell, 2008). Notwithstanding the important and novel findings, there are several limitations that need to be considered when interpreting the evidence. First, the performance measures could be improved, as although every crew member plays an equal role in the speed of the boat, utilising kinematic measures such as telemetry (i.e., power, stroke efficiency, seat speed), would accurately capture individual rowers' performance and corroborate the actual race performance score (Kleshnev, 2010). Additionally, such measures would support the perceived measures of performance, as an individual's perception of their performance can be influenced by the outcome of their race. Furthermore, as crabbing is rare, kinematic measures could also be used to better identify other rowing related technical faults that may be connected to movement specific reinvestment. Second, it is difficult to determine whether the lapses in performance were a "choke" as there is no seasonal data to compare to, as the performance could just be the rower's general performance. Last, there is no measure of anxiety or perceived pressure, therefore this needs to rectified in future studies, as without pressure, reinvestment will not occur, which also may explain some of the null results of the current study (Masters & Maxwell, 2008).

Conclusion

Our study provided broad support for the theory of reinvestment and the trait-activation theory, with movement-specific self-consciousness being negatively associated with actual performance in a competitive racing environment (Iwatsuki et al., 2018; Iwatsuki & Wright, 2016; Masters, 1992; Masters & Maxwell, 2008). In addition, the MSRS subscales were both related to catastrophic performance failure, this provides preliminary support that the scale may be able to identify athletes who may be prone to choke during competition (Masters, 1992; Masters & Maxwell, 2008). Previous research proposed that the roles played by CMP and MSC on performance depend on the experience of the performer (Gallicchio et al., 2016; Zhu et al., 2011), however, this was not confirmed, with experience having no moderating effect. In conclusion, it seems plausible that movement self-consciousness is an undesirable trait to exhibit during a competitive rowing race context. Therefore, coaches could implement interventional strategies, such as mindfulness (Birrer et al., 2012), to prevent rowers from consciously processing during races.

References

Aidman, E., & Schofield, G. (2004). *Personality and individual differences in sport.* In T. Morris & J. Summers (Eds.), *Sport psychology: Theory, applications and issues* (p. 22–47). John Wiley & Sons Australia.

Al-Yaaribi, A., Kavussanu, M., & Ring, C. (2016). Consequences of prosocial and antisocial behavior for the recipient. *Psychology of Sport and Exercise, 26,* 102-112.

Baumeister, R. F. (1984). Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology, 46,* 610-620.

Baumeister, R. F., & Showers, C. J. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental tests. *European Journal of Social Psychology*, *16*(4), 361-383.

Beilock, S. L., & Gray, R. (2012). From attentional control to attentional spillover: A skill-level investigation of attention, movement, and performance outcomes. *Human Movement Science, 31,* 1473-1499.

Birrer, D., Röthlin, P., & Morgan, G. (2012). Mindfulness to enhance athletic performance: Theoretical considerations and possible impact mechanisms. Mindfulness, 3(3), 235–246.

Capio, C. M., Uiga, L., Malhotra, N., Eguia, K. F., & Masters, R. S. (2018). Propensity for movement specific reinvestment by physiotherapists: Implications for education. *Physiotherapy Theory and Practice*, *34*, 926-930.

Cooke, A., Kavussanu, M., McIntyre, D., Boardley, I. D., & Ring, C. (2011). Effects of competitive pressure on expert performance: Underlying psychological, physiological, and kinematic mechanisms. *Psychophysiology, 48,* 1146-1156.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16,* 297-334.

Cuijpers, L. S., Passos, P. J. M., Murgia, A., Hoogerheide, A., Lemmink, K. A. P. M., & de Poel, H. J. (2017). Rocking the boat: does perfect rowing crew synchronization reduce detrimental boat movements?. *Scandinavian journal of medicine & science in sports*, *27*, 1697-1704.

Cumming, S. J., Turner, M. J., & Jones, M. (2017). Longitudinal changes in elite rowers' challenge and threat appraisals of pressure situations: A season-long observational study. *The Sport Psychologist*, *31*, 217-226.

Deikman, A. J. (1966). De-automatization and the mystic experience. *Psychiatry*, *29*, 324-338.

Elendu, I. C., & Dennis, M. I. (2017). Over-emphasis on winning, host-to-win and winning-at-all-cost syndrome in modern sports competitions: implications for unsportsmanship behaviours of sports participants. *International Journal of Physical Education, Sports & Health, 4,* 104-107.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175-191.

Fitts, P. M., & Posner, M. I. (1967). Human performance. Belmont, CA: Brooks/Cole.

Gallicchio, G., Cooke, A., & Ring, C. (2016). Lower left temporal-frontal connectivity characterizes expert and accurate performance: High-alpha T7-Fz connectivity as a marker of conscious processing during movement. *Sport, Exercise, and Performance Psychology, 5,* 14-24.

