# Good- vs. Poor-Trial Feedback in Motor Learning: The Role of Self-Efficacy and Intrinsic Motivation Across Levels of Task Difficulty

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**Abstract**

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-hour 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.

*Keywords:* feedback; knowledge of results; motivation; motor learning; self-efficacy.

# 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 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), 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, Chiviacowksy, 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 hours after practice (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2012; Saemi et al., 2011, 2012), we also employed both 24-hour 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-hour 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 = .28, *SD* = .52; *M* number of hours per week currently playing = .12, *SD* = .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 x 140cm) that was attached to a metal frame and positioned one metre (m) from the putting line. Participants were required to putt a standard golf ball (Dunlop 30%) along a flat carpeted putting surface using a TP13 RH/LH putter into a target hole (diameter = 10.61cm) both 2m and 5m from the starting location. The metal frame, which the curtain was attached to, allowed the curtain to be raised from the floor, meaning the golf ball could pass underneath. The task and experimental set-up is illustrated in Figure 1.

FIGURE 1 NEAR HERE

## 2.3 Measures

**2.3.1 *Self-Efficacy Scale.*** Bandura's (2006) *Guide for Constructing Self-Efficacy Scales* was used to develop the self-efficacy scale. This focussed on learners' ability beliefs when putting to a range of distances (1m, 2m, 3m, 4m, and 5m) and was rated on a 100% scale with a range of 10 equal intervals (i.e., 0 = not confident at all, 100 = completely confident).

**2.3.2 *Intrinsic Motivation Inventory.*** Similar to Badami et al. (2011), a nine-item questionnaire consisting of the interest/enjoyment, perceived competence, and effort/importance sub-scales of the IMI (McAuley et al., 1989) was adapted for use in the study. This assessed participants' subjective experiences related to the target activity. Likert scale responses ranged from 1 = strongly disagree to 7 = strongly agree. Negatively-worded items were re-scored before data analysis. Internal consistency using Cronbach's-α statistic was found to be acceptable for the interest/enjoyment (.78) and effort/importance (.72) sub-scales, and high for the perceived competence sub-scale (.83).

## 2.4 Procedure

**2.4.1 *Assignment to feedback groups.*** Prior to collecting data, participants made ten putts to a target hole at a distance of 3.5m with full vision, all of which were measured and recorded to allow equal assignment to feedback groups (i.e., KR-good, KR-poor, and KR-neutral) based on skill level. This distance was chosen to minimise any additional practice effects at the 2m and 5m distances used in the main study.

**2.4.2. *Distance familiarisation putts.*** To familiarise themselves with the task before the subsequent occluded vision conditions, participants performed ten putts to the target distance; with the 2m and 5m conditions counterbalanced to control for order effects. Thus, throughout the study, participants either completed all trials at familiarisation, pre-test, acquisition, post-test, and retention firstly to the 2m distance, and then to the 5m distance, or vice versa.

**2.4.3 *Pre-test.*** Each participant made ten putts to the target distance (either 2m or 5m) from behind the opaque screen. Performance was measured and recorded as the distance (in cm) from the target hole to where the ball stopped. The direction of the ball from the target was also recorded. All putts were completed without augmented feedback.

**2.4.4 *Acquisition.*** Participants completed five blocks of six trials to the target distance (either 2m or 5m); therefore a total of 60 acquisition trials were completed across the study (30 trials at 2m; 30 trials at 5m). Prior to completing each block of trials, participants were informed that at the end of that block they would receive KR on three of the six trials. 'KR-good' participants received feedback on their three most accurate trials; 'KR-poor' participants received feedback on their three least accurate trials; and 'KR-neutral' participants received feedback on three random trials in each block using a computer-generated randomisation list. To avoid the influence of evaluative feedback from the researcher (Horn, 1987), KR was written on a whiteboard and presented to participants for 15 seconds (see Figure 2). The KR informed participants of the specific attempts they were receiving feedback on, the degree of error from the target, as well as the direction of the error.

FIGURE 2 NEAR HERE

**2.4.5 *Post-test and Retention.*** Once all acquisition blocks had been completed, participants performed an immediate post-test which consisted of ten trials to the target distance without feedback. Retention tests were then completed 24 hours and one week after acquisition, where participants performed ten more putts at each distance without augmented feedback (see Figure 3 for timeline of experimental task).

