Knowledge of results after relatively good trials enhances self-efficacy and motor learning

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ABSTRACT

Objectives: This study sought to determine whether learners’ self-efficacy and motor learning was affected by the type of feedback they were provided.

Method: Participants (N = 24, M age = 19.51 years, SD = 1.08) were randomly assigned into one of two groups: knowledge of result after good versus poor trials. The task included throwing a tennis ball with the non-dominant hand to a target while wearing vision distorting goggles. Participants completed the Self-Efficacy Scale (Bandura, 2006) before performing each block of 6 trials. A retention test without knowledge of results was conducted 24 h after the practice phase.

Results: The results demonstrated that learners’ motor learning was increased by providing knowledge of results after good rather than poor trials. Furthermore, the Self-Efficacy Scale results revealed that learners’ self-efficacy was enhanced by positive feedback.

Conclusions: The current findings indicate that positive feedback impacts learner’s self-efficacy, and enhances performance and motor learning.

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Within the sport psychology and motor learning domains, it is well established that self-efficacy is effective for facilitating motor skill learning and performance (Moritz, Feltz, Fahrbach, & Mack, 2000). Self-efficacy emerged from social cognitive theory and is defined as the belief and judgment which a person has in regard to his/her ability to execute specific actions relative to the achievement of specific outcomes (Bandura, 1977). Generally, individuals with high levels of self-efficacy, attempt new performances in future trials, expend their effort on these performances and commonly display increased success on future motor skills (Gao, Kosma, & Harrison, 2009).

Bandura (1986, 1997), proposed that self-efficacy emerges from several sources of information; with the most effective source being ‘performance accomplishments.’ According to ‘performance accomplishments,’ self-efficacy and the performance ability of individuals are based upon their perceived personal mastery experiences (Bandura, 1997). For example, if an individual executes a successful performance they will have an increased expectation for future successful performances. In contrast, when an individual experiences an unsuccessful performance, this consequently reduces their expectation for later success. One way to inform an individual about their personal mastery is through the use of feedback, specifically feedback about successful performances. Providing performance related feedback to individuals about their successful performances has been shown to improve intrinsic motivation (Badami, VaezMousavi, Wulf, & Namazizadeh, 2011) and motor learning (Chiviacowsky & Wulf, 2007). Furthermore, learners who perceive themselves to be successful are motivated to continue to practice, and those who do not perceive themselves to be successful are less engaged in the acquisition of skill learning (Lee & Wishart, 2005). However, what is not clearly understood is how the content of feedback directly influences self-efficacy and motor learning.

Consistent with Bandura’s (1997) conclusion, a review of relevant literature suggests there is a clear relationship between the utilized level of self-efficacy and the delivery method of augmented feedback when performing a motor skill. For example, in a study by Schunk and Cox (1986) participants received performance feedback regardless of their actual performance; the results revealed that feedback had a strong impact on self-efficacy beliefs. In another study, Baron (1988) assessed the effect of two types of feedback (i.e., positive and negative) on the levels of reported self-efficacy. Results of that study indicated that participants who received negative feedback exhibited lower levels of self-efficacy, while participants receiving positive feedback reported higher levels of self-efficacy. Similar findings have been...
reported by Escarti and Guzman (1999), Balagour, Bray, and Dada (2004), and Mahoney, Devonport, and Lane (2008). In all, these studies suggest information provided in the form of positive feedback is a key factor in enhancing self-efficacy.

A related issue that has received recent attention is the exploration of providing augmented feedback in the form of knowledge of results (KR) after relatively good or relatively poor trials. In a pair of studies Chiviacowsky and Wulf (2007) and Badami et al. (2011) had learners practice a throwing task with their non-dominant arm, and a golf putting task, respectively. In those studies participants were assigned to either a group that received KR on the three best performances after each 6-trial block, or a group that received KR after the three poorest performances. The results of the Chiviacowsky and Wulf (2007) study indicated that participants who received KR after good trials demonstrated more effective motor learning than those who were provided KR after relatively poor trials. Results of the Badami et al. (2011) study indicated that providing feedback after good performances increases intrinsic motivation by enhancing the learners' perceived competence of the practiced task. Consistent with the findings of Chiviacowsky and Wulf (2007) and Badami et al. (2011); the results of a recent study by Saemi, Wulf, Varzaneh, and Zarghami (in press) revealed that intrinsic motivation and motor learning were improved when children practicing a throwing task received feedback after relatively good trials rather than relatively poor trials.

