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Feedback About More Accurate Versus Less Accurate Trials: Differential Effects on Self-Confidence and Activation

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One purpose of the present study was to examine whether self-confidence or anxiety would be differentially affected by feedback from more accurate versus rather than less accurate trials. The second purpose was to determine whether arousal variations (activation) would predict performance. On Day 1, participants performed a golf putting task under one of two conditions: one group received feedback on the most accurate trials, whereas another group received feedback on the least accurate trials. On Day 2, participants completed an inventory and performed a retention test. Skin conductance level, as a measure of arousal, was determined. The results indicated that feedback about more accurate trials resulted in more effective learning as well as increased self-confidence. Also, activation was a predictor of performance.

Key words: Competitive State Anxiety Inventory-2, golf putting, knowledge of results, motor learning

Feedback (knowledge of results[KR]; knowledge of performance [KP]) plays an important role in learning motor skills. Feedback can have different roles including informational and motivational functions (Schmidt & Wrisberg, 2008). Many experimental studies have been concerned with the *informational* function of feedback and its role in providing information about an individual's performance in relation to the task goal. This research has provided important insights into the role of augmented feedback for learning (for reviews, see Schmidt, 1991; Swinnen, 1996; Wulf & Shea, 2004). An aspect of feedback that has been largely neglected, or has been assumed to exert only temporary effects on motor performance, is its *motivational* role (Schmidt & Lee, 2005). Findings have indicated that the motivational properties of feedback can have a direct impact on learning. For example, feedback after good trials (i.e., summary feedback on accurate trials) was found to result in more effective learning than feedback after poor trials (i.e., summary feedback on inaccurate trials; Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Wally, & Borges, 2009). In the first study demonstrating the advantages of feedback after good trials, young adults practiced a task that required them to throw beanbags at a target, with vision being occluded (Chiviacowsky & Wulf, 2007). After every six-trial block, one group (KR good) received KR on the three most accurate trials in that block, whereas another group (KR poor) received feedback on the three least accurate trials. On a retention test without feedback, the KR good group demonstrated more effective learning of the task. More recently, these finding were replicated with older adults (Chiviacowsky et al., 2009).

The authors (Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009) speculated the learning difference was due to motivational factors. However, changes in participants' motivation were not assessed in those studies. Support for the notion that feedback highlighting good as opposed to poor trials has a positive influence on learners' motivation comes from a study by Badami, VaezMousavi, Wulf, and Namazizadeh (2011). Participants

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in that study practiced a golf putting task, with different groups receiving feedback on relatively accurate versus inaccurate trials, similar to previous studies (Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009). At the end of practice, they filled out a questionnaire (Intrinsic Motivation Inventory; McAuley, Duncan, & Tammen, 1989) assessing their intrinsic motivation (i.e., interest/enjoyment, perceived competence, effort/importance). The findings demonstrated that individuals' intrinsic motivation was indeed higher when feedback was provided after accurate trials. In particular, perceived competence was greater in the "KR on good trials" group than in the "KR on poor trials" group. "Perceived competence" has been used in the achievement and mastery motivation literature to indicate the sense that one has the ability to master a task (Feltz, 2007). There is evidence that a higher level of perceived competence is associated with higher levels of performance and lower levels of anxiety (Harter, 1992; Lucangegi & Scruggs, 2003).

Furthermore, in multidimensional anxiety theory, Martens, Burton, Vealey, Bump, and Smith (1990) proposed a series of two-dimensional relationships between state anxiety (consisting of two subcomponents: cognitive and somatic), self-confidence, and performance. Cognitive anxiety is the mental component of anxiety typified by negative expectations of performing a task and cognitive concern. Somatic anxiety is the physical component of anxiety. It is reflected in such responses as rapid heart rate, shortness of breath, clammy hands, butterflies in the stomach, and tense muscles. Self-confidence is one's belief in being able to successfully perform a specific activity (Martens et al., 1990). Empirical findings have shown that higher levels of self-confidence in athletes are associated with greater perceptions of preparedness and increased intensity of positive thoughts and feelings (e.g., Hanton, Mellalieu, & Hall, 2004; Jones, Swain, & Hardy, 1993). Bandura (1977) viewed self-confidence as specific to particular domains of functioning and as being derived from the cognitive appraisal of diverse sources of information. These include enactive and vicarious experiences, social influences, and physiological information. The relationship between anxiety and self-confidence is hypothesized to be negative, and the relationship between self-confidence and performance is assumed to be positive (Martens et al., 1990).