All participants completed the customised self-efficacy scale and the IMI (McAuley et al., 1989) at the end of each test phase (i.e. pre-test, post-test, and 24-hour and one-week retention).

FIGURE 3 NEAR HERE

**2.5 Analysis**

A three-way mixed ANOVA was used for the main analysis, with the between-participants factor being feedback (KR-good, KR-poor, KR-neutral), and the within-participants factors being task difficulty (easy; 2m vs. more difficult; 5m), and test phase (pre-test, post-test, 24-hour retention, one-week retention). Radial error (recorded as the distance in cm from the target hole to where the ball stopped on each trial) was used as the dependent variable to measure putting performance in terms of deviation from the target. Measures of self-efficacy, interest/enjoyment, perceived competence, and effort/importance were also recorded and analysed using separate three-way mixed ANOVAs. Differences in pre-test scores for any measures were subsequently adjusted using two-way ANCOVAs across both the 2m and 5m distance, where appropriate. As a manipulation check, mean radial error for KR and no-KR trials was analysed using a three-way mixed ANOVA, with the between-participants factor being feedback (KR-good, KR-poor, KR-neutral), and the within-participants factors being task difficulty (2m, 5m) and trial type (KR, no-KR). This was to determine whether radial error on KR trials was actually significantly lower (i.e., more accurate) for the KR-good group relative to the KR-poor and KR-neutral groups. Partial eta squared values ($\eta_p^2$) are provided as a measure of effect size for all main effects and interactions and Cohen's *d* values are also reported where comparisons are made between two means. Post-hoc analyses used paired-samples t-tests for within-participants and independent-samples t-tests for between-participants effects (alpha levels adjusted according to number of comparisons). Exact *p*-values are given for all analyses, except where $p < .001$.

## 3. Results

**3.1 Radial Error.** Main effects of feedback ($F_{(2, 27)} = 4.59$, $p = .02$, $\eta_p^2 = .25$), test phase ($F_{(3, 81)} = 17.96$, $p < .001$, $\eta_p^2 = .40$), and task difficulty ($F_{(1, 27)} = 266.25$, $p < .001$, $\eta_p^2 = .91$) were superseded by a significant three-way interaction ($F_{(6, 81)} = 8.20$, $p < .001$, $\eta_p^2 = .38$). There were no differences at pre-test between the KR-good (*M* = 87.34, *SD* = 24.65), KR-poor (*M* = 89.18, *SD* = 18.84), and KR-neutral groups (*M* = 86.21, *SD* = 29.43), however, at one-week retention, the KR-good group (*M* = 58.93, *SD* = 22.96) was more accurate than both the KR-poor (*M* = 80.85, *SD* = 37.24), *d* = .71, and KR-neutral groups (*M* = 79.54, *SD* = 21.57), *d* = .93, who were no different to one another (*d* = .04). Such differences were found to vary across task difficulty, as detailed below.

**3.1.1 *2m distance.*** For the 2m putt, post hoc comparisons (adjusted alpha level of .004) revealed that whilst the KR-good and KR-poor groups improved from pre-test (*M* = 65.96, *SD* = 7.30; *M* = 77.46, *SD* = 17.83) to 24-hour retention (*M* = 47.14, *SD* = 6.97; *M* = 52.69, *SD* = 10.14) (*p*'s < .001, *d*'s = 2.64 and 1.71); only the KR-good group improved from pre-test to one-week retention (*M* = 41.90, *SD* = 5.62) ($p < .001$, $d = 3.69$) but the KR-poor group did not (*M* = 52.17, *SD* = 9.47) ($p = .01$, $d = 1.77$). The KR-neutral group showed no change from pre-test (*M* = 61.67, *SD* = 17.33) to 24-hour (*M* = 51.98, *SD* = 17.74) ($p = .23$, $d = .55$) and to one-week retention (*M* = 62.08, *SD* = 12.88) ($p = .95$, $d = .03$) (see Figure 4).