Previous research has clearly demonstrated that the use of feedback can improve a learners self-efficacy (Balagour et al., 2004; Escarti & Guzman, 1999; Mahoney et al., 2008). Furthermore, it has also been established that providing KR after good performances rather than poor performances also enhances motor learning (Chiviacowsky & Wulf, 2007) and intrinsic motivation (Badami et al., 2011). However, what has not been investigated is how self-efficacy is impacted when KR is provided after relatively good, or relatively poor motor skill performances while learning a motor skill. Therefore, in the present study, we focused on different types of KR (i.e., KR provided after good trials versus KR provided after poor trials) which was provided to learners performing a throwing task. Rather than providing KR after each trial, we chose to provide summary KR about good or poor performances following a set (e.g., 6) of practice trials. The use of summary KR is an effective method for delivering feedback at a reduced frequency in motor learning paradigms (Lavery, 1962; Magill, 2001; Wulf & Shea, 2004). We hypothesized that learner’s receiving summary KR after good trials would have a higher self-efficacy compared to learners receiving summary KR after poor trials. We also hypothesized that participants who received summary KR after good trials would also display superior throwing performance during practice and retention compared to participants that received summary KR after poor trials. Such a finding would not only be valuable for theoretical reasons, but would also be useful for practitioners.

**Method**

**Participants**

Twenty- four male undergraduate students (M age = 19.51 years, SD = 1.08) participated in this study. None of them had experience with the prescribed task, and all were naive to the purpose of the experiment. Prior to the study, we obtained the necessary Institutional Review Board approval and informed consent was obtained from all participants.

**Apparatus and task**

The task was similar to one used in several previous studies (e.g., Chiviacowsky & Wulf, 2007; Saemi et al., in press), and required participants to toss a tennis ball with their non-dominant arm to a target that was placed on the floor in front of them. Participants’ non-dominant arm was determined by asking which arm they did not use when writing. During the performance of all practice and retention test trials participants were required to wear opaque eye goggles to prevent them from viewing the outcome of their throw. The target was placed 3 m from the participant. The center of the target was circular and had a radius of 10 cm. The center of the target was surrounded by a series of nine concentric circles with radii of 20, 30, 40, 50, 60, 70, 80, 90 and 100 cm, respectively, which served as zones to assess throwing accuracy. If the ball landed in the center of the target, 100 points were awarded, any values decreased as the ball landed farther away from the center of the target. Specifically, if it landed in one of the other zones, or outside the outer circle, 90, 80, 70, 60, 50, 40, 30, 20, 10, or 0 points, respectively, were recorded. If the ball landed on a line separating two rings, the participant was awarded the higher score. All practice and retention test trials took place in a controlled research laboratory. The same scorer was used for all practice and testing trials. The score was located perpendicular to the center of the target for all trials.

To measure the learner’s self-efficacy, we adapted a scale from Bandura’s Guide for Constructing Self-Efficacy Scales (2006). This measure had ten questions that focused on learner’s ability beliefs in throwing a tennis ball. Each question was rated on a 100% scale with a range of 10 equal intervals [for example, 0 = not confident at all, 100 = completely confident]. The overall self-efficacy was calculated by summing the scores from all 10 questions (see Table 1). Also, internal consistency of the scale was calculated using Cronbach’s α statistic, which revealed that the internal consistency was significantly high (.96).

**Procedure**

Participants were randomly assigned to either the “KR after good trials” (n = 12; M age = 19.25 years; SD = 1.02) or the “KR after poor trials” (n = 12; M age = 19.77 years; SD = 1.14) group. All participants were informed that the task goal was to toss the tennis ball with their non-dominant arm to the center of the target in front of them. All participants completed 10 blocks of 6 trials for a total of 60 practice trials. After each block of 6 trials, participants in the “KR after good trials” group received KR on their 3 best tosses in that block, whereas those in the “KR after poor trials” group received KR on their 3 poorest tosses in the block. Before the initiation of the practice session, participants in both groups were informed that at the end of each block of 6 trials they would receive KR on three of the trials completed in the previous block. However, participants did not know if the provided KR was related to poor or good performances; rather they were informed that they were simply going to receive feedback about 3 attempts from the previous block of 6 trials. KR was written on a board and presented to them for a period of 15 s; participants removed their opaque goggles during this 15 s interval so they could accurately read the provided KR. The provided KR consisted of the trial number and respective earned score. Participants in both groups completed the Self-Efficacy Scale (Bandura, 2006) before they performed each block of 6 trials, and following the last block of 6 trials for a total of 11 self-efficacy assessments. All participants returned after 24 h and completed a 10 trial retention test; no KR was provided during the testing session.

