

Feedback after good versus poor trials enhances motor learning in children

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Abstract

The present study investigated whether children would benefit from feedback (knowledge of results, KR) provided after relatively good as opposed to poor trials. The task required participants to throw beanbags at a circular target that was placed on the floor at a distance of 3 m. Twenty-eight elementary school children (mean age: 10.6 years) participated in this experiment. The practice phase consisted of 10 blocks of 6 trials. After each 6-trial block, one group (KR good) received KR on the 3 most accurate tosses, whereas another group (KR poor) was given KR on the 3 least accurate ones. Participants were not informed about the trials on which they were provided feedback. Immediately following the practice phase, participants completed the intrinsic motivation inventory. One day after the practice phase, a retention test consisting of 10 trials without KR was conducted. The results demonstrated that learning was enhanced by providing KR after good trials during practice. Furthermore, the questionnaire results revealed that learners' intrinsic motivation was increased by positive feedback. The present findings add to the accumulating evidence that the motivational effects of feedback have a direct impact on learning.

UNITERMS: Motivation; Knowledge of results; Throwing; IMI.

Introduction

Augmented feedback (knowledge of result, knowledge of performance) has long been considered to be one of the most important variables for motor skill learning (e.g., SCHMIDT & LEE, 2005). Yet, the views of how exactly feedback influences learning have changed over time. According to early accounts of feedback, learning was not believed to occur in its absence (e.g., BILODEAU & BILODEAU, 1958; BILODEAU, BILODEAU & SCHUMSKY, 1959). In the 1980s, this view changed with the review and re-appraisal of the feedback literature by SALMONI, SCHMIDT, and WALTER (1984). According to the guidance hypothesis proposed by SALMONI, SCHMIDT, and WALTER (1984), frequent feedback guides the performer toward the goal movement. However, if feedback is provided too frequently, learners tend to become dependent to the augmented information, and their performance tends to be relatively inconsistent due to constant corrections of even small errors. The result is in degraded learning

compared to when feedback is provided less frequently. While numerous studies have provided support for the guidance hypothesis (for reviews, see SCHMIDT, 1991; SWINNEN, 1996), there are also findings that are inconsistent with the guidance idea (e.g., SWINNEN, LEE, VERSCHUEREN, SERRIEN, & BOGAERDS, 1997; WULF, MCCONNELL, GÄRTNER, & SCHWARZ, 2002; WULF, SHEA, & MATSCHINER, 1998; for a review, see WULF & SHEA, 2004).

In recent years, another effective feedback manipulation has emerged that cannot be accounted for by the guidance explanation. Studies investigating the effects of self-controlled KR or KP have demonstrated that giving learners the opportunity to decide when to receive feedback enhanced learning compared to not having this opportunity (e.g., CHIVIAKOWSKY & WULF, 2002, 2005; CHIVIAKOWSKY, WULF, LAROQUE DE MEDEIROS, KAEFER, & TANI, 2008; JANELLE, BARBA, FREHLICH, TENNANT, & CAURAUGH,

1997; JANELLE, KIM, & SINGER, 1995; WULF, CLAUSS, SHEA, & WHITACRE, 2001). An interesting finding that emerged from studies in which questionnaires were used to determine when or why learners with self-control asked for KR (CHIVIAKOWSKY & WULF, 2002; CHIVIAKOWSKY, WULF, WALLY, & BORGES, 2009) was that learners preferred to receive KR after they thought they had a relatively successful trial, but not when they thought their performance was relatively poor.