**3.1.2 *5m distance.*** For the 5m putt, post hoc comparisons (adjusted alpha level of .004) revealed that the KR-good group improved significantly from pre-test (*M* = 108.71, *SD* = 14.63) to 24-hour (*M* = 79.38, *SD* = 11.73) and to one-week retention (*M* = 75.95, *SD* =

20.90) (*p*'s < .001, *d*'s = 2.21 and 1.82), whereas the KR-poor group showed no significant differences from pre-test (*M* = 100.89, *SD* = 11.26) to 24-hour (*M* = 121.91, *SD* = 32.89; *p* = .05, *d* = .86) and to one-week retention (*M* = 109.53, *SD* = 31.79; *p* = .32, *d* = .36). The KR-neutral group showed a significant improvement from pre-test (*M* = 110.75, *SD* = 13.78) to 24-hour retention (*M* = 94.49, *SD* = 17.40; *p* = .001, *d* = 1.04), but no difference from pre-test to one-week retention (*M* = 96.99, *SD* = 11.82; *p* = .03, *d* = 1.07) (see Figure 4).

FIGURE 4 NEAR HERE

**3.1.3. *KR vs. no-KR trials manipulation check.*** Analysis of mean radial error on KR versus no-KR trials during acquisition revealed a significant feedback x task difficulty x trial type interaction ($F_{(2, 27)} = 16.61$, $p < .001$, $\eta_p^2 = .55$). Post hoc comparisons (adjusted alpha level of .017) showed that for both the 2m and 5m distance, the KR-good group did in fact receive KR on relatively more accurate trials, and the KR-poor group received KR on relatively less accurate trials, in comparison to KR-neutral (*p*'s < .001); while the opposite was true for no-KR trials (see Figure 5 for an illustration of radial error on KR and no-KR trials for each feedback group across all practice blocks).

FIGURE 5 NEAR HERE

**3.2 Self-Efficacy.** Pre-test differences in self-efficacy scores between the KR-neutral group (*M* = 70.00, *SD* = 8.90) and both the KR-good (*M* = 62.00, *SD* = 12.68) (*p* = .01, *d* = .73) and KR-poor group (*M* = 44.75, *SD* = 10.24) (*p* < .001, *d* = 2.63) were adjusted using a two-way ANCOVA across both the 2m and 5m distance. Analyses revealed a significant main effect of feedback ($F_{(2, 26)} = 6.43$, $p = .01$, $\eta_p^2 = .33$) and a main effect of test phase ($F_{(2, 52)} = 7.10$, $p = .01$, $\eta_p^2 = .22$), after controlling for pre-test scores. Overall, levels of self-efficacy increased from pre-test (*M* = 58.92, *SD* = 14.89) to post-test (*M* = 62.25, *SD* = 17.95) (*p* =

.01, *d* = .20) and from pre-test to one-day (*M* = 63.25, *SD* = 18.03) (*p* = .01, *d* = .26) and one-week retention (*M* = 65.75, *SD* = 14.01) (*p* < .001, *d* = .47). Participants in the KR-good group reported significantly higher levels of self-efficacy (*M* = 68.89, *SD* = 5.73) compared to the KR-poor group overall (*M* = 58.51, *SD* = 7.24) (*p* = .01, *d* = 1.59). The KR-neutral group (*M* = 63.86, *SD* = 6.67) did not significantly differ from either KR-good (*p* = .21, *d* = .81) or KR-poor (*p* = .45, *d* = .77) groups (see Table 1). There were no other significant effects at *p* < .05.

**3.3 Interest/Enjoyment.** There was a significant main effect of feedback ($F_{(2, 27)}$ = 17.03, *p* < .001, $\eta_p^2$ = .56) (see Table 1) and a significant feedback x test phase interaction ($F_{(6, 81)}$ = 6.26, *p* < .001, $\eta_p^2$ = .32). While there were no differences in levels of interest/enjoyment between the KR-good (*M* = 5.63, *SD* = .57), KR-poor (*M* = 5.60, *SD* = .50), and KR-neutral groups (*M* = 5.13, *SD* = .74) at pre-test, post-hoc comparisons (adjusted alpha level of .008) revealed that the KR-good group showed significant increases in interest/enjoyment from pre-test to 24-hour (*M* = 6.37, *SD* = .47; *p* = .004, *d* = 1.42) and to one-week retention (*M* = 6.48, *SD* = .60; *p* = .001, *d* = 1.45), while the KR-poor (*p*'s = .06 and .02, respectively; *d*'s = .62 and .65) and KR-neutral groups (*p*'s = .81 and .61, respectively; *d*'s = .08 and .11) showed no differences from pre-test to both 24-hour and one-week retention. There were no other significant effects at *p* < .05.

