Psychology of Sport and Exercise 18 (2015) 1–8

Contents lists available at ScienceDirect

Psychology of Sport and Exercise

journal homepage: www.elsevier.com/locate/psychsport

Dimensions of movement specific reinvestment in practice of a golf putting task

Neha Malhotra [a, *, 1], Jamie M. Poolton [a, d, 1], Mark R. Wilson [b, 1], Sadahiro Omuro [a, 1], Rich S.W. Masters [a, c, 1]

[a] Institute of Human Performance, University of Hong Kong, Hong Kong
[b] School of Sport and Health Sciences, College of Life and Environmental Sciences, University of Exeter, UK
[c] Department of Sport and Leisure Studies, University of Waikato, New Zealand
[d] School of Sport, Carnegie Faculty, Leeds Beckett University, UK

ARTICLE INFO

Article history:
Received 23 June 2014
Received in revised form
17 November 2014
Accepted 17 November 2014
Available online 5 December 2014

Keywords:
Reinvestment
Conscious motor processing
Movement self-consciousness
Practice
Golf putting

ABSTRACT

Objectives: This study aimed to investigate the role of the two dimensions of movement specific reinvestment (conscious motor processing and movement self-consciousness) in performance of a complex task early and later in practice. Furthermore, the study also examined the underlying kinematic mechanisms by which conscious motor processing and movement self-consciousness influence performance in practice.
Methods: Trait measures of conscious motor processing and movement self-consciousness were obtained from participants using the Movement Specific Reinvestment Scale. Participants ($n = 30$) with no prior golf putting experience practiced 300 golf putts over the course of two days. Putting proficiency (number of putts holed) and variability of movement kinematics (SD impact velocity and SD putter face angle at impact) were assessed early and later in practice.
Results: Movement self-consciousness positively influenced putting proficiency early and later in practice by reducing variability of impact velocity and putter face angle at impact. Conscious motor processing positively influenced putting proficiency early in practice by reducing variability of impact velocity and putter face angle at impact. Later in practice, conscious motor processing was not associated with putting proficiency.
Conclusion: The findings suggest that higher propensity for movement self-consciousness potentially influences performance early and later in practice by reducing variability of impact velocity and putter face angle at impact. A higher propensity for conscious motor processing benefits performance in a similar manner as movement self-consciousness early in practice but it does not seem to influence performance later in practice. The findings of the current study suggest that movement self-consciousness and conscious motor processing differentially influence performance at different stages in practice of a complex motor skill, suggesting that they might depict different types of conscious processing.

Introduction

The theory of reinvestment proposes that relatively automated skills can be disrupted by attempts to consciously monitor and control the mechanics of movements (Masters, 1992; Masters & Maxwell, 2008; Masters, Polman, & Hammond, 1993). The theory is underpinned by an assumption that conscious monitoring and control mechanisms if used inappropriately can disrupt motor automaticity (i.e., *'deautomatization'*, Deikman, 1966), resulting in performance that is suboptimal.

The likelihood that conscious monitoring and control mechanisms will become involved in motor processes is a function of situational contexts, such as psychological pressure, or individual personality differences. An individual's propensity for reinvestment can be quantified by the Reinvestment Scale (Masters et al., 1993). Previous studies have consistently demonstrated a

* Corresponding author. Institute of Human Performance, 3/F, The Hong Kong Jockey Club Building for Interdisciplinary Research, 5 Sassoon Road, Pokfulam, Hong Kong. Tel.: +852 28315282; fax: +852 28551712.
E-mail address: nehamal@hku.hk (N. Malhotra).
[1] These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.psychsport.2014.11.008
1469-0292/

negative association between reinvestment and performance under pressure in sport (Chell, Graydon, Crowley, & Child, 2003; Jackson, Ashford, & Norsworthy, 2006; Jackson, Kinrade, Hicks, & Wills, 2013; Maxwell, Masters, & Poolton, 2006). Although reinvestment has been extensively investigated within the context of pressured situations, less is known about its role during distinctive stages of practice. Moreover, reinvestment has been treated as a negative personality trait, but its negative influence may be evoked only by certain contingencies, such as psychological pressure.

The pervasive view that conscious engagement in online skill execution (reinvestment) necessarily hinders performance has recently been challenged by researchers who have suggested that consciousness might be useful in certain circumstances (Toner & Moran, 2014, 2015). For instance, when well-learned techniques need to be subtly changed or *refined*, reinvestment might prove advantageous for performance (Carson, Collins, & Richards, 2014; Toner & Moran, 2014). For example, consciously monitoring movements might help skilled performers to identify aspects of their movements that are in need of refinement and conscious control might help when refining those movements. Additionally, for novices it is possible that reinvestment early in practice may facilitate the identification of appropriate solutions to the motor problem (Baddeley & Wilson, 1994; Berry & Broadbent, 1988; Gentile, 1998).