In a follow-up study, CHIVIAKOWSKY and WULF (2007) provided learners with KR after “good” or “poor” trials. Young adults (average age: 21.1 years) practiced a throwing task with their non-dominant arm, with participants being assigned to either a group that received KR on the three best (i.e., most accurate) tosses after each 6-trial block, or a group that received KR after the three poorest tosses. The results showed that participants who received KR after good trials demonstrated more effective learning than those who were provided KR after relatively poor trials. CHIVIAKOWSKY et al. (2009) replicated these findings with older adults (average age 65.9 years). Various possible reasons have been suggested for the learning benefits of “positive” KR. CHIVIAKOWSKY and WULF (2007) hypothesized that KR after good trials may be more motivating for learners than negative feedback, which, in turn, could lead to more effective learning. BADAMI, VAEZMOUSAVI, WULF, and NAMAZIZADEH (2011) directly examined the effects of KR after good versus poor trials on intrinsic motivation. Their results confirmed the notion that KR after good trials enhanced learners’ intrinsic motivation. In addition, learners who received KR after good trials demonstrated greater self-confidence and more effective arousal management in another study (BADAMI, VAEZMOUSAVI, NAMAZIZADEH, & WULF, in press). These findings appear to be inconsistent with the guidance hypothesis, according to which feedback should be more effective after poor trials or large errors. Moreover, these recent results highlight the need to consider social-cognitive-affective influences on motor learning, rather than simply the informational role of practice variables (LEWTHWAITE & WULF, 2010a). Traditional views of feedback with their emphasis on the informational properties of feedback are not able to adequately explain newer findings that demonstrate motivational influences of feedback on motor learning.

An interesting question - from both theoretical and practical perspectives - is whether the findings from studies with adults showing more effective learning with KR after good rather than poor trials (CHIVIAKOWSKY & WULF, 200; CHIVIAKOWSKY et al., 2009) would generalize to learning in children. Children have been shown to have limited information-processing capabilities compared to those of adults (e.g., BADAN, HAUERT, & MOUNOUD, 2000; CHI, 1977; CONNOLLY, 1970, 1977; LAMBERT & BARD, 2005; POLLOCK & LEE, 1997; SULLIVAN, KANTAK, & BURTNER, 2008). For example, children are less effective in attending to and interpreting intrinsic feedback, and have greater difficulty with the detection and estimation of movement errors (for a review, see SULLIVAN, KANTAK, & BURTNER, 2008). Thus, one may assume that children might need more error information (i.e., KR on poor trials). Yet, if the benefits of KR on good trials are mainly motivational in nature - that is, due to enhanced intrinsic motivation, self-confidence, and arousal management (BADAMI et al., 2011, in press) - one would expect to see the same learning advantages in children that have been found for adults.

Therefore, one purpose of the present study was to examine whether feedback after good trials would benefit motor learning in children, relative to feedback after poor trials. CHIVIAKOWSKY et al. (2008), who examined the effects of self-controlled feedback in 10-year-old children, found that participants asked for feedback more frequently after relatively good rather than poor trials. However, the learning effectiveness of KR after good versus poor trials has not been directly assessed yet. Also, the influence of these two types of KR on children’s intrinsic motivation has not yet been examined. Thus, a second purpose of the present study was to address this issue. Ten-year old children practiced a beanbag-throwing task, similar to the tasks used by Chiviakowsky and colleagues (CHIVIAKOWSKY & WULF, 2007; CHIVIAKOWSKY et al., 2009), while being provided KR on either the 3 most accurate or inaccurate throws, respectively, after each block of 6 trials. Learning was assessed by a delayed retention test without KR. We examined the effects of feedback on children’s intrinsic motivation by using the Intrinsic Motivation Inventory (IMI) (see BADAMI et al., 2011).

Methods

Participants

Twenty-eight children (mean age = 10.61 years, SD = 0.88) participated in this experiment. They were recruited from four classes in a local elementary school. Informed consent was obtained from the elementary school and the parents, and assent was obtained from the students. Participants had no prior experience with the experimental task and were not aware of our specific study purpose.

Apparatus and task

The apparatus, task, and procedure were similar to those used in previous studies (BADAMI et al., 2011; CHIVIAKOWSKY & WULF, 2007; CHIVIAKOWSKY et al., 2008, 2009). The task required participants to toss beanbags to a target placed on the floor, using their non-dominant arm. The target was circular, had a radius of 10 cm, and was placed at a distance of 3 m from the participant. Concentric circles with radii of 20, 30, 40, 50, 60, 70, 80, 90, and 100 cm were drawn around the target. These served as zones to assess the accuracy of the throws. If the beanbag landed on the target, 100 points were awarded. If it landed in one of the other zones, or outside the circles, 90, 80, 70, 60, 50, 40, 30, 20, 10, or 0 points, respectively, were recorded. If the ball landed on a line separating two zones, the participant was

awarded the higher score. Also, the target was divided into four quadrants for the provision of KR (see the FIGURE 1). All testing took place during normal physical education class periods.