**Data analysis**

Throwing accuracy was analyzed in a 2 (Group: KR after good trials/KR after poor trials) × 10 (Blocks) analysis of variance
Table 1

Items of the Self-Efficacy Scale used in the present study (Bandura, 2006). Please rate your degree of confidence by circling a number from 0 to 100 for each of the following questions using the scale given below.

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Scores</th>
</tr>
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<tbody>
<tr>
<td>1. How confident you were in your ability to score 10 in the tennis ball throwing task?</td>
<td>Cannot do at all</td>
</tr>
<tr>
<td>2. How confident you were in your ability to score 20 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>3. How confident you were in your ability to score 30 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>4. How confident you were in your ability to score 40 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>5. How confident you were in your ability to score 50 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>6. How confident you were in your ability to score 60 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>7. How confident you were in your ability to score 70 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>8. How confident you were in your ability to score 80 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>9. How confident you were in your ability to score 90 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
<tr>
<td>10. How confident you were in your ability to score 100 in the tennis ball throwing task?</td>
<td>0</td>
</tr>
</tbody>
</table>

(ANOVA) with repeated measures on the last factor. Scores of the learners’ Self-Efficacy Scale were analyzed in a 2 (Group: KR after good trials/KR after poor trials) × 11 (Times) ANOVA with repeated measures on the last factor. To ensure that both groups were similar at the beginning of the practice session, we assessed the accuracy scores from the first trial block and the scores from the first assessment of the Self-Efficacy Scale with independent t-tests. In addition, the retention test scores were analyzed with an analysis of covariance (ANCOVA).

Results

Accuracy scores

Practice phase

Analysis of accuracy scores from the first trial block indicated that the experimental groups were not significantly different at the initiation of practice, \( T(22) = .32, p = .75 \). The analysis of accuracy scores revealed a main effect for Block, \( F(9, 198) = 2.11, p < .05, \eta^2_p = .08 \). Furthermore, the main effect for Group, \( F(1, 22) = 6.29, p < .05, \eta^2_p = .22 \), was also significant. Thus indicating the KR good group had higher scores than the KR poor group across the practice phase (see Fig. 1). Additionally, post hoc analysis results indicated that the KR good group showed significant improvement during practice, while the KR poor group did not improve. The interaction of Group × Block was not significant \( F(9, 198) = .84, p > .05 \).

Retention

Retention test scores were analyzed using an ANCOVA, with the first trial block of acquisition serving as the covariant. The results of the ANCOVA indicated that the KR after good trials group (\( M = 51.91, SD = 13.16 \)) was significantly better than the KR after poor trials group (\( M = 34.25, SD = 23.79 \)), \( F(1, 24) = 4.87, p = .039, \eta^2 = .18 \) (see Fig. 1).

Self-efficacy scores

Similar to the accuracy scores, analysis of the first block of scores from the Self-Efficacy Scale indicated that the two experimental groups were similar at the beginning of practice, \( T(1, 22) = .82, p = .41 \). The KR good group (\( M = 762.72 \)) tended to have higher self-efficacy scores than KR poor (\( M = 522.95 \)) across the practice phase. The main effect for Groups was significant, \( F(1, 22) = 16.79, p < .05, \eta^2_p = .43 \). However, the main effect for time was not significant, \( F(10, 220) = 1.21, p > .05 \). Furthermore, the interaction of Group and...
Time was significant $F(10, 220) = 2.86$, $p < .05$, $\eta^2_p = .11$. Follow up analysis revealed the significant interaction was the result of the self-efficacy scores of the two Groups diverging across the practice session (see Fig. 2).

Discussion

The purpose of this study was to investigate if providing KR after good or poor motor performances influenced a learner’s self-efficacy and motor performance and learning. We predicted participants that received KR after good trials would have higher levels of self-efficacy and would also display superior motor skill performance during practice and on a delayed retention test compared to participants receiving KR after relatively poor trials. The results of the present study supported our experimental hypotheses by demonstrating that learners’ accuracy was enhanced by providing KR after relatively good trials versus poor trials. Additionally, results indicated that providing KR after good trials resulted in elevated self-efficacy compared to providing KR after weaker performances. These findings are in line with previous studies showing enhanced motor learning as a result of providing feedback after high quality performances. The findings of the present study are also consistent with research investigating the positive effects of having an elevated self-efficacy.