Geukes, K., Harvey, J. T., Trezise, A., & Mesagno, C. (2017). Personality and performance in real-world competitions: Testing trait activation of fear of negative evaluation, dispositional reinvestment, and athletic identity in the field. *Psychology of Sport and Exercise, 30,* 101-109.

Geukes, K., Mesagno, C., Hanrahan, S. J., & Kellmann, M. (2013). Performing under pressure in private: Activation of self-focus traits. *International Journal of Sport and Exercise Psychology*, *11*, 11-23.

Gignac, G. E., & Szodorai, E. T. (2016). Effect size guidelines for individual differences researchers. *Personality and individual differences*, *102*, 74-78.

Gutierrez, L. (2018). *Examining movement-specific reinvestment and the yips in professional baseball* (Doctoral dissertation, Grand Canyon University).

Hayes, A F. (2017). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. New York (NY): Guilford publications.

Hill, D. M., & Shaw, G. (2013). A qualitative examination of choking under pressure in team sport. *Psychology of Sport and Exercise*, *14*(1), 103-110.

Hill, D. M., Cheesbrough, M., Gorczynski, P., & Matthews, N. (2019). The consequences of choking in sport: a constructive or destructive experience?. *Sport Psychologist, 33(1).*

Hodges, N., & Williams, A. M. (Eds.). (2012). *Skill acquisition in sport: Research, theory and practice*. Routledge.

Iwatsuki, T., & Wright, P. (2016). Relationships among movement reinvestment, decision-making reinvestment, and perceived choking. *International Journal of Coaching Science, 10,* 25-35.

Iwatsuki, T., Van Raalte, J. L., Brewer, B. W., Petitpas, A., & Takahashi, M. (2018). Relations among reinvestment, self-regulation, and perception of choking under pressure. *Journal of Human Kinetics*, *65*, 281-290.

Iwatsuki, T., Van Raalte, J. L., Brewer, B. W., Petitpas, A., & Takahashi, M. (2018). Relations among reinvestment, self-regulation, and perception of choking under pressure. *Journal of Human Kinetics*, *65*, 281-290.

Jackson, R. C., Ashford, K. J., & Norsworthy, G. (2006). Attentional focus, dispositional reinvestment, and skilled motor performance under pressure. *Journal of Sport and Exercise Psychology*, *28*, 49-68.

Jackson, R. C., Kinrade, N. P., Hicks, T., & Wills, R. (2013). Individual propensity for reinvestment: Field-based evidence for the predictive validity of three scales. *International Journal of Sport Psychology, 44,* 331-350.

Kinrade, N. P., Jackson, R. C., Ashford, K. J., & Bishop, D. T. (2010). Development and validation of the decision-specific reinvestment scale. Journal of Sports Sciences, 28(10), 1127-1135.

Klämpfl, M K, Lobinger, B H, & Raab, M. (2013). How to detect the yips in golf. Human Movement Science, 32(6), 1270–1287.

Kleshnev, V. (2010). Boat acceleration, temporal structure of the stroke cycle, and effectiveness in rowing. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering and Technology, 224(1),* 63-74.

Laborde, S., Dosseville, F., & Kinrade, N. P. (2014). Decision-specific reinvestment scale: an exploration of its construct validity, and association with stress and coping appraisals. *Psychology of Sport and Exercise, 15,* 238-246.

Laborde, S., Guillén, F., & Mosley, E. (2016). Positive personality-trait-like individual differences in athletes from individual-and team sports and in non-athletes. *Psychology of sport and exercise*, *26*, 9-13.

Laborde, S., Musculus, L., Kalicinski, M., Klämpfl, M. K., Kinrade, N. P., & Lobinger, B. H. (2015). Reinvestment: Examining convergent, discriminant, and criterion validity using psychometric and behavioral measures. *Personality and Individual Differences, 78,* 77-87.

Larson, W., & Larson, C. (2016). The contributions of body awareness to "choking under pressure". *The Journal of Undergraduate Research, 14,* 2.

Malhotra, N., Poolton, J. M., Wilson, M. R., Fan, J. K., & Masters, R. S. W. (2014). Conscious motor processing and movement self-consciousness: Two dimensions of personality that influence laparoscopic training. *Journal of Surgical Education, 71,* 798-804.

Malhotra, N., Poolton, J. M., Wilson, M. R., Leung, G., Zhu, F., Fan, J. K., & Masters, R. S. W. (2015c). Exploring personality dimensions that influence practice and performance of a simulated laparoscopic task in the objective structured clinical examination. *Journal of Surgical Education, 72,* 662-669.

Malhotra, N., Poolton, J. M., Wilson, M. R., Ngo, K., & Masters, R. S. (2012). Conscious monitoring and control (reinvestment) in surgical performance under pressure. *Surgical Endoscopy, 26,* 2423-2429.

Malhotra, N., Poolton, J. M., Wilson, M. R., Omuro, S., & Masters, R. S. W. (2015a). Dimensions of movement specific reinvestment in practice of a golf putting task. *Psychology of Sport and Exercise, 18,* 1-8.