To measure intrinsic motivation, the children responded to questions on the IMI, which was translated into the Farsi (see BADAMI et al., 2011). The IMI assesses participants' subjective experience related to a target activity. It consists of 6 subscales, including items related to interest/enjoyment, perceived competence, effort/importance, value/usefulness, pressure and tension, and perceived choice while performing a given activity (e.g., MCAULEY, DUNCAN, & TAMMEN, 1989; PLANT & RYAN, 1985; RYAN, MIMS, & KOESTNER, 1983). For the present study, the nine items of the IMI related to the interest/enjoyment, perceived competence, and effort/importance subscales were adapted to measure the participants' intrinsic motivation (as in BADAMI et al., 2011) (see TABLE 1). Response choices ranged from 7 (strongly agree) to 1 (strongly disagree). The IMI for assessing intrinsic motivation in children has also been used in previous studies (e.g. GOUDAS, DERMITZAKI, & BAGIATIS, 2000; BARIC, ERPIC, & BABIC, 2002; KOKA & HEIN, 2003). Internal consistency of each subscale was calculated using Cronbach's α statistic. They were high: interest/enjoyment (0.88), perceived competence (0.81), and effort/importance (0.8).

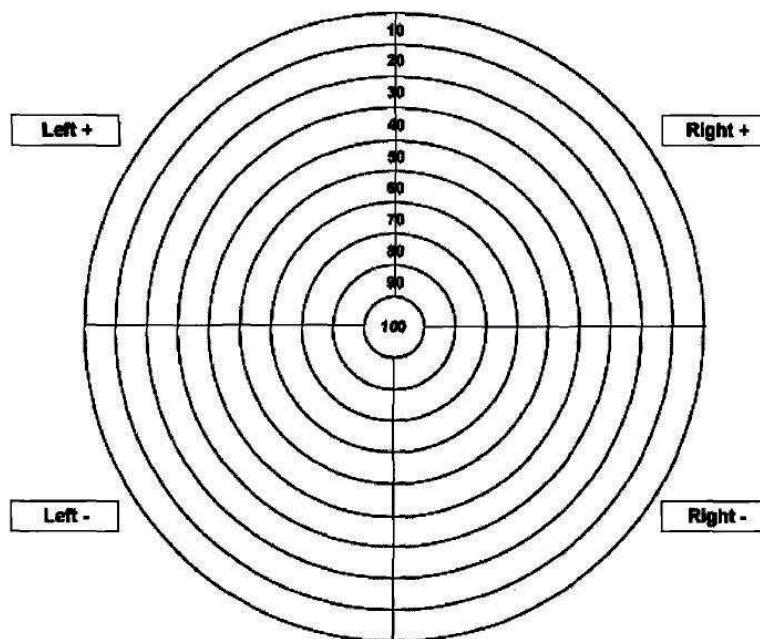


FIGURE 1 - Schematic of the target and zones used for providing feedback.

Procedure

Participants were randomly assigned to the “KR good” group and “KR poor” group (14 participants per group). All participants were informed about the task goal, and they were instructed to toss the beanbags overhand, while standing with both feet on the ground. After each block of 6 trials, participants in the KR good group received KR on the 3 best (i.e., most accurate) tosses in that block, whereas those in the KR poor group received KR on the three poorest tosses. Participants in both groups were informed that, at the end of each block of 6 trials, they would receive KR on the 3 of those trials. However, they did not know for which trials they would receive KR. KR was provided in terms of the direction and the extent of the deviation from the target (CHIVIAKOWSKY & WULF, 2007; CHIVIAKOWSKY et al., 2009). Specifically, it consisted of the trial number and the respective score, as well as directional information. Participants were allowed to look at the target before each 6-trial block. During the experimental phase (practice, retention) participants were required to wear opaque swimming goggles to prevent them from viewing the outcome. To control the timing of the trials and KR presentation, a digital timer was used. Participants had 6 s to complete each trial. KR was written on a board and presented for 15 s. Thus, the inter-trial interval was about 21 s after every 6th trial. All participants performed 60 practice trials. At the end of practice phase, participants in both groups completed the IMI. A retention test consisting of 10 trials without KR was conducted 24 hours after the practice phase.

