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Full Length Article

The effects of autonomous difficulty selection on engagement, motivation, and learning in a motion-controlled video game task

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ABSTRACT

This experiment investigated the relationship between motivation, engagement, and learning in a video game task. Previous studies have shown increased autonomy during practice leads to superior retention of motor skills, but it is not clear why this benefit occurs. Some studies suggest this benefit arises from increased motivation during practice; others suggest the benefit arises from better information processing. Sixty novice participants were randomly assigned to a self-controlled group, who chose the progression of difficulty during practice, or to a yoked group, who experienced the same difficulty progression but did not have choice. At the end of practice, participants completed surveys measuring intrinsic motivation and engagement. One week later, participants returned for a series of retention tests at three different difficulty levels. RM-ANCOVA (controlling for pre-test) showed that the self-controlled group had improved retention compared to the yoked group, on average, $\beta = 46.78$, 95% CI = [2.68, 90.87], $p = 0.04$, but this difference was only statistically significant on the moderate difficulty post-test ($p = 0.004$). The self-controlled group also showed greater intrinsic motivation during practice, $t(58) = 2.61$, $p = 0.01$. However, there was no evidence that individual differences in engagement ($p = 0.20$) or motivation ($p = 0.87$) were associated with learning, which was the relationship this experiment was powered to detect. These data are inconsistent with strictly motivational accounts of how autonomy benefits learning, instead suggesting the benefits of autonomy may be mediated through other mechanisms. For instance, within the information processing framework, the learning benefits may emerge from learners appropriately adjusting difficulty to maintain an appropriate level of challenge (i.e., maintaining the relationship between task demands and cognitive resources).

1. Introduction

From very fundamental skills in the laboratory to complex skills in applied settings (e.g., rehabilitation), motion-controlled video games have the potential to improve motor learning (Laver et al., 2012; Lohse, Boyd, & Hodges, 2015;

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Saposnik et al., 2010). These games may enhance learning, not because of something inherent to video games, but because well-designed games utilize mechanics that increase engagement and motivation in their players (Hunicke, LeBlanc, & Zubek, 2004).

Engagement is a psychological state experienced during activity that has both affective and cognitive components (Leiker et al., 2016; O'Brien and Toms, 2008). In games, engagement comprises concepts of enjoyment, immersion, flow, and presence (Boyle, Connolly, Hainey, & Boyle, 2012). Game mechanics that are thought to contribute to engagement include viscerally pleasing stimuli, interactivity/choice, clear goals/mechanics, feedback, novelty/exploration, and adaptive difficulty (Lohse, Shirzad, Verster, Hodges, & Van der Loos, 2013; Zimmerli, Jacky, Lünenburger, Riener, & Bolliger, 2013). It is important to distinguish between engagement and motivation, although they are similar constructs, as a participant could be motivated to play a game, but if the game no longer offers adequate challenge, they may not be engaged by the game, potentially reducing future motivation. Also, in our previous work, we have found separable effects of engagement and motivation (Leiker et al., 2016; Lohse et al., 2015). Furthermore, in the present study, we are specifically interested in *intrinsic motivation*, motivation that is driven by interest/enjoyment in an activity itself, not external rewards or pressures (Ryan & Deci, 2000).

In order to explore how engagement and motivation change as a function of the practice environment, the game mechanic we chose to manipulate was interactivity/choice. Interactivity is what allows the player to communicate with the gaming system through various actions (Ritterfeld, Shen, Wang, Nocera, & Wong, 2009), while choice is the freedom to make decisions during the game. These two mechanics are intertwined, as interactivity involves choosing an option, and making a choice that affects the game is an interaction. Thus, we collectively refer to this mechanic simply as *choice*. More specifically, we gave participants choice over how difficulty progressed during practice, by allowing some participants to choose when and how to adjust the difficulty of practice. Progressive and appropriate challenge is regarded as a key component of "flow", which is a state of full immersion and enjoyment in an activity, such as a game (Csikszentmihalyi & Csikszentmihalyi, 1992). If a game is too easy or too hard in the beginning, then players will become either bored or frustrated, respectively, and lose motivation to play the game. However, gamers seem to enjoy what is known as "positive failure", or falling just short of success (Ravaja, Saari, Salminen, Laarni, & Kallinen, 2006). Some studies indicate that players can be nominally failing approximately 80% of the time during game play, yet they are still engaged and optimistic to try again (Lazzaro, 2004).

The concept of using choice to potentiate learning has also been examined in the motor learning literature. Autonomy over when to receive feedback (Chiviacowsky & Wulf, 2002, 2005; Fairbrother, Laughlin, & Nguyen, 2012; Grand et al., 2015), when to view a video demonstration (Wulf, Raupach, & Pfeiffer, 2005), and the number of trials (Post, Fairbrother, Barros, & Kulpa, 2014) during practice has been shown to enhance motor skill learning compared to yoked conditions. When given control over difficulty levels throughout a motor task that required intercepting falling targets by displacing a stylus on a pen tablet, participants performed better and with more accuracy during immediate and delayed retention tasks than their yoked counterparts (Andrieux, Danna, & Thon, 2012). Thus, self-control over different aspects of practice seems to be advantageous for motor learning (compared to control conditions), but the underlying mechanism/s for this advantage are still unknown.

There are two major hypotheses for why autonomous conditions may improve learning and performance. The first hypothesis is that having control over aspects of practice may allow participants to receive information that is better suited for their preferences and needs (Chiviacowsky & Wulf, 2002). Participants are able to ask for what they need when they need it, which in turn may increase the amount of information processing that occurs (Grand et al., 2015; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997). The second hypothesis is that self-control increases motivation and engagement during practice, subsequently increasing learning (McNevin, Wulf, & Carlson, 2000). Behaviorally, a number of studies have shown that engagement and motivation during practice are associated with superior learning at the group level (Chiviacowsky, Wulf, Lewthwaite, & Campos, 2012; Lohse et al., 2015). To the contrary, there has also been evidence that suggests there is not a direct, causal effect of motivation and engagement on learning (Ste-Marie, Carter, Law, Vertes, & Smith, 2015).

The goal of the present study was to explore the relationship between autonomy, motivation, and engagement, but primarily to see if increased engagement during practice was associated with better learning of the skill, similar to Lohse et al. (2015). In that study, Lohse et al. manipulated the aesthetics of a gaming environment while keeping the amount of practice and the mechanics of the game constant. Participants who trained in the "game" group (complex, space-themed graphics with ambient and task-related sound) showed statistically superior retention and transfer compared to participants in the "sterile" group (simple, geometric graphics with no sounds). Additionally, the game group self-reported statistically higher levels of engagement than the sterile group, however, the individual engagement scores were not correlated with participants' post-test performances.

In the current experiment, we manipulated a different game mechanic, choice, during a motion-controlled video game using only the "game" aesthetic condition adapted from Lohse et al. (2015). Participants were assigned to either a self-controlled or a yoked group, completed one day of practice, and then returned one week later for delayed retention tests. We hypothesized that participants in the self-controlled group would show superior learning (i.e., better performance on retention and transfer tests) compared to the yoked group. We also hypothesized that if autonomy were related to motivation and engagement, then participants in the self-controlled group would learn more and have higher self-reported levels of motivation and engagement than the yoked group.