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Expecting to teach enhances motor learning and information processing during practice

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ABSTRACT

Recent research has revealed that having learners study and practice a motor skill with the expectation of having to teach it enhances motor learning. However, the mechanisms underlying this effect remain unknown. We attempted to replicate this effect and elucidate the mechanisms underlying it. Thus, participants studied golf putting instructions and practiced putting either with the expectation of having to teach another participant how to putt or the expectation of being tested on their putting. During this acquisition phase, participants' motivation, anxiety, and information processing (the duration they took preparing each putt) were indexed as possible mechanisms underlying a motor learning effect. One day and seven days after the acquisition phase, learning was assessed by testing all participants on their golf putting. Results revealed that expecting to teach enhanced motor learning, replicating the original finding. Moreover, expecting to teach increased the duration participants took preparing each putt, which was correlated with superior motor learning. Thus, results suggest expecting to teach enhances motor learning by increasing information processing during practice.

1. Introduction

Determining practical ways to enhance motor learning is crucial to facilitate motor behavior. In light of this, Daou, Buchanan, Lindsey, Lohse, and Miller (in press) investigated a novel means to enhance motor learning: have learners study and practice a skill with the expectation of having to teach it. The impetus for this investigation was the small body of literature indicating that expecting to teach may enhance the learning of declarative knowledge, like academic information (Bargh & Schul, 1980; Benware & Deci, 1984; Nestojko, Bui, Kornell, & Bjork, 2014). However, no previous research had investigated the effects of expecting to teach on motor learning, which relies heavily on procedural knowledge. Thus, Daou et al. attempted to address this shortcoming.

Specifically, Daou et al. (in press) had participants study and practice golf putting during an acquisition phase either with the expectation of having to teach the skill to another participant (Teach group) or being tested on the skill the next day (Test group). Participants' study time and practice repetitions were allowed to vary in order to test whether expecting to teach would have an indirect and/or direct effect on motor learning. Specifically, Daou et al. sought to determine whether expecting to teach would increase studying and practice, thereby *indirectly* enhancing learning, or whether expecting to teach would *directly* improve learning, after statistically controlling for studying and practice. Upon arriving for the second day

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of the experiment, Teach participants were told the participant they were supposed to teach could not come, and so the Teach participant would be tested on their putting instead. Thus, Teach and Test participants completed retention and transfer tests (posttests). Teach participants exhibited superior posttest putting accuracy and consistency, even after controlling for the amount of time participants spent studying and the number of putts they practiced during acquisition, which did not differ between the groups. Therefore, Daou et al. revealed that expecting to teach *directly* (controlling for quantity of skill study and practice) enhances motor learning. Further, Teach participants remembered more key concepts about golf putting on a free recall test. The purpose of the present experiment was to replicate and expand upon Daou et al.'s results. We attempted to replicate the null result for the indirect effect and the positive result for the direct effect.

In addition to revealing expecting to teach enhances motor learning, Daou et al. (in press) also investigated possible mechanisms underlying their results. Specifically, Daou et al. examined motivation, which has been associated with both expecting to teach (Benware & Deci, 1984; Fiorella & Mayer, 2014, Experiment 1) and motor learning (for review, see Wulf & Lewthwaite, 2016). Daou et al. also assessed anxiety (pressure), which has been linked to expecting to teach (Fiorella & Mayer, 2014, Experiment 1) and may elicit adaptive levels of arousal (Yerkes & Dodson, 1908). However, Daou et al. observed no differences in motivation or anxiety between Teach and Test participants. The absence of differences might be related to the way in which motivation and anxiety were measured. Specifically, motivation and anxiety were indexed with single-item visual analog scales, which may have poorly represented the constructs. Additionally, Daou et al. measured general motivation, and expecting to teach has been shown to specifically enhance intrinsic motivation (Benware & Deci, 1984; Fiorella & Mayer, 2014, Experiment 1). Thus, we sought to overcome Daou et al.'s shortcomings in measuring motivation and pressure by indexing several types of motivation (intrinsic, internalized, and general) and pressure with the multi-item subscales of the Intrinsic Motivation Inventory (IMI; McAuley, Duncan, & Tammen, 1989).

Another shortcoming of Daou et al. (in press) is that they limited their investigation to social-affective mechanisms, when information processing mechanisms could have explained the motor learning effect. For example, participants could have engaged in greater information processing prior to acquisition phase trials, which has been associated with motor learning (e.g., Cross, Schmitt, & Grafton, 2007). Information processing prior to acquisition trials may benefit motor learning in multiple ways. For example, information processing may enhance the elaborateness and distinctiveness of a generalized motor program's representation, thereby improving its encoding (Shea & Zimny, 1983). As another example, information processing could facilitate learning the proper parameterization of a motor program given certain environmental conditions (e.g., distance to target), which could facilitate parameterization during program retrieval. In both cases, increased information processing prior to acquisition trials may elongate the preparation preceding each trial, as learners deliberately program their movement. Thus, we sought to index information processing during acquisition by quantifying the duration participants took preparing each putt.

A final shortcoming of Daou et al. (in press) is the problem that the Teach participants had their expectations violated just before their posttests, when they were told that they wouldn't be teaching. Conversely, the Test participants did not have their expectations violated, because they performed the posttests as anticipated. To address this confound, we added a second day of posttests, at which both Teach and Test participants knew they were going to be tested on their putting. This second day of posttests was 1 week after the acquisition phase, so these posttests also allowed examination of the relative durability of the motor learning effect.

We addressed Daou et al. (in press)'s shortcomings and attempted to replicate the motor learning effects: superior accuracy and consistency on retention and transfer tests, controlling for pretest accuracy/consistency, skill studying, and skill practice. Finally, we also explored the nature of the motor learning effects. Specifically, we investigated whether Teach participants developed a more elaborate generalized motor program than their Test counterparts, or were implementing a similar motor program but parameterizing it better. To examine this question, reaction time to begin the putting movement was recorded at a pretest and at the posttests (based on work by Henry & Rogers, 1960). Although a longer reaction time to begin a movement can indicate a more elaborate motor program is being 'opened', this means of assessing motor program complexity is weak. Specifically, there are many other factors that could contribute to reaction time, such as the sense of urgency brought about the 'go' signal (see Section 2.3.1). As such, this dependent variable should be sensitive to response programming, but is certainly not specific to response programming.

2. Methods

2.1. Participants

Fifty-six right-handed, young adults (31 females, M_{age} = 21.5, SD = 2.12 years; see Table 1 for detailed descriptive data) completed the experiment after providing informed written consent to an institution-approved research protocol. Two participants did not show up for Day 3, so their data were excluded from all analyses, and all information in the manuscript reflects the *exclusion* of these participants. Sample size was determined with an a priori power calculation providing 80% power ($\alpha \leqslant 0.05$) to detect a moderate-sized effect ($f^2 = 0.15$) of expecting to teach on motor learning, controlling for the quantity of time spent studying, repetitions of practice, and baseline (pretest) motor skill performance in a multiple regression model (Faul, Erdfelder, Lang, & Buchner, 2007). Participants were recruited from university courses and by word-of-mouth, and they were compensated with course credit and/or entry into a raffle for a monetary award.