Results

Throwing accuracy

Practice

Accuracy scores during practice fluctuated somewhat, with the KR good group tending to show a somewhat greater increase across blocks compared to the KR poor group (see the FIGURE 2, left). The main effect of block, $F(9, 234) = 1.96, p < 0.05, \eta^2 = 0.07$, was significant. Post-hoc tests (LSD) on the Block effect indicated that accuracy scores were significantly higher on Block 8 relative to Blocks 3, 5, 6, 7, and 10. In addition, Blocks 4 and 9 had higher

TABLE 1 - Items from each subscale of the IMI used in the present study.

Enjoyment / Interest
1. Throwing beanbags was fun to do.
2. While I was throwing, I was thinking about how much I enjoyed it.
3. I thought throwing beanbags was a boring activity. (R)
Perceived Competence
4. After throwing for awhile, I felt pretty competent.
5. I am satisfied with my throwing performance.
6. Throwing beanbags was an activity that I couldn't do very well. (R)
Effort / Importance
7. I didn't try very hard to do well at throwing beanbags. (R)
8. It was important to me to do well at throwing beanbags.
9. I tried very hard while throwing

Data analysis

Accuracy scores for the practice phase were averaged across blocks of 6 trials and analyzed in a 2 (group: KR good versus KR poor) \times 10 (6-trial blocks) analysis of variance (ANOVA) with repeated measures on the last factor. The retention test scores were averaged across all 10 trials and analyzed in a one-way ANOVA. Independent t-tests were used to investigate the effects of KR after good trials versus poor trials on participants' overall intrinsic motivation as well as the 3 subscales of the IMI (interest/enjoyment, perceived competence, and effort/importance).

scores than Block 7; and scores on Block 9 were higher than those on Block 5 ($p < 0.05$). Furthermore, the Group main effect was significant, with $F(1, 26) = 8.88, p < 0.05, \eta^2 = 0.26$, indicating that the KR good group generally outperformed the KR poor group across practice. The interaction of group and block was not significant $F(9, 234) = 0.99, p > 0.05$.

Retention

On the no-KR retention test, performed one day after practice phase, the KR good group again demonstrated higher accuracy scores than KR poor group. The main

effect of group was significant, $F(1, 30) = 13.39, p < 0.05, \eta^2 = 0.309$ (see FIGURE 2, right).

Motivation

The average intrinsic motivation scores can be seen in TABLE 2. Receiving KR on good trials resulted in significantly higher perceived competence scores

than KR on poor trials, $t(26) = 5.18, p < 0.001$. In contrast, the KR poor group had higher scores on effort/importance than the KR good group, $t(26) = -2.68, p < 0.05$. There were no significant differences between groups in terms of interest/enjoyment, $t(26) = 1.45, p > 0.05$. Overall, intrinsic motivation was significantly higher in the KR good group than in the KR poor group, $t(26) = 3.58, p < 0.001$.

