Human Movement Science 45 (2016) 63–70

Contents lists available at ScienceDirect

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Judgments of learning are significantly higher following feedback on relatively good versus relatively poor trials despite no actual learning differences

Michael J. Carter *, Victoria Smith, Diane M. Ste-Marie

School of Human Kinetics, University of Ottawa, Ottawa, Canada

ARTICLE INFO

Article history:
Received 26 June 2015
Revised 30 October 2015
Accepted 14 November 2015

Keywords:
Skill acquisition
Motor learning
Knowledge of results
Metacognition

ABSTRACT

Studies have consistently shown that prospective metacognitive judgments of learning are often inaccurate because humans mistakenly interpret current performance levels as valid indices of learning. These metacognitive discrepancies are strongly related to conditions of practice. Here, we examined how the type of feedback (after good versus poor trials) received during practice and awareness (aware versus unaware) of this manipulation affected judgments of learning and actual learning. After each six-trial block, participants received feedback on their three best trials or three worst trials and half of the participants were made explicitly aware of the type of feedback they received while the other half were unaware. Judgments of learning were made at the end of each six-trial block and before the 24-h retention test. Results indicated no motor performance differences between groups in practice or retention; however, receiving feedback on relatively good compared to relatively poor trials resulted in significantly higher judgments of learning in practice and retention, irrespective of awareness. These results suggest that KR on relatively good versus relatively poor trials can have dissociable effects on judgments of learning in the absence of actual learning differences, even when participants are made aware of their feedback manipulation.

1. Introduction

In motor learning, knowledge of results (KR) refers to movement outcome information regarding the success of a motor response relative to a task goal that can be provided from an external source such as a coach, therapist, or teacher (Salmoni, Schmidt, & Walter, 1984; Schmidt & Lee, 2011). To date, much of the motor learning research concerned with the provision of KR has been theoretically driven by the guidance hypothesis (Salmoni et al., 1984). In a seminal review and reappraisal of the KR literature, Salmoni et al. (1984) acknowledged secondary motivational and associational functions of KR, but placed greater emphasis on the importance of the informational role of KR. The authors proposed that KR provided information to guide the performer to the goal response by resolving any discrepancies between the performer's intended movement and the actual movement outcome.

* Corresponding author at: School of Human Kinetics, University of Ottawa, 125 University Private, Ottawa, ON, Canada.
E-mail addresses: carterjmike@gmail.com, michael.carter@uottawa.ca (M.J. Carter), vsmit092@uottawa.ca (V. Smith), diane.ste-marie@uottawa.ca (D.M. Ste-Marie).

http://dx.doi.org/10.1016/j.humov.2015.11.006
0167-9457/

More recently however, the guidance hypothesis has been criticized for overemphasizing the informational properties of KR at the expense of its motivational influences on motor learning (e.g., Chiviacowsky & Wulf, 2007; see Wulf, Shea, & Lewthwaite, 2010 for a review). For example, Chiviacowsky and Wulf (2007) investigated the effectiveness of providing KR about either the three best (i.e., "good") or the three worst (i.e., "poor") trials in a six trial block while participants learned to throw a beanbag toward a target without vision using their non-preferred hand. It was found that providing KR about relatively "good" rather than relatively "poor" trials was more advantageous for learning as measured by motor performance on a next-day retention test. The authors interpreted this finding to be incongruent with the guidance function (i.e., informational) of KR on the grounds that it would be expected that KR provided after larger errors (or poor trials) would be more beneficial for learning than KR after smaller errors (or good trials).[1] Instead, Chiviacowsky and Wulf (2007) proposed that KR after good, rather than poor trials, may have created a motivational success experience for the learners, which in turn enhanced the learning process. From this perspective, the motivational properties of KR might have a more direct and lasting influence on memory and learning than the indirect and transient effect originally proposed by Salmoni et al. (1984).

