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Perceived distance during golf putting

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ABSTRACT

This study examined the effect of anxiety states on the relationship between golf-putting distance and performance in an environment requiring high movement accuracy. Twenty-three amateur golfers attempted 15 putts at each of three putting distances, 1.25, 1.50, and 1.75 m, under conditions characterized by both control demands and pressure. All attempts were recorded, and kinematic features were analyzed. Under conditions involving an audience and a monetary reward, the mean score on the State-Trait Anxiety Inventory Y-1 and the mean heart rate increased by 14 points and 11 bpm, respectively. We grouped participants on an *a posteriori* basis using the median split. The backswing of high-anxiety performers shortened, the downswing speed declined, and the relative time to peak club-head velocity changed when putting under pressure from 1.25 m. In contrast, no change in backswing or relative time to peak velocity was observed in low-anxiety performers, although impact velocity increased under this condition. These results indicate that the degree to which both low- and high-anxiety golfers were anxious about failure affected motor control at the 1.25-m distance, suggesting that a distortion in perceived distance may result from the interaction between putting distance and anxiety related to failure during golf putting.

1. Introduction

Does movement become more difficult as one is farther from a target? Smith et al. (2000) used questionnaires to study the anxiety experienced by more than 1000 golfers while putting. Unexpectedly, they found that golfers tended to exhibit greater anxiety for putts of 5 feet (1.52 m) or less

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compared with those of longer distances. This result may be caused by a distortion, based on experience, in the perceived distance. That is, golfers' movements are affected by an interaction with the environment, such as that occurring during perception-action coupling (Bootsma & van Wieringen, 1990; Kugler & Turvey, 1987), and may reflect the effect of a critical boundary (i.e., 1.52 m) which may evoke anxiety according to the golfers' experiences (Hristovski, Davids, Araùjo, & Button, 2006; Okumura et al., 2012). Additionally, their behavior is influenced not only by a distortion in perceived distance but also by task demands such as pressure. In the present study, we examined the influence of putting distance on movement performance in an environment with a high requirement for movement accuracy. In other words, we clarified the discontinuous relationship between putting distance and putting movements under pressure.

Using tapping tasks, Fitts (1954) discovered that movement distance, movement accuracy, and movement time are linked by simple principles. The essential point of these principles is the trade-off between speed and accuracy that exists for the performer while executing a movement. Moreover, Fitts introduced a binary index of difficulty based on Shannon's information theory (Shannon & Weaver, 1949). According to this formula, the movement task becomes more difficult as the distance between targets become greater and the targets become smaller. Schmidt, Zelaznik, Hawkins, Frank, and Quinn (1979) found a positive proportional relationship between movement speed and the variance of the end point. In recent years, Fitts' law has been extended to the minimum-variance theory (Harris & Wolpert, 1998). These studies have one thing in common: as movement speed increases or the amplitude of movement becomes greater, the accuracy of the movement declines. Research supporting these principles using more practical movement tasks is available (Etnyre, 1998; Gross & Gill, 1982), but results indicating the absence of a trade-off between speed and accuracy have also been reported (Beilock, Bertenthal, Mccoy, & Carr, 2004; Landlinger, Stöggl, Lindinger, Wagner, & Müller, 2012; van den Tillaar & Ettema, 2006; Wagner, Pfusterschmied, Klous, von Duvillard, & Müller, 2012). Therefore, cases in which Fitts' law may not apply due to task constraints and skill level can be found.

However, movement performance is affected by pressure. The phenomenon of a decline in performance due to the effect of pressure is called "choking under pressure" (Baumeister, 1984). Research investigating the effect of pressure on performance has used increased state anxiety as an indicator of pressure, and it has been commonly postulated that an increase in pressure is reflected in increased state anxiety (e.g., Beilock, Kulp, Holt, & Carr, 2004; Cooke, Kavussanu, McIntyre, Boadley, & Ring, 2011; Cooke, Kavussanu, McIntyre, & Ring, 2010; Gucciardi & Dimmock, 2008; Jackson, Ashford, & Norsworthy, 2006; Masters, 1992; Tanaka & Sekiya, 2010; Vickers & Williams, 2007; Wilson, Chattington, Marple-Horvat, & Smith, 2007). State anxiety can occasionally improve performance (Otten, 2009; known as "clutch performance"), but high levels of anxiety often decrease performance (Otten, 2009; known as "choking performance") (e.g., Arent & Landers, 2003; Hardy, 1996; Hardy, Beattie, & Woodman, 2007; Hardy & Parfitt, 1991; Hardy, Parfitt, & Pates, 1994; Hasegawa, Yano, Koyama, & Inomata, 2011; Sonstroem & Bernardo, 1982). When state anxiety is evoked due to pressure, movement kinematics and movement speed change, which affects movement accuracy (Cooke et al., 2011; Higuchi, Imanaka, & Hatayama, 2002; Nieuwenhuys & Oudejans, 2010; Tanaka & Sekiya, 2010; Yoshie, Kudo, & Ohtsuki, 2008).

Three different possibilities have been considered as primary reasons for this type of change in motor control patterns due to pressure. The first is a change in strategy. When a performer is in an environment where a high level of accuracy is required, the performer chooses a strategy of freezing degrees of freedom and moving slowly with compact motion to move more precisely (Higuchi et al., 2002). The second is the effect of perception. Prior research has shown that emotions such as anxiety affect the perception and realization of affordance (Pijpers, Oudejans, Bakker, & Beek, 2006). For example, both perceived and actual maximum reaching height were lower when reaching in high places than when reaching in low places (Pijpers et al., 2006). A correlation between estimates of the distance to a target and anxiety state has also been reported, showing that the greater the state of anxiety, the more the distance is overestimated (Stefanucci & Proffitt, 2009). Moreover, research focused on golf putting has found that better putting scores are associated with perceptions that the hole is larger and that the size of the hole is perceived to be larger when putting from short distances under pressure compared with when putting from longer distances under pressure (Witt, Linkenauger,