If feedback after more accurate, as opposed to less accurate, trials results in greater perceived competence, one may expect that feedback after good trials results in greater self-confidence and lower anxiety, which may influence performance. That prediction is based on the Badami et al. (2011) study, which found that KR after good trials improved motivation, and in particular perceived competence. Therefore, the first purpose of the present study was to assess whether the type of feedback learners receive about their performance affected their self-confidence, as well as somatic and cognitive anxiety.

We also wanted to examine whether activation (or arousal variations relative to a baseline level; Barry, Clarke, McCarthy, Selikowitz, & Rushby, 2005; VaezMousavi, Barry, & Clarke, 2009; VaezMousavi, Barry, Rushby, & Clarke, 2007a, 2007b; VaezMousavi, Hashemi-Masoumi **[No hyphen in Refs.]**, & Jalali, 2008) would predict performance.

A series of studies (Barry et al., 2005; VaezMousavi et al, 2007a, b; 2008; 2009) demonstrated that task performance depends on activation rather than the current arousal level. This was the case for children (Barry et al., 2005) and adults (VaezMousavi et al., 2007a). Participants in those studies practiced a continuous performance task that required them to click a button when they saw the ''target" stimulus on a screen. Their reaction time and the number of errors were recorded. The findings demonstrated that activation, not arousal, affected performance (Barry et al., 2005; VaezMousavi et al., 2007a, b). A within-participants/across-trials study of performance (VaezMousavi et al., 2007b) and an individual difference study (VaezMousavi et al., 2009) also demonstrated that activation affected performance. Another study examined the effect of activation on performance in a sport task and found that activation affected air rifle shooting performance (VaezMousavi et al., 2008).

In the present study, we examined whether feedback on good versus poor trials would differentially affect activation levels, and whether activation would predict retention performance. If so, this would provide more direct evidence for the motivational influences of feedback on learning. We used skin conductance level (SCL) to measure the degree of arousal in the two feedback conditions. SCL is a sensitive measure of the tonic modulation of sympathetic activity (Malmo, 1959) and continues to be regarded as the "gold standard" in the measurement of arousal (e.g., Barry & Sokolov, 1993).

Method

Participants

Participants were 40 female **[university?]** students (M age = 19.5 years, SD = 1.9). All participants provided informed consent. They had no prior experience with the experimental task and were not aware of our specific study purpose. The experimental protocol was reviewed and approved by the university's Advising Committee of Science and Research.

Apparatus, Task, and Procedure

The task required participants to putt a golf ball to a target placed on the floor. The circular target had a 5-cm radius and was placed 4 m from the participant. Fourteen concentric circles with radii of 10, 15, 20, 25…75 cm were drawn around the target (as in Badami et al., 2011). The circles were labeled with capital letters. Specifically, the inner circle was labeled A, the next circle B, and so forth, with the last circle being labeled O. These served as zones to assess the accuracy of the strokes. If the ball came to rest on the target (A), 150 points were awarded. If it ended up in another other zone, or outside the circles, 140 (B), 130 (C)….10 (O), or 0 points, respectively, were recorded. Although participants could see the path of the ball, it was difficult to see the relatively small (English) letters from a distance. The fact that participants in the present study, as well as in a previous study (Badami et al., 2011), did not realize for which trials they were given feedback (good or poor) supports the notion that the feedback was not redundant.

The Competitive State Anxiety Inventory-2 (CSAI-2; Martens et al., 1990) was used to assess participants' cognitive and somatic anxiety as well as self-confidence. This instrument is a sport-specific, self-report inventory shown to be a reliable and valid measure of cognitive and somatic anxiety and self-confidence, with Cronbach's alpha coefficients ranging from 0.70 to 0.90 (Martens et al., 1990). The CSAI-2 consists of 27 items, 9 for each subscale (cognitive anxiety, somatic anxiety, and self-confidence). Each item was rated on a 4-point Likert-type scale, producing a score ranging from 9 to 36 for each subscale.