**3.4 Perceived Competence.** Pre-test differences in perceived competence between the KR-good (*M* = 4.05, *SD* = .56) and KR-neutral group (*M* = 4.78, *SD* = .47) (*p* = .01, *d* = 1.41) were adjusted using a two-way ANCOVA across both the 2m and 5m distance. Analyses revealed a significant main effect of feedback ($F_{(2, 26)}$ = 21.92, *p* < .001, $\eta_p^2$ = .63) after controlling for pre-test scores. The KR-good group (*M* = 5.76, *SD* = .53) reported significantly higher levels of perceived competence overall, compared to the KR-poor (*M* =

4.27, *SD* = .51; $p < .001$, *d* = 2.86) and KR-neutral group (*M* = 4.61, *SD* = .55; $p < .001$, *d* = 2.13). There were no differences in perceived competence between the KR-poor and KR-neutral group (*p* = .53, *d* = .64) (see Table 1). No other significant effects were reported at $p < .05$.

**3.5 Effort/Importance.** Pre-test differences in levels of effort/importance between the KR-good (*M* = 6.05, *SD* = .44) and KR-poor group (*M* = 5.40, *SD* = .61) (*p* = .01, *d* = 1.22) were adjusted using a two-way ANCOVA across both the 2m and 5m distance. Analyses revealed a significant main effect of feedback ($F_{(2, 26)} = 10.33$, $p < .001$, $\eta_p^2 = .44$) after controlling for pre-test scores. The KR-good group (*M* = 6.57, *SD* = .45) reported significantly higher levels of effort/importance overall, compared to the KR-poor (*M* = 5.73, *SD* = .48; *p* = .01, *d* = 1.81) and KR-neutral group (*M* = 5.80, *SD* = .44; *p* = .01, *d* = 1.73). There were no differences in effort/importance between the KR-poor and KR-neutral group (*p* = .99, *d* = .15) (see Table 1). No other significant effects were reported at $p < .05$.

TABLE 1 NEAR HERE

## 4. Discussion

In this study we aimed to investigate the motivational properties of augmented feedback in learning simple and more difficult motor skills. Specifically, we tested whether receiving feedback after more accurate (KR-good) trials enhanced self-efficacy and intrinsic motivation, relative to receiving feedback after less accurate (KR-poor) trials and a control (KR-neutral) condition. We hypothesised that if feedback has a motivational effect on learning, participants in the KR-good condition would show increases in self-efficacy and intrinsic motivation, compared to those receiving KR-poor and KR-neutral feedback. We also predicted that performance on the putting task would be more accurate for the KR-good group at retention in comparison to KR-poor and KR-neutral groups, regardless of task difficulty.

As hypothesised, levels of self-efficacy and intrinsic motivation (as measured by the interest/enjoyment sub-scale of the IMI) were found to increase from pre-test to 24-hour and one-week retention, whereby participants receiving feedback after good trials reported higher levels of self-efficacy and interest/enjoyment compared to those receiving feedback after poor trials. Similarly, for the perceived competence and effort/importance sub-scales of the IMI, participants receiving feedback after good trials reported higher levels on these measures relative to the KR-poor and KR-neutral groups, who were found to not differ from one another. Thus, even though participants were not told for which trials they would receive KR and were not explicitly told that their feedback related to good, poor, or neutral performance attempts, the type of feedback given affected, to some extent, their self-efficacy, as well as indicators of intrinsic motivation as measured through the IMI, with such effects generalising across task difficulty.

Importantly, when considering the link between perceptions of competence and intrinsic motivation with motor learning, participants in the KR-good group also demonstrated more accurate performance in the golf putting task at 24-hour and one-week retention, indicative of enhanced learning. These findings are consistent with previous research showing a motivational role of augmented feedback (e.g., Badami et al., 2011; Chiviacowsky et al., 2009, 2012; Chiviacowsky & Wulf, 2007; Saemi et al., 2012) when feedback is provided after good rather than poor performance attempts. However, these cited examples only measured retention performance 24 hours following acquisition. Here, we have demonstrated these observed effects to be maintained, and even become more pronounced, at one-week compared to 24-hour retention. The observed effects at 24-hour retention did not subside despite a relatively small number of acquisition trials, highlighting the beneficial effects of providing feedback after positive performances on learning, and the way some motivational constructs can impact this.

