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Good-vs. poor-trial feedback in motor learning: The role of self-efficacy and intrinsic motivation across levels of task difficulty

Z.A. Abbas [a,*], J.S. North [b]

[a] Department of Psychology, University of Roehampton, UK
[b] Expert Performance and Skill Acquisition Research Group, School of Sport, Health and Applied Science, St. Mary's University, Twickenham, UK

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A B S T R A C T

In this study we examined the effects of feedback (knowledge of results; KR) after good and poor performances on self-efficacy and intrinsic motivation when learning easy and more difficult motor tasks. Participants were assigned to a KR-good, KR-poor, or KR-neutral (control) condition where they putted a golf ball to a target hole at distances of 2m (easy) and 5m (more difficult). All participants received KR on three trials in each six-trial block. Measures of self-efficacy and intrinsic motivation were taken after each test phase; and learning was inferred from 24-h and one-week retention tests. The KR-good group showed the highest levels of self-efficacy and intrinsic motivation, relative to the other two feedback groups, and more accurate putting performance. These effects persisted after one week and were more pronounced for the more difficult task. There is evidence for the motivational effects of feedback on motor learning, which has implications for theory and practice.

1. Introduction

Primarily, research into the role of augmented feedback in learning has focussed on its informational properties and been theoretically driven by the guidance hypothesis (Salmoni, Schmidt, & Walter, 1984). The central premise of the guidance hypothesis is that augmented feedback has strong guiding properties that directs the learner to the correct response, yet under certain conditions (i.e., if feedback is provided too often or too soon) the learner bypasses important intrinsic processing mechanisms and becomes dependent on the external source. Additionally, frequent KR prompts performers to adjust small response errors that may simply represent inherent variability in the motor system; thus, leading to an inability to recognise and produce stable behaviour in retention (Schmidt, 1991).

Recently, researchers have begun to pay attention to the motivational properties of this informational feedback, and how it may influence motor learning. The motivational properties of KR have been long acknowledged (e.g., Thorndike, 1927) but are relatively under researched in comparison to its informational role. It has been found that learners who are allowed to decide when to receive feedback (i.e., self-controlled feedback) show superior performance in delayed retention tests compared to control and yoked groups of participants (Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, Laroque de Medeiros, Kaefer, & Tani, 2008). Post-experiment interviews have shown that learners both prefer and request feedback more often after relatively successful ('good') trials than less successful ('poor') trials (Chiviacowsky & Wulf, 2002, 2005; Fairbrother, Laughlin, & Nguyen, 2012; Patterson & Carter, 2010; Patterson, Carter, & Sanli, 2011). Similarly, when experimenter-controlled feedback is provided after relatively good trials, it has resulted in more effective performance in retention tests than when it is provided after relatively poor trials (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Wally, & Borges, 2009).

Whilst such findings have been argued to suggest an important role for motivation in skill learning (Lewthwaite & Wulf, 2010), researchers have recently shown that the strategies for requesting KR may vary as a function of the number of practice trials completed (e.g., Carter & Patterson, 2012; Carter, Rathwell, & Ste-Marie, 2016), with KR being requested only after relatively good trials later in practice. Moreover, researchers have also shown that awareness of KR content (i.e., whether KR is given after the three best or three worst trials) results in superior learning, irrespective of whether the KR reflects good or poor trials (Patterson & Azizieh, 2012). It has been suggested that explicitly grouping KR trials as a function of the participant's performance (regardless of whether it

* Corresponding author. Department of Psychology, University of Roehampton, SW15 4JD, UK.
E-mail address: zara.abbas@roehampton.ac.uk (Z.A. Abbas).

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relates to KR-good or KR-poor) may increase the informational value of KR, thus providing a meaningful referent to modulate future responses (Patterson & Azizieh, 2012). Learning, however, is dynamic in nature and as Guadagnoli and Lee (2004) highlight, the relative effectiveness of any practice condition may depend on the interplay of learner characteristics, the characteristics of the motor task, and task complexity, which may account for these equivocal findings.

A limitation of much of the motor learning literature investigating the role of motivation is that motivational effects have often only been presumed rather than quantified through validated inventories (see Sanli, Patterson, Bray, & Lee, 2013). Badami, VaezMousavi, Wulf, and Namazizadeh (2011) addressed this issue by using the Intrinsic Motivation Inventory (IMI; McAuley, Duncan, & Tammen, 1989) to measure motivation, and reported that participants who received KR after good trials had higher levels of intrinsic motivation than those receiving KR on their poor trials, particularly on the dimension of perceived competence. Though the findings of Badami et al. (2011) suggest that providing feedback after good trials increases intrinsic motivation by enhancing perceived competence of the practiced task, the authors did not measure performance of the primary task (golf-putting) meaning it is difficult to correlate any beneficial effects of this motivational feedback with motor learning. Saemi, Wulf, Varzaneh, and Zarghami (2011) did report both intrinsic motivation and motor learning to be improved when children practising a throwing task received good-trial feedback compared to poor-trial feedback. However, the extent to which this finding can be generalised from children to adults is an open question given that age has been shown to interact with other feedback variables in defining optimum learning conditions (see Pollock & Lee, 1997; Sullivan, Kantak, & Burtner, 2008). Moreover, given that it is the interest/enjoyment sub-scale of the IMI that is considered the self-report measure of intrinsic motivation (McAuley et al., 1989), in both Badami et al. (2011) and Saemi et al. (2011), the authors were incorrect to sum the different sub-scales into an overall measure of intrinsic motivation and to conclude that their findings on KR-good feedback were due to motivational factors. In both of these studies, scores on the IMI overall, and the perceived competence sub-scale, were found to be significantly higher in the KR-good group than the KR-poor group. Thus, it may have been more accurate to conclude that KR on relatively good trials affected perceived competence rather than intrinsic motivation per se.