Skin conductance level was recorded from 7-mm diameter Ag/AgCl electrodes on the sole of the participant's foot, with an electrolyte of 0.05 M NaCl in an inert viscous ointment base. A constant voltage device (Model 2701SC for SCL/SCR data collection system; UFI, Morro Bay, CA), set at 0.5 V, was used to record electrodermal data (e.g., Barry et al., 2005; VaezMousavi et al., 2009).

Participants were randomly assigned to groups receiving KR either on more accurate trials (group MA) or less accurate trials (group LA). After each block of six trials, participants in the MA group received KR on their three most accurate (i.e., best) putts in that block, whereas those in the LA group received KR on their three least accurate putts (similar to Badami et al., 2011; Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009).

Participants in both groups were informed that, at the end of each block of six trials, they would receive KR on three of those trials. However, they were not told for which trials they would receive KR. KR was written on a board and presented to them for a period of 15 s. It consisted of the trial number and respective score. Although circles had been marked with English letters (A, B, C, etc.), participants received quantitative feedback. Participants were aware that scores ranged between 150 and 0. A plus or minus sign was included with each score to indicate whether the target was overshot or undershot, respectively (Badami et al., 2011). All participants performed 60 trials during the practice phase; on the following day, they performed a retention test consisting of 10 trials without KR. Participants completed the CSAI-2 prior to the retention test. Skin conductance level was also constantly recorded during the retention test. The mean SCL from .5-s epochs immediately before each stroke during the retention test was taken as the task-related arousal level for each stroke for each participant. In other words, because our sampling rate was 10 Hz (i.e., 10 data points per second), to calculate the arousal for a given putt, we averaged the five measurements just prior to ball contact (i.e., 5 s before the putt). This was used as our measure of arousal (similar to the procedure used by Barry et al., 2005; VaezMousavi et al., 2007a; 2007b; 2008; 2009). Five minutes after completing the retention test, participants performed another block without a target (during this block, the target was covered with a piece of cloth). The same measure of electrodermal activity for each participant in this block was taken as the reference arousal level for each stroke. The difference between these arousal levels was taken as the activation level in the retention phase.

Data Analysis

Putting accuracy scores were analyzed in a 2 (groups: MA, LA) × 10 (blocks of 6 trials) analysis of variance (ANOVA) with repeated measures on the last factor for the practice phase. In addition, to determine whether accuracy scores on KR trials were actually higher for the MA group than for the LA group, we analyzed the scores separately for KR and no-KR trials in a 2 (groups: MA, LA) x 2 (trial type: with KR vs. without KR) ANOVA. Four independent t tests were conducted for putting performance on the retention test as well as the three subscales of the CSAI2 (cognitive anxiety, somatic anxiety, and self-confidence). A linear regression analysis was conducted to test the hypothesized relationship between activation and retention performance.

Results

Practice

Accuracy Scores. Both groups increased their putting scores across practice blocks (see Figure 1). The MA group tended to have higher scores than the LA group. The main effect of block was significant, with $F(9, 342) = 2.99$, $p = .004$. Neither the main effect of group, $F(1, 38) = 2.29$, $p > .05$, nor the Group × Block interaction, $F(9, 342) < 1$, were significant.

Accuracy Scores on With KR Versus Without KR Trials. Analysis of the accuracy scores on with KR practice trials versus without KR trials revealed that scores on with KR trials were higher for the MA group (61.38) than the LA group (28.18). Conversely, scores on without KR trials were higher for the LA group (53.89) compared to the MA group (32.21). The interaction of group and trial type was significant, $F(1, 38) = 175.838$, $p < .001$, $\eta^2 = .82$. Thus, higher scores were reported for the MA group compared to the LA group.