It has been suggested that individuals are intrinsically motivated to pursue an activity when they feel competent and self-determined with regard to that activity and as such, feedback that influences learners' perceptions of competence can ultimately impact intrinsic motivation (Ryan & Deci, 2000, 2002). Feelings of competence, in the form of self-efficacy beliefs, have been suggested to be integral for motivation (Bandura, 1986) and important for facilitating motor skill learning (Feltz & Lirgg, 2001; Moritz, Feltz, Fahrbach, & Mach, 2000) whereby mastery experiences are one of the strongest predictors of enhanced self-efficacy (Bandura, 1997). Here, although participants in the KR-good group reported higher levels of self-efficacy overall, those receiving KR-neutral feedback did not significantly differ from either the KR-good or KR-poor groups, and thus, it is not possible to attribute motivational effects of feedback to self-efficacy alone. Interestingly, though conceptually similar to self-efficacy, levels of perceived competence were found to be higher for the KR-good group compared to both KR-poor and KR-neutral, who did not significantly differ from one another. Though these constructs share common conceptual ground, there are theoretical differences suggested to make the two distinct from one another (Bandura, 1997), as reflected in the measures used. Whilst the perceived competence sub-scale of the IMI focuses on how well the learner felt they performed the practiced task (i.e., an experiential judgment), the self-efficacy scale focuses on a task-relevant prediction of ability (i.e., a future judgment). It seems that the type of feedback given to learners impacted to a greater extent their perceived competence of the practiced task, more so than their efficacy for executing a future behaviour (Bandura, 1997). The perceived competence measure may have been more sensitive to this due to it being considered within the context of the practiced task, which in turn had personal relevance to the learner in the situation at that given time (e.g., see White, 1959). Given this is one of the first studies to look at the combined effects of self-efficacy and intrinsic motivation within the good- vs. poor-trial feedback paradigm, it would be of interest for future research to explore these effects further as there appears to be evidence for a role of at least some motivational properties in the feedback given to learners, though it is not entirely clear which mechanisms may account for this. Future research may also benefit from analysing a range of distances when measuring self-efficacy, rather than just the 2m and 5m distances reported here, as this may provide greater sensitivity in measures of self-efficacy for similar studies going forward.

Overall, the findings presented here are consistent with some of the assertions of the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016), which suggests conditions that enhance expectations of success may be beneficial to learning and motivation. While the findings in the present study offer support for these proposals, it is important to note that when putting to the 2m distance, participants in the KR-poor group did show some improvement in putting performance at 24-hour retention; but unlike the KR-good group, this was not maintained at one-week retention. It has been suggested that explicitly grouping KR trials as a function of the participant's performance (regardless of whether it relates to KR-good or KR-poor) may increase the informational value of KR (Patterson & Azizieh, 2012); suggesting that whilst there may be some role of motivational feedback on learning, this is not always the key contributor to effective performance. In addition, it is worth noting that consistency has been argued to be a better indicator of learning than performance accuracy (e.g., Fischman, 2015; Schmidt & Lee, 2011), and this is an important consideration for future motor learning research as our radial error findings limit the conclusions that can be drawn here. However, given that learning is said to reflect a relatively long-term change in performance (Schmidt, 1991), the inclusion of a one-week retention test in the present study seems to at least be a more sensitive measure of long-term learning, and may account for the lack of effects for the KR-poor group under extended retention periods.

A novel aspect of our research, and an area relatively under researched to-date, was the comparison between an easier and more difficult task. We replicated findings from previous research that had reported positive effects of good-trial feedback on motor learning in simple tasks (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009) and found these effects transferred to learning more difficult tasks too. In fact these effects became more pronounced for the more difficult (5m) compared to the easy (2m) task, suggesting the motivational properties of feedback may be more beneficial to learners as task difficulty increases. The learning of more difficult or complex tasks has received very little attention compared to simple skills (Sigrist, Rauter, Riener, & Wolf, 2013), and thus our findings add to the growing body of literature on the motivational role of feedback in motor learning by highlighting its generalisability to learning more difficult skills.

In conclusion, our results add to the converging evidence concerning the motivational role of feedback in facilitating motor skill learning. Research to-date has not looked at self-efficacy and intrinsic motivation in combination and thus, this is the first study to demonstrate the way some of these motivational constructs may impact learning as a result of augmented feedback after good performances. Moreover, we have highlighted that such effects apply to learning more difficult versions of a skill. Given the benefits of engaging in activities for more intrinsic reasons, identifying factors related to the development and facilitation of intrinsically-motivating behaviours is important for enhancing learning; and suggests that simple changes in the feedback given to learners may help create the conditions necessary for optimal learning by enhancing some of its motivational properties.