In recent years a number of experiments have replicated the motor learning benefits of providing KR on relatively good versus relatively poor trials with researchers associating KR after good trials with motivational factors such as increased self-confidence (Badami, VaezMousavi, Wulf, & Namazizadeh, 2012) and increased self-efficacy (Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki, 2012). Moreover, researchers have also queried participants on whether the feedback they received during practice (i.e., after their 3 best or 3 worst trials) facilitated their motivation to learn the task with some researchers finding higher motivation for KR after good trials (Badami, VaezMousavi, Wulf, & Namazizadeh, 2011) while others have reported no differences (Patterson & Azizieh, 2012). The conclusions of Badami et al. (2011), in which they attributed the learning advantages of KR on relatively good trials to increased intrinsic motivation must be interpreted with caution because the authors did not report any behavioral data regarding motor performance and learning based on the KR manipulation. Thus, these higher levels of motivation may have only been a transient performance effect of the KR they received rather than having a relatively permanent effect on learning. In addition, only one out of the three subscales of the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989) that were used was found to be significantly different between the KR groups. Specifically, perceived confidence was found to be different between the groups but interest/enjoyment and effort/importance were not. As a result, it would be more accurate to conclude that KR on relatively good trials affected *perceived confidence* rather than intrinsic motivation per se.

In the KR on relatively good versus relatively poor trials literature, Patterson and Azizieh (2012) noted that participants have always been unaware that the KR they received was based on a relative performance distinction within a block of six trials. As a result, Patterson and Azizieh (2012) investigated whether the learning advantages of KR on relatively good rather than relatively poor trials would persist if participants were made aware that their KR reflected either their three best or three worst trials. Thus, four groups were created using a factorial combination of awareness (aware or unaware) and KR content (good or poor trials). It was found that being aware of the type of KR received throughout practice resulted in superior learning, independent of whether the KR reflected relatively good or relatively poor trials. No differences, however, were found between the groups who were unaware of their KR content, thus failing to replicate the results of others (e.g., Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Wally, & Borges, 2009). Based on these findings, the authors suggested that being aware may have provided the learners with a more meaningful referent to modulate future responses which optimized the learning process.

In the present experiment we examined whether the content of one's KR schedule (relatively good or relatively poor trials) and awareness (aware or unaware) of this manipulation would differentially impact motor performance and learning, as well as prospective metacognitive judgments. An important and widely used metacognitive index is the judgment of learning (Soderstrom & Bjork, 2015). A judgment of learning requires a participant to predict their ability to execute a task at a future time assuming they received no more practice. In other words, a judgment of learning is a subjective assessment of one's current level of learning. Research in both the motor learning and verbal learning literature has consistently revealed dissociations between judgments of learning and objective indices of learning as participants have a propensity to view immediate, yet potentially transient performance levels as valid indices of learning (see Jacoby, Bjork, & Kelley, 1994; Soderstrom & Bjork, 2015; Son & Simon, 2012 for respective reviews). For example, Simon and Bjork (2001) had participants practice three different 5-digit key pressing sequences with either a blocked (i.e., fixed-order) or random (i.e., interleaved) repetition schedule and examined how the order of practice repetitions influenced judgments of learning and actual motor learning as measured using a delayed 24-h retention test. Participants made a judgment of learning after each practice block (six in total) and one prior to the 24-h retention test. The results revealed that the participants who experienced a blocked schedule had more accurate performance during practice and also reported significantly higher judgments of learning than the participants that experienced a random schedule. When participants returned the following day and were asked to predict their upcoming retention performance for each key pressing sequence, the blocked schedule participants continued to

[1] In their seminal paper, Salmoni et al., 1984 did not state that based on their proposed informational role of KR that it would be more beneficial for learning after larger errors (i.e., poor trials) compared to smaller errors (i.e., good trials). Instead, they proposed that the informational role of KR was to guide the learner toward the correct response as KR provides information about response outcome which can be used to generate a new and more accurate response on future trials (p. 380). Therefore, error information based on response outcome is always present independent of whether KR is provided after relatively poor or relatively good trials. Based on this misinterpretation of the guidance hypothesis, the conclusions made in the KR after relatively good versus relatively poor trials literature have overemphasized their motivational role of KR while ignoring that the informational role is still present.