Retention

On the retention test without KR, performed 1 day after the practice phase, the MA group had higher accuracy scores than the LA group. This group difference was significant, $t(38) = 2.76$, $p = .004$, $\eta^2 = .17$. Thus, providing KR after the most accurate trials during practice resulted in superior learning compared to providing KR after the least effective trials.

CSAI-2 Inventory

Means and standard deviations for the three CSAI-2 subscales are shown in Table 1. The LA group had lower self-confidence scores than the MA group and tended to have higher scores on cognitive and somatic anxiety. While group differences failed to reach significance for cognitive and somatic anxiety, $t(38) < 1$, the groups differed significantly in self-confidence, $t(38) = 2.88$, $p = .003$ (significant after Bonferroni adjustment for multiple comparisons), $\eta^2 = .18$.

Activation and Retention Performance

The results of the linear regression indicated that activation significantly predicted retention scores, $\beta = .34$, $t(38) = 2.22$, $p = .03$. Activation also explained a significant proportion of variance in retention scores, $R^2 = .11$, $F(1, 38) = 4.93$, $p = .03$.

Discussion

Recent studies have found that motor learning was enhanced when feedback was provided after good rather than poor trials (i.e., the most accurate rather than the least accurate trials) (Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009). The purpose of the present study was to examine whether a possible explanation for the benefits of feedback after good trials could be that such feedback enhances self-confidence and decreases anxiety relative to feedback after poor trials. We replicated the results of previous studies showing learning advantages of feedback after relatively accurate trials (Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009). Retention performance of the MA group was more effective than that of the LA group, thus, providing additional evidence for the benefits of feedback after trials with relatively small errors.

The learning advantage of feedback provided on accurate trials challenges the traditional view (e.g., Schmidt

Table1. Accuracy scores in retention, self-confidence ratings, and somatic and cognitive anxiety

Variables	LA group		MA group	
	M	*SD*	*M*	*SD*
Retention performance	52.20	12.35	41.55	12.05
Self-confidence	29.30	4.48	25.20	4.49
Somatic anxiety	15.80	6.09	16.75	5.18
Cognitive anxiety	20.20	6.78	21.50	5.44

Note. M = mean; *SD* = standard deviation; MA = more accurate trials; LA = less accurate trials.

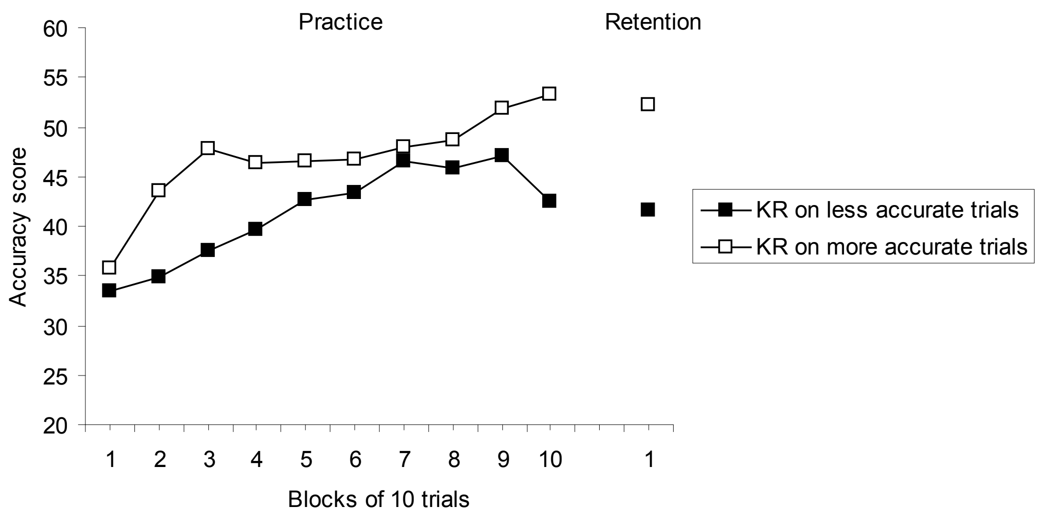

Figure 1. Accuracy scores for knowledge of results (KR) on more accurate trials and KR on less accurate trials groups during practice and retention.