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## Tables and Table Captions

| | 2m Distance | | | 5m Distance | | |
|---|---|---|---|---|---|---|
| | KR-Good | KR-Poor | KR-Neutral | KR-Good | KR-Poor | KR-Neutral |
| **Self-Efficacy** | 81.95 (SD = 8.89) | 62.14 (SD = 9.15) | 68.24 (SD = 10.06) | 66.04 (SD = 8.57) | 41.70 (SD = 9.27) | 62.43 (SD = 9.22) |
| **Interest/Enjoyment** | 6.17 (SD = .80) | 5.47 (SD = .64) | 5.28 (SD = .59) | 6.13 (SD = .52) | 5.19 (SD = .52) | 5.11 (SD = .65) |
| **Perceived Competence** | 5.65 (SD = .70) | 4.50 (SD = .67) | 4.69 (SD = .71) | 5.79 (SD = .56) | 4.02 (SD = .55) | 4.62 (SD = .57) |
| **Effort/Importance** | 6.58 (SD = .63) | 5.71 (SD = .65) | 5.90 (SD = .61) | 6.70 (SD = .45) | 5.55 (SD = .48) | 5.78 (SD = .45) |

Table 1. Mean scores on the self-efficacy, interest/enjoyment, perceived competence, and effort/importance measures for the KR-good, KR-poor, and KR-neutral group at both the 2m and 5m distance.[1]

[1] Values represent adjusted scores to account for any pre-test differences between the groups.

**Figures and Figure Captions**

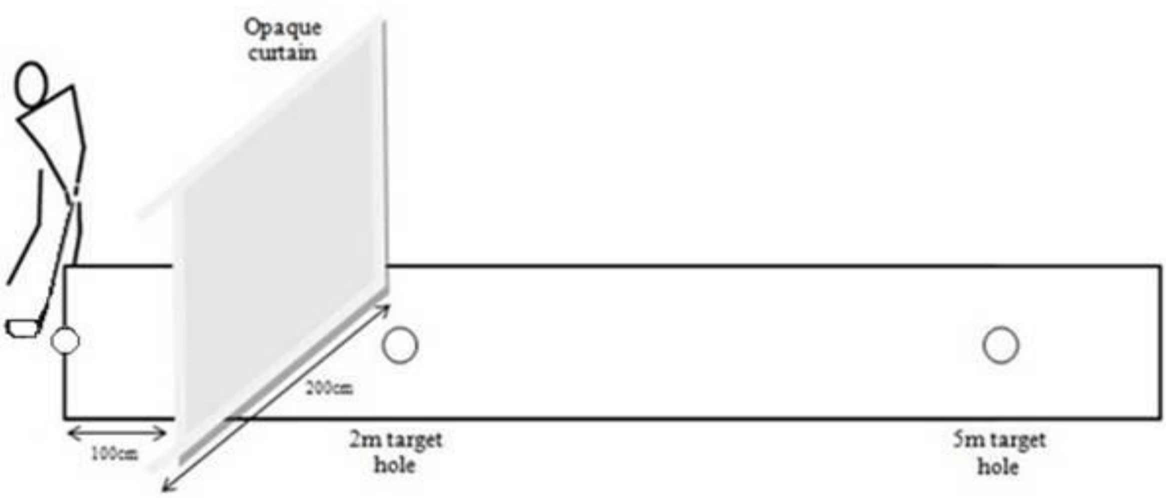


Figure 1. The golf-putting task:  Participants were required to putt a golf ball into a target hole at distances of both 2m and 5m from behind an opaque screen.

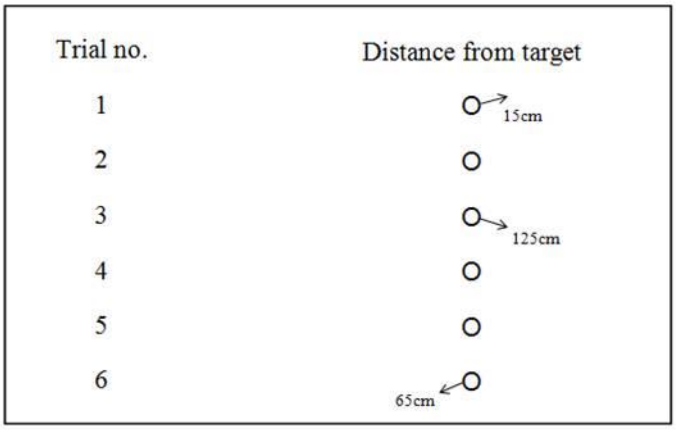


Figure 2. Example of KR presentation to participants for three trials in a block. The whiteboard displayed the trial number, respective error distance, and direction of the ball from the target (as indicated by an arrow).