Novices have a tendency to learn by 'trial and error'. In response to unsuccessful movement outcomes, individuals form and test hypotheses in a search for the most effective motor solution (Masters & Poolton, 2012). Individuals with a high propensity for reinvestment (as compared to a lower propensity) tend to accumulate more technical knowledge as a result of practicing (Maxwell, Masters, & Eves, 2000) and also display greater verbal-analytical processing of movements as indexed by neuropsychological measures (Zhu, Poolton, Wilson, Maxwell, & Masters, 2011). Given that hypothesis testing can result in the accrual of technical skill-relevant knowledge that has been shown to disrupt performance of relatively automated skills, researchers have advocated implicit motor learning paradigms that limit the accrual of declarative knowledge (Masters, 1992; Masters & Poolton, 2012).

Prior research has also revealed that although directing conscious attention to movements is debilitative during performance of well-practiced skills, it might not be debilitative during performance of less-practiced skills (Beilock, Carr, MacMahon, & Starkes, 2002; Beilock & Gray, 2012; Ford, Williams, & Hodges, 2005; Gray, 2004). Individuals with a high propensity for reinvestment (high reinvestors) might be more inclined to engage in hypothesis testing behavior, which might initially lead to inconsistencies in the pattern and parameterization of movement; however, it should lead to the identification of effective actions earlier in practice. For example, a novice golfer who is a high reinvestor might start off making several technical adjustments in force and/or angle of the putter face at ball impact, leading to fluctuations in performance outcome, but should be quicker at determining the optimal kinematics of putting stroke than a low reinvestor. Following this line of reasoning, high reinvestors might have an advantage early in practice. However, later in practice, when novice golfers should have developed appropriate motor solutions (e.g., correct force to hit the ball), reinvestment should no longer support performance.

Jackson et al. (2006) raised concerns about whether the items of the original Reinvestment Scale (RS) are a true representation of the process of reinvestment or instead a mere representation of '… conceptually linked items that predict this process' (p. 65). Masters and colleagues have since remodeled the original RS (Movement Specific Reinvestment Scale, Masters, Eves, & Maxwell, 2005), isolating two dimensions specific to movement; conscious motor processing and movement self-consciousness. Conscious motor processing reflects an individual's tendency to *'consciously control'* the underlying mechanics of movement and movement self-consciousness reflects an individual's tendency to harbor concerns about his/her *'style'* of movement such that she/he would be more concerned about making a good impression when carrying out a movement. Thus, conscious motor processing and movement self-consciousness seem to depict different *types* of conscious processing, which may influence performance under different circumstances and potentially in different ways. The limited empirical research that has examined the distinctive influence of the two dimensions has primarily been conducted on clinical populations (Parkinson's disease, Masters, Pall, MacMahon, & Eves, 2007; stroke, Orrell, Masters, & Eves, 2009; elderly, Wong, Masters, Maxwell, & Abernethy, 2008) but this research nevertheless verifies the uniqueness of the two dimensions. Despite this knowledge, researchers continue to discuss reinvestment in terms of conscious motor processing and inferences about movement self-consciousness have been left to speculation.

Recently, Malhotra, Poolton, Wilson, Fan, and Masters (2014) examined the roles of the two dimensions of movement specific reinvestment during distinctive points in learning a laparoscopic surgical task. Movement self-consciousness uniquely predicted task performance early in learning and when expert-derived levels of task proficiency had been attained; a stronger inclination to be movement self-conscious lengthened task completion times in both instances. However, transfer to the use of a more complex cross-handed technique was uniquely predicted by conscious motor processing. Malhotra et al. (2014) argued that the complexity of the task (i.e., greater number of degrees of freedom of movement) possibly encouraged conscious motor processing and resulted in longer task completion times by individuals with a higher propensity for conscious involvement in motor control. The strength of the conclusions that can be drawn from this study is limited however, by the use of only a crude performance outcome measure (completion time). Indeed, it has been frequently suggested that performance outcome measures should be supplemented by assessment of the underlying kinematic mechanisms by which conscious processing impacts performance (Land & Tenenbaum, 2012; Pijpers, Oudejans, Holsheimer, & Bakker, 2003; Toner & Moran, 2011).

Technological advancements have equipped researchers with the means to capture the involvement of underlying mechanisms of movement specific reinvestment on motor performance. For instance, Cooke, Kavussanu, McIntyre, Boardley, and Ring (2011), recently provided some insight into the underlying kinematic processes that are linked to conscious motor processing. In their study, expert golfers' performance was assessed under low-, medium- and high-pressure conditions. Expert golfers tended to perform better and displayed lower levels of conscious motor processing under medium as opposed to high- and low-pressure conditions. More importantly, the study revealed subtle links between the propensity for conscious motor processing and the kinematics of movements, with lower levels of conscious motor processing in the medium-pressure condition accompanied by lower impact velocities, and slower less jerky swings.

In a rare attempt to investigate how different *types* of conscious processing might impact performance, Toner and Moran (2011) examined the differential impact of conscious *control* and of conscious *monitoring* on skilled performance. Expert golfers were instructed to attempt to refine their putting stroke, in order to evoke conscious motor processes, or directly instructed to monitor the point of clubhead impact. The conscious control manipulation did not impact putting proficiency (e.g., number of putts holed), but did result in less consistent putting strokes. On the contrary, the conscious monitoring manipulation impaired putting proficiency,