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The influence of monetary reward and punishment on psychological, physiological, behavioral and performance aspects of a golf putting task

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ABSTRACT

The primary purpose of the present study was to examine kinematic characteristics and force control during a golf-putting task under a pressure condition. The secondary purpose was to provide an exploratory investigation of the relationship between changes in behavior (kinematics and force control) and performance on the one hand, and psychological (attention and affect) and physiological (arousal level) changes on the other hand. Twenty male novices performed 150 acquisition trials, followed by 10 test trials during a pressure condition induced by performance-contingent distracters: a cash reward or punishment. A three-dimensional motion analysis revealed that, during the pressure test, angular displacements of rotational movements at the horizontal plane and movement time of the arms and club during the backswing and downswing phases all decreased, while acceleration of the elbows during the downswing phase increased. Mean performance indices in all participants' were unchanged in spite of the kinematic changes under the pressure condition. Multiple regression analyses indicated that the decrement in performance, as well as increased variability of movement time and speed, were more likely to increase when participants shifted their attention to movements. Furthermore, changes in heart rate and negative affect were related to both the increase in movement acceleration and a decrease in grip force. These findings suggest that performance and behavioral changes during golf-putting under pressure can be

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associated with attentional changes, along with the influences of physiological-emotional responses.

1. Introduction

Various kinds of psychological stressors occur in a competitive sports context, including presence of an audience, potential acquisition of prize money, and evaluation of one's performance by others. One such psychological stressor is pressure. Pressure is defined as "any factor, or combination of factors that increases the importance of performing well on a particular occasion (Baumeister, 1984, p. 610)". Baumeister also defined choking under pressure as "performance decrements under pressure circumstances". Overcoming performance decrements under pressure is a serious challenge faced by many athletes.

Many previous studies have examined motor behavior under pressure. These studies evaluated motor performance as well as stress responses across three different dimensions: psychological, physiological and behavioral. In terms of the psychological dimension of the stress response, it has been reported that changes in attention are observed under pressure, including increased self-awareness (Liao & Masters, 2002) and increased mental effort directed toward completion of tasks (Williams, Vickers, & Rodrigues, 2002; Wilson, Smith, Chattigton, Ford, & Marple-Horvat, 2006), along with emotional changes such as increased state anxiety (e.g., Weinberg & Hunt, 1976). As for the physiological dimension, changes in autonomic nervous and endocrine system functioning have been observed, including increased heart rate (HR) (e.g., Beuter, Duda, & Widule, 1989), decreased percentage of high-frequency sub-band in HR variability (Mullen, Hardy, & Tattersall, 2005), and increased production of cortisol (Salvador, Suay, González-Bono, & Serrano, 2003), indicating that physiological arousal tends to increase under pressure.

The behavioral dimension of motor performance under pressure has been studied from both the kinematics and kinetics points of view. Previous studies that examined kinematic characteristics using two-dimensional motion analysis found decreased movement displacement (Beuter et al., 1989; Tanaka & Sekiya, 2010a), movement speed (Tanaka & Sekiya, 2010a), and movement coordination (Tanaka, Urimoto, Murayama, & Sekiya, 2009) under pressure. Previous studies of variability in kinematic functions under pressure have reported contradictory results, including both increases (Gray, 2004; Higuchi, 2000; Tanaka & Sekiya, 2006) and decreases (Court, Bennett, Williams, & Davids, 2005; Tanaka, Yamamoto, & Sekiya, 2010; Tanaka et al., 2009). These contradictory findings might pertain to optimal control theory. In this theory, increased variability in task-irrelevant movement parameters is considered to be a positive factor in terms of performance outcomes, whereas increased variability of task-relevant movement leads to poor motor performance (Diedrichsen, Shadmehr, & Ivry, 2010; Todorov & Jordan, 2002).

These studies employed two-dimensional motion analysis. Two-dimensional motion analysis can be used to calculate kinematic variables pertaining to translational movements on one dimension. However, this approach cannot be used to calculate many other kinds of variables, including those pertaining to rotational movements. It is therefore necessary to use three-dimensional motion analysis to calculate kinematic variables such as movement displacement, movement speed and movement time, including both translational and rotational movements, and this approach should therefore prove more useful in the evaluation of the effects of pressure on motor behavior. Williams et al. (2002) examined motor behavior during table tennis and provided the only study to date that has used three-dimensional motion analysis to examine kinematic variables under pressure. While Williams et al. observed some behavioral changes under pressure, including decreases in performance accuracy and increases in gaze frequency, they did not identify any kinematic changes.

Previous studies that measured electromyograms (EMG) report that pressure causes kinetic changes such as prolonged EMG dwell time (Weinberg & Hunt, 1976), higher EMG amplitude (Tanaka, Funase, Sekiya, Sasaki, & Takemoto, 2011; Yoshie, Kudo, Murakoshi, & Ohtsuki, 2009; Yoshie, Kudo, & Ohtsuki, 2008), and increased co-contraction between prime movers (agonists) and antagonists