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Progressive reduction versus fixed level of support during training: When less is less

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A R T I C L E I N F O

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A B S T R A C T

Previous empirical and theoretical work suggests that effective skill acquisition requires movements to be generated actively and that learning new skills supports the acquisition of prospective control. However, there are many ways in which practice can be structured, that may affect the acquisition and use of prospective control after training. Here, we tested whether the progressive modulation and reduction of support during training was required to yield good performance after training without support. The task was to use a stylus to push a bead over a complex 3D wire path. The support "magnetically" attracted and held the stylus onto the wire. Three groups of adult participants each experienced one of three training regimes: gradual reduction of magnetic attraction, only a medium level of attraction, or low magnetic attraction. The results showed that use of a single (medium) level of support was significantly less effective in yielding good performance with low support after training. Training with low support yielded post-training performance that was equally good as that yielded by training with progressive reduction of support; however, performance during training was significantly poorer in the former. Thus, less support during training yields effective learning but more difficult training sessions. The results are discussed in the context of application to training with special populations.

1. Introduction

The process of learning a new perceptuo-motor task has been characterized as a matter of first producing an approximation to the task specific movements, one that is qualitatively correct if quantitatively lacking (Newell, 1991; Swinnen, 1996). Quantitative improvement follows with practice. How best to foster improvement, either qualitative or quantitative, remains unclear. However, there is a growing body of evidence supporting the conclusion that the active generation of movements is required to yield effective learning of the corresponding skill (e.g., Beets et al., 2012; Liu, Cramer, & Reinkensmeyer, 2006; Snapp-Childs, Casserley, Mon-Williams, & Bingham, 2013; Reinkensmeyer & Patton, 2009; Wong, Kistemaker, Chin, & Gribble, 2012). Actively generated movement entails prospective control. That is, movements are future oriented – the actor uses perceptual guidance that anticipates each successive phase of a skilled movement allowing requisite control to be in place and operating as each new phase of a movement is entered. For instance, when driving a car or guiding a bead around a complexly curved wire, each turn must be anticipated and suitable control must begin before the curve is actually entered (Marchal-Crespo, McHughen, Cramer, & Reinkensmeyer, 2010; Snapp-Childs, Casserley, et al., 2013).

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The requirement for active generation of movements in the context of training for movement skill acquisition poses a problem for training methods (especially when training individuals with motor impairments). Passive modeling is ineffective, so how should the learner be guided? The answer is to provide support that allows the learner to produce task specific movements effectively while requiring those movements to be actively generated. Support can then be gradually reduced and eventually eliminated as the learner acquires the ability to perform the task. This was the approach taken by Snapp-Childs, Mon-Williams, and Bingham (2013) when formulating a method for training improved manual control by children of a stylus in drawing and handwriting tasks. They made a wire path magnetic so that the stylus was held onto the wire in a 3D tracing task, allowing the learner to concentrate on moving the stylus to push the bead around the curved wire path. The goal of the training was to yield better compliance control in the performance of drawing and writing. The best way to move the stylus along the wire path with the magnetic attraction was to move compliantly so as to better sense the wire and allow it to guide the movement. Snapp-Childs, Casserley, et al. (2013) found that the method yielded improved compliance control of the movements but only when movements were performed actively. However, only one form of active practice was tested – progressive reduction of support. It is well known that the structure of practice is important and that training schedules should be tailored to suit the goals of the learner (e.g., see Keetch, Schmidt, Lee, & Young, 2005). So, it remains unclear whether the progressive-reduction training schedule was optimal.

1.1. Present study

The purpose of the present study was to determine how variations in practice structure affect the efficacy of motor learning. Specifically, we examined whether a single level of support yields performance improvements equivalent to those yielded by the regimen of progressively modulated support. To do this, we tested three groups of adult participants who trained on a 3D tracing task. The first group experienced the training regimen used in the previous studies. They started with a high level of support (strong magnetic attraction) that was progressively reduced within each training session. The second group experienced a single medium level of support throughout the training. A third group experienced a single level of low support throughout the training.

First, we made predictions regarding the pre- and post-training performances. To anticipate which regimen might yield more effective learning requires an estimation of the contribution of errors to learning. If having too many errors is disruptive, then the progressive regimen might be expected to be better overall, followed by the medium support level and then the low support level. On the other hand, if the specificity of practice is important (Proteau, 1992), that is, that one learns what one has experienced in training, then the progressive and low support regimens would be required to yield significant improvement in performance of the task with low support, because both of these training regimens include practice with low support. We predicted that, after training, both the progressive and the low support regimens should yield good performance on the low support conditions; while the moderate support regimen should not. Next, we made predictions regarding the performance during training. The progressively modulated support was designed (and expected) to keep the rate of error production fairly low. In contrast, using a single level of moderate support was expected to produce higher error rates than the progressive training regimen at first and lower rates at the end. The low support training regimen should yield very high error rates to start, and while the errors should decrease over training, they were also expected to remain higher overall than the other training regimens.

2. Methods

2.1. Participants

Thirty-six adults participated in this experiment. Twelve participants were assigned to each of three groups (progressive support: 5 females, 7 males, 20–35 years old; medium support: 9 females, 3 males, 19–32 years old; low support: 8 females, 4 males, 18–29 years old). All of the participants reported normal or corrected-to-normal vision, no history of motor or neurological impairments. All participants, except for two, were right-handed. All participants used their preferred hand in the testing and training phases of the study.

2.2. Ethics statement

This study was approved by the Institutional Review Board at IU Bloomington and all participants gave written informed consent.

2.3. Apparatus

Participants interacted with a 3D display by moving a handheld stylus with their dominant hand/arm. The display was presented on a 15″ computer screen that was located on a desk 70 cm from participants. The stylus was attached to a desktop force feedback haptic virtual reality device, a PHANTOM Omni (Sensable Technologies, Inc.) and was located 50 cm in front and 10 cm to the right (or left for left-handed participants) of the computer screen. The PHANTOM is an impedance control