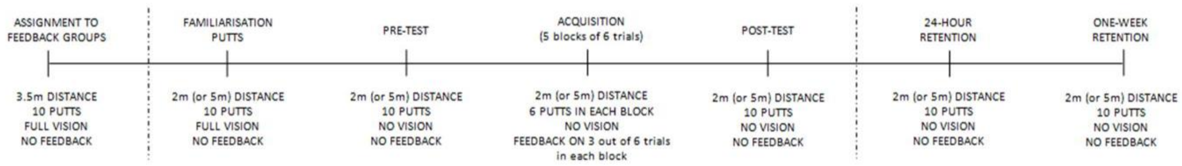


Figure 3. Timeline of experimental task. The 2m and 5m distance were counterbalanced across the study; thus, participants either completed all trials at familiarisation, pre-test, acquisition, and post-test firstly to the 2m distance, and then to the 5m distance, or vice versa.

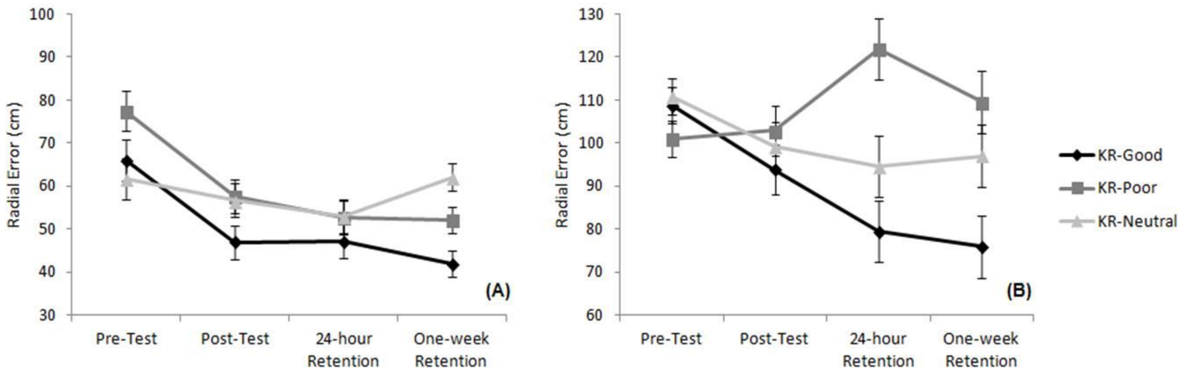


Figure 4. Mean radial error (cm) for the KR-good, KR-poor, and KR-neutral group across each test phase when putting to 2m (A) and 5m (B). Error bars represent standard error.

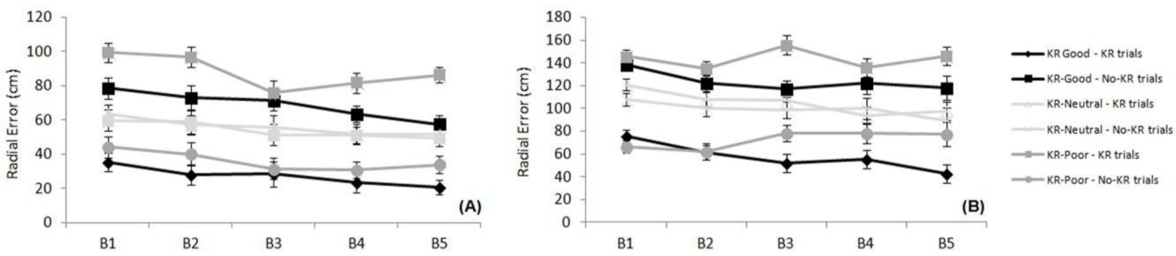


Figure 5. Mean radial error (cm) on KR trials and no-KR trials for the KR-good, KR-poor, and KR-neutral group across practice blocks when putting to 2m (A) and 5m (B). Error bars represent standard error.