& Lee, 2005). In fact, according to the guidance hypothesis (e.g., Salmoni, Schmidt, & Walter, 1984), feedback about errors should be beneficial as it guides the learner to the correct response. Numerous experiments provided support for this view (e.g., Schmidt, Young, Swinnen, & Shapiro, 1989; Wulf & Schmidt, 1996; Young & Schmidt, 1992). However, none compared the effect of feedback about larger versus smaller errors on learning. Our findings, as well as those of previous studies (Chiviacowsky & Wulf, 2007; Chiviacowsky et al., 2009), support the idea that feedback, separate from its guidance function, has important motivational influences on learning. A recent study provided direct evidence that feedback on accurate trials enhanced learners' intrinsic motivation, in particular their perceived competence (Badami et al., 2011). Other findings also pointed to motivational influences of feedback on motor performance and learning (Hutchinson, Sherman, Martinovic, & Tenenbaum, 2008; Lewthwaite & Wulf, 2010; Wulf, Chiviacowsky, & Lewthwaite, 2010). For example, Wulf et al., (2010) gave participants feedback about their actual performance when learning a timing task. For two groups, this feedback was supplemented by fabricated normative feedback about a peer group's average block-to-block improvement after each block of 10 trials. Those individuals who were led to believe that they performed above average demonstrated more effective learning than those who believed their performance was below average. Thus, positive social-comparative information enhanced learning. Together, these findings suggest the motivational properties of feedback *directly* affect learning—rather than having an indirect effect on learning (e.g., keeping learners alert, making practice more enjoyable; Schmidt & Lee, 2005).

How does positive feedback affect the learner's motivation and, as a consequence, learning? Feedback on accurate trials has been shown to influence individuals' perception of personal capability (i.e., perceived competence; Badami et al., 2011). Intrinsic motivation and optimal functioning or learning in a broad range of domains has been found to depend on the satisfaction of basic psychological needs, including the need to feel competent (e.g., Deci & Ryan, 2000, 2008). The perception of competence, in turn, presumably increases the learner's self-confidence, as demonstrated by the current findings. A heightened sense of competence and increased self-confidence may reduce self-related concerns and facilitate task-related attention and learning. In contrast to feedback on less accurate trials, the enhanced self-confidence resulting from "positive" feedback may have reduced the need for the allocation of attentional resources to self-regulatory activities, including thought or negative affect suppression (Carver & Scheier, 1978 **[Include in Refs.]**; Schmader, Johns, & Forbes, 2008 **[Include in Refs.]**). Thus, more effort and attention could be directed to task performance. The greater positive affect, perhaps experienced by MA group participants, may have led to higher goal setting (e.g., Aarts, Custers, & Holland, 2007; Ilies & Judge, 2005) compared to participants in the LA condition. Perhaps most importantly, our findings demonstrated that individuals' self-confidence was indeed higher when feedback was provided on accurate trials. This result is in line with findings of Escarti and Guzman (1999) who used bogus feedback to manipulate participants' perception of past performance. They found increased self-confidence when positive feedback was presented, compared to negative feedback (Feltz, 2007). The present findings provide an important link between the type of feedback and self-confidence, on the one hand, and learning, on the other. Both individuals' self-confidence and learning were increased when feedback was provided on accurate trials. Consistent with this finding, results of other studies have shown that performance is predicted by beliefs induced through feedback from a coach (Crust, 2005 **[AQ: Incl. in Refs.]**; Fitzsimmons, Landers, Thomas, & van der Mars, 1991). These findings have demonstrated that self-confidence may be a mediating factor between feedback and performance. Also, these findings are in line with previous studies that have demonstrated a positive relationship between self-confidence and performance (e.g., Bortoli & Robazza, 1997; Burton, 1988 **[AQ: Incl. in Refs.]**; George 1994; Martin & Gill, 1991; Taylor, 1987; Thelwell & Maynard, 1998).