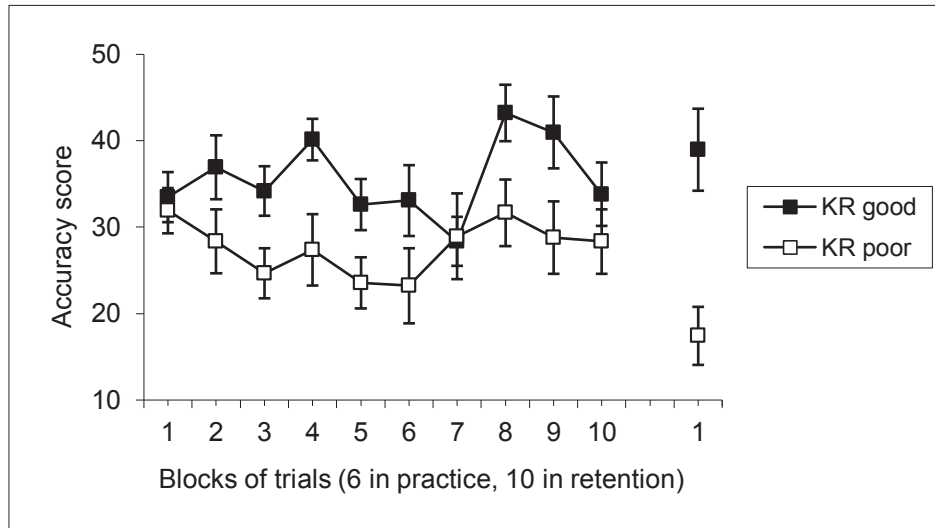


FIGURE 2 - Accuracy scores of the KR good and KR poor groups during the practice and retention phases.

TABLE 2 - Means and standard errors (SE) on the 3 subscales (interest/enjoyment, perceived competence, effort/importance) of the IMI and overall intrinsic motivation for the KR good and KR poor groups.

Groups	Variables	KR good group		KR poor group	
		Mean	SE	Mean	SE
	Interest/enjoyment	6.17	0.26	5.60	0.29
	Perceived competence	6.12	0.20	3.55	0.46
	Effort/importance	5.24	0.08	5.88	0.23
	Intrinsic motivation	5.84	0.12	5.01	0.20

Discussion

Recent studies have demonstrated the learning effectiveness of providing KR after good as opposed to poor trials for learning in adults (BADAMI et al., 2011; CHIVIAKOWSKY & WULF, 2007; CHIVIAKOWSKY et al., 2009). In the present study, we asked whether children would show similar learning benefits when receiving KR after good trials. In addition, we

attempted to replicate previous findings (BADAMI et al., 2011) demonstrating enhanced intrinsic motivation as a function of “positive” KR in adults.

The present findings demonstrated that children’s motivation was indeed enhanced when they were given KR on trials with relatively small rather than larger errors. Thus, even though participants were not told

on which trials they would receive KR, the type of KR impacted their intrinsic motivation. In particular, KR on good trials enhanced learner's perceived competence. The feeling of competence is an integral aspect of motivation, and motivation generally increases with the feeling of competence. In fact, competence is considered to be a fundamental psychological need (along with autonomy and social relatedness) (e.g., DECI & RYAN, 2000, 2008). Optimal functioning and learning in a broad range of domains appears to depend on the satisfaction of those basic needs.

Interestingly, participants who received KR on poor trials seemed to increase their effort as a function of the feedback. Their ratings of their effort exerted and importance of doing well on the task were significantly higher than those of participants in the KR good group. Yet, despite their stated effort, they were outperformed by learners who received more positive feedback. That is, the increased intrinsic motivation resulting from increased in perceived competence produced more effective learning in the KR good condition.

These findings are in line with those of previous studies showing increased intrinsic motivation (BADAMI et al., 2011) and enhanced motor learning (CHIVIAKOWSKY & WULF, 2007; CHIVIAKOWSKY et al., 2009) in adults. In fact, there is accumulating evidence that the motivational role of feedback in the learning process is more important than previously thought. In the motor learning literature, feedback is assumed to have two roles in facilitating the learning process. Most importantly, feedback is assumed to have an informational role, providing the learner with knowledge about refinements of the movement plan and its execution (e.g., SCHMIDT & LEE, 2005). A secondary role of feedback is its motivational role - thought to enhance task interest and encourage continued effort, persistence, and attention to goal accomplishment (e.g., SCHMIDT & LEE, 2005; SCHMIDT & WRISBERG, 2008). Yet, the direct impact of the motivational properties of feedback on learning has only become evident more recently.