While the present findings are consistent with previous research in the role of augmented feedback and self-efficacy in improving motor behavior, it is worth noting that the current studies findings are in contrast with predictions made by the guidance hypothesis (Salmoni, Schmidt, & Walter, 1984). According to the guidance hypothesis, KR should be beneficial if it is provided after poor trials or larger errors rather than good trials or smaller errors. The guidance hypothesis further proposes that providing feedback related to errors or poor performances will assist in correcting errors by guiding the learner toward a more desirable outcome. However, recent studies by Chiviacowsky and Wulf (2005, 2007) and Chiviacowsky, Wulf, Wally, and Borge (2009) have raised significant questions regarding this fundamental assumption of the guidance hypothesis. Chiviacowsky and Wulf (2005, 2007) and Chiviacowsky et al. (2009) suggests that providing feedback after smaller rather than larger errors was advantageous and enhanced motor behavior. The authors argued that KR after good trials rather than poor trials might encourage learners to try to repeat successful movements, resulting in a higher frequency of desired outcomes. In addition, the learning advantages of KR after good rather than poor trials are likely to increase motivation to continue to practice and succeed (Chiviacowsky & Wulf, 2007). Furthermore, previous studies have also shown that learners’ self-efficacy can be affected by positive feedback (Bandura & Jourden, 1991; Chan & Lam, 2010; Escarti & Guzman, 1999; Mahoney et al., 2008).

Self-efficacy is determined by multiple variables, such as previous experience or performance accomplishments (i.e., success and failure) and social and verbal persuasion (i.e., from coaches, colleagues, educators). When learners are provided KR after relatively successful rather than failed trials, they are subsequently being informed about their performance output. In the present study, it appears that providing participants with KR regarding their best performances improved their self-efficacy which likely increased their motivation to repeat correct behaviors through continued practice. In contrast, when learners were provided KR about their worst performances, it lowered their self-efficacy consequently reducing their motivation to continue to effectively practice. This reduced belief of self, as a result of KR related to poor performance depressed motor skill learning. By point of comparison, having an inflated self-efficacy, or improved belief of self, facilitated motor skill learning. This elevated self-efficacy as a result of positive KR increased the likelihood that successful behaviors would be repeated on later trials, thus blocking the rehearsal of less effective motor patterns.

An additional interpretation of the present findings is based on participant’s judgments of learning. The ability to accurately determine if you are successfully learning a motor skill is critical for developing the motivation for continued practice; it also influences how confident a person feels about their motor abilities (Lee & Wishart, 2005; Simon & Bjork, 2001). Moreover, Bjork (1994, 1998) suggest that creating a practice environment that makes learners aware of mistakes will result in reduced motivation to participate in effortful practice, lower confidence and negatively influence their judgment of learning. The present findings support these conclusions. Specifically, providing participants in the good KR group positive feedback facilitated the development of a confident judgment of learning through continued validation of ‘performance accomplishments.’ As a result participants in the good KR group had an inflation of self-efficacy which led to greater motivation to practice with more effort. However, providing summary KR about poor performances reduced the learner’s ability to positively judge their learning of the prescribed throwing task. This perceived inability to accomplish the task lowered self-efficacy and motivation for continued effortful practice. As a result of having lowered self-efficacy participants in the KR after poor trials group did not effectively learn the throwing task, as demonstrated by the present results.

In conclusion, the present findings add to our knowledge about how different types of feedback such as KR after good rather than poor trials affect learners’ self-efficacy and motor behaviors. The findings presented here indicate positive feedback presented as KR after good practice trials increased self-efficacy and improved motor skill performance and learning. The present findings also have important instructive and practical implications for educational environments such as physical education classrooms, coaching athletics, and physical therapy/rehabilitative settings. For example, practitioners should provide learners KR after good rather than poor trials. Doing so will increase the learners self-efficacy and facilitate motor performance improvements. In general, if learners have a good judgment of their capabilities to achieve certain goals or cope with certain task demands, their performance will be increased (Bandura, 1986). The present study focused on the effect of specifically providing KR after relatively good rather than poor trials upon learners’ self-efficacy in a throwing task. Future studies should incorporate other types of feedback, self-efficacy measures, and other potential contributory factors such as intrinsic and extrinsic motivation to examine more directly the relationship between feedback, self-efficacy, performance, motivation, and motor skill learning.

References