In cognitive evaluation theory (CET; Deci, 1975; Deci & Ryan, 1985), a desire for competence is considered a basic psychological need (Deci & Ryan, 2000), with individuals being intrinsically motivated to pursue an activity when they feel competent and self-determined towards it (Ryan & Deci, 2002). Conceptually similar to the construct of self-efficacy (Bandura, 1997), highly self-efficacious individuals have been found to show more persistence in acquiring a skill (Feltz, Short, & Sullivan, 2008), leading to enhanced learning and engagement with the task (Deci & Ryan, 2008; Sheldon & Filak, 2008). Thus, the provision of augmented feedback that positively impacts a learner's perceptions of competence and self-efficacy would be expected to ultimately impact subsequent intrinsic motivation (Ryan & Deci, 2000, 2002).

Self-efficacy, which refers to the belief a person has in regard to their ability to execute specific actions relative to the achievement of specific outcomes (Bandura, 1997; Feltz, 2007, pp. 278–294), is both important for motor learning and affected by feedback. Saemi, Porter, Ghotbi-Varzaneh, Zarghami, and Maleki (2012) found participants who received KR on their most successful trials in a tennis ball throwing task were more accurate in a delayed retention test and reported higher levels of self-efficacy than participants who received feedback on their least successful trials. Similarly, by manipulating learners' perceptions of competence and related self-efficacy, Chiviacowsky, Wulf, and Lewthwaite (2012) found the typical learning benefits of self-controlled practice (see Chiviacowsky & Wulf, 2002, 2005) can be reduced by denying learners the opportunity to experience competence through good performance.

Perceptions of competence and self-efficacy appear to have an important influence on motor skill learning and, consistent with Wulf and Lewthwaite's (2016) OPTIMAL theory of motor learning, enhancing expectations of future performance success may be beneficial to learning. In a recent study, Palmer, Chiviacowsky, and Wulf (2016) had participants practice a putting task, where different groups were informed that balls coming to rest in a large or small circle, respectively, would be considered 'good' putts. Participants with the large circle criterion (i.e., the relatively easy goal) were found to outperform the group with the small circle criterion (i.e., the relatively difficult goal) on both retention and transfer tests. Though learning was facilitated by enhancing learners' expectation of success, only performance measures were used in this study and, as the authors themselves highlight, measures of self-efficacy or perceived competence would be useful in future studies (Palmer et al., 2016).

In the present study we aimed to further investigate the motivational properties of feedback, and how feedback as a learning variable may operate. Specifically, the aim was to investigate how KR after good trials affects self-efficacy, intrinsic motivation, and motor learning relative to KR after poor trials, and whether any observed effects apply for learning both simple and more difficult tasks. We used a motor task in which participants were required to putt a golf ball into a target hole at distances of 2m (easy task) and 5m (difficult task) (tasks described as capturing easy and more difficult levels by Guadagnoli, Holcomb, & Davis, 2002). To address limitations of previous research (e.g., Badami et al., 2011; Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009; Saemi et al., 2012), we also included a control condition to determine whether poor-trial feedback reduces self-efficacy and motivation relative to 'neutral' feedback. Given that learning reflects a relatively long-term change in performance (Schmidt, 1991) but has typically been measured only 24-h after practice (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2012; Saemi et al., 2011, 2012), we also employed both 24-h and one-week retention tests.

As providing KR after more accurate (KR-good) compared to less accurate (KR-poor) trials is believed to have motivational effects on learning, we predicted that participants in the KR-good group would show increases in self-efficacy and intrinsic motivation compared to the KR-poor group, and KR-neutral (control) condition. We also predicted that golf-putting accuracy would be better for the KR-good group on 24-h and one-week retention tests regardless of task difficulty.

2. Method

2.1. Participants

An opportunity sample of 30 participants (16 males, 14 females) completed the study (*M* age = 29.67 years, *SD* = 9.36). All participants, except three, were right-hand dominant and all had minimal golfing experience (*M* number of years playing experience = 0.28, *SD* = 0.52; *M* number of hours per week currently playing = 0.12, *SD* = 0.41). All participants provided informed consent and the study was carried out according to institutional ethical guidelines.

2.2. Task and apparatus

Participants stood behind an opaque curtain (170cm × 140cm)

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