For example, self-controlled feedback satisfies individuals' need to act autonomously (e.g., DECI & RYAN, 2000) - which is presumably one reason for its beneficial effects on learning (e.g., CHIVIAKOWSKY & WULF, 2002, 2005; JANELLE et al., 1997; PATTERSON & CARTER, 2010). Moreover, it allows learners to request feedback after good trials (CHIVIAKOWSKY & WULF, 2002; CHIVIAKOWSKY et al., 2008), thus enhancing participants' feeling of competence. To be intrinsically motivated, individuals need to perceive

themselves as both autonomous and competent. Learners' perceived competence - and subsequent performance or learning - can also be increased by social-comparative feedback indicating that they are performing better than the "norm" or their peers (HUTCHINSON, SHERMAN, MARTINOVIC, & TENENBAUM, 2008; LEWTHWAITE & WULF, 2010b; WULF, CHIVIAKOWSKY, & LEWTHWAITE, 2010). For instance, in a recent study (LEWTHWAITE & WULF, 2010b) that examined effect of positive versus negative social-comparative information on the learning of balance task, learners were led to believe their performance was either above or below average. Participants who believed they were more skilled (or competent) than others demonstrated more effective learning of the task than participants who assumed their performance was below average, or control participants who were not given normative feedback. Interestingly, the two latter groups showed similar learning. This suggests that it is the positive information and its affective consequences that promote learning. Learners who believe their performance is worse than that of others, or who are unsure about how their performance compares to that of others (control conditions) may also adopt a more self-related focus of attention (WULF & LEWTHWAITE, 2010). Concerns about performance have been known to increase conscious effort to control actions in attempts to improve performance (e.g., BAUMEISTER, 1984). The greater effort expressed by KR poor group participants in the present study is in line with the notion. Yet, an increase in conscious control attempts is usually detrimental to performance and learning (e.g., BAUMEISTER, 1984; WULF, 2007; WULF & LEWTHWAITE, 2010).

Overall, the findings of the present study add to the converging evidence that the motivational consequences of feedback directly impact the learning of motor skills. To our knowledge, they are the first to demonstrate the beneficial effects of KR after good trials on learning in children. Moreover, the present results show that these effects are mediated by an increase in intrinsic motivation, and in particular learners' perceived competence. Clearly, the motivational role of feedback - and of practice conditions, in general - needs to be given more attention in future studies on motor learning. The present findings also have implications for practical and instructional settings, in which instructors tend to give feedback when they assume the child needs it most to avoid errors, and to guide

the child to the correct movement pattern. It now appears that another, and perhaps more fruitful approach may be to reserve feedback for good

performances, to highlight aspects of the skill that are performed correctly, or to focus on the child's improvement.

Resumo

"Feedback" após boas versus más tentativas melhora a aprendizagem motora em crianças

O presente estudo investigou se a aprendizagem motora de crianças pode ser beneficiada pelo "feedback" (conhecimento de resultados -CR) fornecido após tentativas relativamente boas de prática, ao invés de após tentativas ruins. A tarefa requereu que os participantes arremessassem saquinhos de feijão em um alvo circular fixo, posicionado no chão, a uma distância de 3 m. Vinte e oito crianças do ensino fundamental (idade média: 10,6 anos) participaram deste experimento. A fase de prática consistiu de 10 blocos de seis tentativas. Após cada bloco de tentativas, um grupo (KR "good") recebeu CR relacionado aos três arremessos mais precisos, enquanto ao outro grupo (KR "poor") foi fornecido CR relacionado aos três arremessos menos precisos. Os participantes não foram informados sobre as tentativas nas quais o "feedback" seria fornecido. Imediatamente após a fase de prática, os participantes preencheram o questionário de motivação intrínseca. Um dia após a fase de prática, foi conduzido um teste de retenção composto por 10 tentativas, sem CR. Os resultados demonstraram que a aprendizagem foi melhorada através do fornecimento de CR após as boas tentativas de prática. Ainda, os resultados do questionário revelaram que a motivação intrínseca dos aprendizes foi aumentada pelo "feedback" positivo. Os presentes achados adicionam evidências de que os efeitos motivacionais do "feedback" possuem um impacto direto sobre a aprendizagem.

UNITERMOS: Motivação; Conhecimento de resultados; Arremesso; IML.

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