Malhotra, N., Poolton, J. M., Wilson, M. R., Uiga, L., & Masters, R. S. W. (2015b). Examining movement-specific reinvestment and performance in demanding contexts. *Journal of Sport and Exercise Psychology, 37,* 327-338.

Masters, R. S. W. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology, 83,* 343-358.

Masters, R. S. W., Eves, F. F., & Maxwell, J. P. (2005). Development of a movement specific reinvestment scale. In *International Society of Sport Psychology (ISSP) World Congress*. International Society of Sport Psychology (ISSP).

Masters, R. S. W., Polman, R. C., & Hammond, N. V. (1993). 'Reinvestment': A dimension of personality implicated in skill breakdown under pressure. *Personality and Individual Differences, 14,* 655-666.

Masters, R., & Maxwell, J. (2008). The theory of reinvestment. *International Review of Sport and Exercise Psychology, 1*, 160-183.

Mesagno, C., & Hill, D. M. (2013). Definition of choking in sport: re-conceptualization and debate. *International Journal of Sport Psychology, 44,* 267-277.

Morgan, W. P., & Johnson, R. W. (1978). Personality characteristics of successful and unsuccessful oarsmen. *International Journal of Sport Psychology, 9*, 119-133.

Mosley, E., & Laborde, S. (2015). Performing with all my heart: heart rate variability and its relationship with Personality-Trait-Like-Individual-Differences (PTLIDs) in pressurized performance situations. In: S. Walters (Ed.) *Heart rate variability (HRV): Prognostic significance, risk factors and clinical applications* (pp. 291-314). Nova Science Publishers, Inc.

Mosley, E., Laborde, S., & Kavanagh, E. (2017). The contribution of coping related variables and cardiac vagal activity on the performance of a dart throwing task under pressure. *Physiology & Behavior, 179,* 116-125.

Neumann, D. L., Walsh, N., Moffitt, R. L., & Hannan, T. E. (2020). Specific internal and external attentional focus instructions have differential effects on rowing performance. *Psychology of Sport and Exercise*, 101722.

Nyberg, G. (2015). Developing a 'somatic velocimeter': the practical knowledge of free skiers. *Qualitative Research in Sport, Exercise and Health, 7,* 488-503.

Orn, A. (2017). *Effects of Pressure and Free Throw Routine on Basketball Kinematics and Sport Performance* (Doctoral dissertation, Arizona State University).

Parr, R., & Button, C. (2009). End-point focus of attention: learning the 'catch' in rowing. *International Journal of Sport Psychology, 40, 616-635.*

Raab, M., & Laborde, S. (2011). When to blink and when to think: preference for intuitive decisions results in faster and better tactical choices. *Research Quarterly for Exercise and Sport*, *82*, 89-98.

Schücker, L., Jedamski, J., Hagemann, N., & Vater, H. (2015). Don't think about your movements: Effects of attentional instructions on rowing performance. *International Journal of Sports Science & Coaching*, *10*(5), 829-839.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, *48*, 1273-1296.

Tett, R P, & Guterman, H A. (2000). Situation trait relevance, trait expression, and cross-situational consistency: Testing a principle of trait activation. Journal of Research in Personality, 34(4), 397–423.

Toner, J., & Moran, A. (2011). The effects of conscious processing on golf putting proficiency and kinematics. *Journal of Sports Sciences, 29,* 673-683.

Toner, J., & Moran, A. (2014). In praise of conscious awareness: a new framework for the investigation of "continuous improvement" in expert athletes. *Frontiers in Psychology, 5,* 769.

Toner, J., & Moran, A. (2015). Toward an explanation of continuous improvement in expert athletes: The role of consciousness in deliberate practice. *International Journal of Sport Psychology, 46,* 666-675.

van Ginneken, W. F., Poolton, J. M., Masters, R. S., Capio, C. M., Kal, E. C., & van der Kamp, J. (2017). Comparing the effects of conscious monitoring and conscious control on motor performance. *Psychology of Sport and Exercise*, *30*, 145-152.

Zhu, F. F., Poolton, J. M., Wilson, M. R., Maxwell, J. P., & Masters, R. S. W. (2011). Neural co-activation as a yardstick of implicit motor learning and the propensity for conscious control of movement. *Biological Psychology, 87,* 66-73.

Notes

1. The ‘catch’ is the moment where the rower enters the blade into the water at the front end of the stroke, the quicker this is entered at this point the more efficient and longer the stroke is.
2. The ranking system was used due to the different racing formats i.e. there being more boats in one race than another. Therefore, a boat that places 2/2 arguably has not raced as well as a boat that finishes 2/5, as this latter boat held off three other boats for that position during the race, whilst the boat that finished 2/2 may have given up after being overtaken
3. Head race is an endurance event, over a long distance (> 3 km) and is a time-trial.
4. Regatta takes place over shorter distances (500 – 2000 m) and is a sprint, with side-by-side racing.