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Enhancing performance expectancies through visual illusions facilitates motor learning in children

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ABSTRACT

In a recent study by Chauvel, Wulf, and Maquestiaux (2015), golf putting performance was found to be affected by the Ebbinghaus illusion. Specifically, adult participants demonstrated more effective learning when they practiced with a hole that was surrounded by small circles, making it look larger, than when the hole was surrounded by large circles, making it look smaller. The present study examined whether this learning advantage would generalize to children who are assumed to be less sensitive to the visual illusion. Two groups of 10-year olds practiced putting golf balls from a distance of 2 m, with perceived larger or smaller holes resulting from the visual illusion. Self-efficacy was increased in the group with the perceived larger hole. The latter group also demonstrated more accurate putting performance during practice. Importantly, learning (i.e., delayed retention performance without the illusion) was enhanced in the group that practiced with the perceived larger hole. The findings replicate previous results with adult learners and are in line with the notion that enhanced performance expectancies are key to optimal motor learning (Wulf & Lewthwaite, 2016).

1. Introduction

Enhancing learners' expectancies for future performance has been shown to be an important factor in motor skill learning, and enhanced expectancies are a key factor in the OPTIMAL theory of motor learning (Wulf & Lewthwaite, 2016). Learners' expectancies (e.g., self-efficacy) can be enhanced in various ways. For instance, defining "good" performance liberally, thereby increasing individuals' experience of success, has been demonstrated to facilitate learning (e.g., Palmer, Chiviacowsky, & Wulf, 2016; Trempe, Sabourin, & Proteau, 2012). In the study by Palmer et al., participants were asked to learn a golf-putting task. One group was informed that putting within the larger of two concentric circles surrounding the target would constitute good putts. Another group was told that balls coming to rest in the smaller circle would represent good performance. The group whose success was defined by the larger circle performed more accurately, with smaller error to the central target, during the practice phase. More importantly, that group also showed more effective learning, as measured by delayed retention and transfer tests with the circles removed. Thus, having experienced a higher percentage of successful putts during practice had lasting benefits. Furthermore, providing learners with positive feedback – for instance, feedback after relatively successful rather than unsuccessful trials – has been found to enhance their confidence in their ability to perform well in the future and facilitate learning (e.g., Chiviacowsky & Wulf, 2007; Clark & Ste-Marie,

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2007; Saemi, Porter, Ghotbi-Varzaneh, Zarghami, & Maleki, 2012). Similarly, social-comparative feedback indicating better-than-average performance or improvement (e.g., Lewthwaite & Wulf, 2010; Wulf, Chiviacowsky, & Lewthwaite, 2010) has been shown to enhance learning.

In another series of studies, researchers have used visual illusions (e.g., Witt, Linkenauger, & Proffitt, 2012; Wood, Vine, & Wilson, 2013) to manipulate the perceived size of a target (i.e., golf hole). When the golf hole was surrounded by smaller circles it appeared to be larger, and when it was surrounded by larger circles it appeared to be smaller (Ebbinghaus illusion). The question these researchers tried to answer was whether the perception of a larger target could increase putting accuracy. They found that putting accuracy was indeed higher when the target appeared larger rather than smaller. In an effort to determine a possible underlying mechanism of this effect, Wood and colleagues demonstrated that the apparent target size affected the "quiet eye" duration (Vickers, 1992). That is, the target was fixated longer when the target appeared larger rather than smaller. Wood et al. concluded that motor planning was aided with the longer target fixation, leading to more effective putting performance. It could also be argued that the task appeared less difficult or daunting and more likely to result in holing the putt – thereby enhancing performers' expectancies for movement success – which in turn contributed to more effective performance.

A follow-up study by Chauvel, Wulf, and Maquestiaux (2015) appears to provide some support for this contention. These authors included a delayed retention test without visual illusions to determine whether the effects seen during practice (with visual illusions present) would have an effect on *learning*. Motor learning is typically measured by retention or transfer tests, with the independent variables removed, conducted after a delay of at least one day (Schmidt & Lee, 2011). These conditions allow memory consolidation to take effect (Shadmehr & Holcomb, 1997). Moreover, removal of the independent variables ensures that potential temporary effects of these variables are not confounded with relatively permanent changes in performance (i.e., learning). The results of Chauvel et al.'s study showed that the performance-enhancing effects of the larger-looking hole were relatively permanent. Thus, learning was more effective in a group that practiced with a perceived larger hole compared with a group that practiced with a smaller looking hole. Chauvel and colleagues also assessed self-efficacy and found that participants' self-efficacy, or confidence in their ability to hit the target, was increased in the former group as well. In addition, self-efficacy predicted practice performance, and performance during practice predicted learning (i.e., retention performance). Overall, those findings indicated that the effects of practice under conditions involving visual illusions can be relatively permanent and persist when the illusions are removed – presumably due to their influence on perceptions of task difficulty and related performance or outcome expectations.

Chauvel et al.'s (2015) findings were recently challenged by Cañal-Bruland, van der Meer, and Moerman (2016). These authors used a marble-shooting task and were unable to replicate the previous findings (Chauvel et al., 2015; Witt et al., 2012; Wood et al., 2013). Cañal-Bruland et al. instead found performance improvements from a pre- to a post-test for a group with a perceived smaller target (and a control group), but not for a group with a perceived larger target. What might explain the discrepant findings? Aside from task differences, the two studies differed in other respects as well (e.g., number of practice trials). Yet, a likely and parsimonious explanation for the different results is the fact that Cañal-Bruland et al. had relatively large group differences on the pre-test. The group that later experienced the larger looking hole already had smaller errors than the other groups on the pre-test. Thus, the groups with a perceived smaller target or no visual illusion (control group) had more room for improvement from pre- to post-test. Nevertheless, additional research seemed to be in order to verify the beneficial learning effects resulting from enhanced learner expectancies by means of visual illusions.

In the present study, we therefore use methods similar to those used in previous studies (Chauvel et al., 2015; Witt et al., 2012; Wood et al., 2013). However, in contrast to those studies, in which adults were used as participants, 10-year old children participated in the present study. Children appear to be less sensitive to the Ebbinghaus illusion than adults (Doherty, Campbell, Tsuji, & Phillips, 2010). In particular, below age 7, children's discrimination of circle sizes was found to be more accurate compared with adults. That is, children's judgments were less affected by the size of the surrounding circles. Even at age 10, children were less sensitive to the illusion than adults were in the study by Doherty and colleagues (2010). Thus, in the present attempt to replicate Chauvel et al.'s findings, we used a more "challenging" population. Similar to Chauvel et al., we used a golf putting task. After a pre-test, two groups practiced the task with the hole being surrounded by smaller or larger circles (Ebbinghaus illusion) and then performed a delayed retention test without surrounding circles to assess learning. In addition to putting accuracy, we measured participants' perceptions of hole size and self-efficacy before and after practice, as well as before the retention test. We predicted differences in perceived hole size resulting from the visual illusions, as well as differential effects on self-efficacy and learning (i.e., retention performance). Correlational and regression analyses were used to explore possible relationships between learning, perceived hole size, and self-efficacy.

2. Method

2.1. Participants

Thirty 10 year-old boys ($M = 10.66$ and $SD = 0.41$) participated in the study at an Iranian university. A G*Power analysis showed that a total of 28 participants would be sufficient to correctly reject the null hypothesis (with $\alpha = 0.05$, $1\text{-}\beta = 0.90$). None of the participants had prior experience with the task. They were naïve as to the purpose of the study, and they gave their assent before participation, and the parents/guardians provided informed consent. The study was approved by the university's institutional review board.