According to Lucangegi and Scrugg's (2003) study, indicating a negative correlation between perceived competence and anxiety, and the Badami et al. (2011) study, demonstrating individuals' perceived competence was higher when feedback was provided on accurate versus inaccurate trials, we hypothesized that individuals' somatic and cognitive anxiety would be lower when feedback was provided on accurate trials. However, these hypotheses were not supported. The most viable explanation for this lack of effect may be related to the anxiety measurement. The method of measuring anxiety can have an affect on effect sizes (Woodman & Hardy, 2003). The CSAI-2 measures only the level of anxiety (i.e., intensity), and fails to take into account the individual's interpretation of the symptoms, that is, whether they have a positive or negative effect on performance (i.e., direction). Recent studies have found that the subjective interpretation of anxiety may be an important moderating variable. Participants may be similar in anxiety intensity but different in the interpretation of anxiety (e.g., Jones, Hanton, & Swain, 1994; Jones et al., 1993). Self-confidence has been shown to serve as a moderating factor in the interpretation of anxiety symptoms. Individuals who reported their anxiety to be facilitative towards performance had higher levels of self-confidence than those who viewed it as debilitating (e.g., Hanton et al., 2004; Jones & Swain, 1995; Mellalieu, Neil, & Hanton, 2006; Wadey & Hanton, 2008). The use of a modified version of the CSAI-2, which measures both the intensity of these symptoms on the original scale and the direction on a bipolar scale ranging from debilitative to facilitative (Jones & Swain, 1992), may be fruitful in future studies.

The present findings indicate that arousal changes (activation) predict retention performance. This result is in line with recent studies (Barry et al., 2005; VaezMousavi et al., 2007a, b; 2008; 2009) that demonstrated performance on a task depends on task-related arousal changes. This result is consistent with collative motivation theory, which predicts that change in arousal level plays a role in determining the quality and intensity of affective responses (Chapman & Foot, 1996). Furthermore, the MA group showed greater self-confidence and learning, suggesting that greater arousal management may be an explanation for the benefits of receiving KR after accurate trials compared to inaccurate trials. This notion appears to be supported by several studies that have observed self-confidence to affect arousal management (e.g., Hanton, Mellalieu, & Hall, 2004; Hardy, Jones, & Gould, 1996). More specifically, self-confidence has been shown to allow the performer to control negative thoughts and, assisted by tcontrol, interpret the experienced symptoms as facilitating performance (Carver & Scheier, 1999; Jones & Hanton, 2001). Also, confident athletes have a strong intrinsic motivation to develop their game and continue to succeed (Burton & Raedeke, 2008 **[AQ: Incl. in Refs.]**).

In conclusion, the present findings demonstrated that feedback after relatively accurate, as opposed to inaccurate, trials resulted in greater self-confidence and arousal management, which, in turn, influenced learning. The present results have implications for practical settings. In contrast to more experienced performers whose self-efficacy is based on previous experience with similar situations, novices tend to rely on instructor feedback when judging their capabilities (Fredenburg, Lee, & Solmon, 2001). Our findings suggest that positive feedback is a potentially powerful tool, with multiple benefits, that practitioners (e.g., teachers, coaches, physical therapists) can use when teaching novices. Future research should examine if similar patterns of results would be found in experienced performers.

In this study, all participants were female. We encourage future researchers to examine possible gender differences, as some studies have shown that, compared with men, women report higher anxiety and lower self-confidence in important situations (Martens et al., 1990), and lower perceived competence and enjoyment in physical education settings (Carroll & Loumidis, 2001). Also, Nicaise and his colleagues (Nicaise, Bois, Fairclough, Amorose, & Cogerino, 2007; Nicaise, Cogerino, Bois, & Amorose, 2006) have argued that there is not always congruence between teacher feedback and how students perceive and interpret the information. They suggested that girls' and boys' perceptions of teacher feedback are different. Furthermore, individual differences might play a role in this context. For example, introverts and extroverts tend to differ in state anxiety and their responses to performance feedback (Thompson & Perlini, 1998 **[AQ: Incl. in Refs.]**). Future studies should consider using the two-dimensional performance variability error measure as well as overall accuracy. This assessment technique ensures more valid and accurate measures of performance (Hancock, Butler, & Fischman, 1995). The present findings add to the converging evidence that feedback has an important motivational role in the learning process.

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