



Influence of practice schedules and attention on skill development and retention



Louisa D. Raisbeck^{a,*}, Alison Regal^b, Jed A. Diekfuss^a, Christopher K. Rhea^a, Paul Ward^c

^a Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, NC, USA

^b Department of Exercise Science, Finlandia University, Hancock, MI, USA

^c Department of Psychology, University of Huddersfield, United Kingdom

ARTICLE INFO

Article history:

Received 17 March 2015

Revised 17 June 2015

Accepted 24 July 2015

Available online 3 August 2015

Keywords:

Skill acquisition

Skill-focus

Extraneous focus

Practice scheduling

Contextual interference

Dual-tasks

ABSTRACT

Focus of attention during dual-tasks and practice schedules are important components of motor skill performance and learning; often studied in isolation. The current study required participants to complete a simple key-pressing task under a blocked or random practice schedule. To manipulate attention, participants reported their finger position (i.e., skill-focused attention) or the pitch of an auditory tone (i.e., extraneous attention) while performing two variations of a dual-task key-pressing task. Analyses were conducted at baseline, 10 min and 24 h after acquisition. The results revealed that participants in a blocked schedule, extraneous focus condition had significantly faster movement times during retention compared to a blocked schedule, skill focus condition. Furthermore, greatest improvements from baseline to immediate and delayed retention were evident for an extraneous attention compared to the skill-focused attention, regardless of practice schedule. A discussion of the unique benefits an extraneous focus of attention may have on the learning process during dual-task conditions is presented.

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1. Introduction

The early stages of motor learning are known to be cognitively demanding, interpretive, and effortful (Anderson, 1982; Ericsson, 2006; Fitts & Posner, 1967). Decades of research has focused on how skill development progresses through more advanced stages of learning, allowing skillful behavior to emerge (Adams, 1987; Salmoni, Schmidt, & Walter, 1984; Wolpert, Diedrichsen, & Flanagan, 2011). Two factors influencing skill development that have been extensively studied are practice schedules (Magill & Hall, 1990; Shea & Kohl, 1990) and the focus of attention during dual-tasks (e.g., Beilock & Carr, 2001; Beilock & Gray, 2012; Castaneda & Gray, 2007; Gray, 2004). While these factors have expansive literature explaining their importance in skill development, they have mostly been studied in isolation relative to the other. From a practical perspective, both practice scheduling *and* the focus of attention during attention-demanding situations (i.e., dual-tasks) would be manipulated in a real-world setting, and there may be an interaction between these factors influencing skill development. Thus, we provide a brief overview of the literature related to practice scheduling and dual-task literature, and then lay the foundation for examining both factors concurrently within a skill development context.

One way practice schedules are defined is in terms of blocked and random practice. The former refers to performing the same skill repeatedly, whereas the latter intertwines practicing different skills within the training session. Previous work has

* Corresponding author at: Department of Kinesiology, Health and Human Performance (HHP) Building, University of North Carolina at Greensboro, 1408 Walker Ave., Greensboro, NC 27412, USA.

E-mail address: ldraisbe@uncg.edu (L.D. Raisbeck).

demonstrated that skill development is enhanced with blocked practice (Magill & Hall, 1990; Porter & Magill, 2010; Shea & Morgan, 1979; Simon & Bjork, 2001). However, the skill is more strongly retained and/or transferred to a similar movement pattern when a random practice schedule is used (Magill & Hall, 1990; Porter & Magill, 2010; Shea & Morgan, 1979; Shea & Zimny, 1983; Simon & Bjork, 2001). It has been posited that a random practice schedule forces learners to continuously reconstruct the to-be-learned skill through elaboration and/or forgetting. That is, providing interference during the learning process, termed contextual interference (CI), can actually enhance skill retention and skill transfer (Magill & Hall, 1990; Shea & Morgan, 1979; Shea & Zimny, 1983). CI is defined as interference occurring as a result of practicing a task alongside other tasks (Schmidt & Lee, 2005). It is important to note that the majority of research examining CI compares a blocked order of the same trials (low CI) with a random order of practice trials (high CI). Typical results from such studies demonstrate superior retention rates for learning when high CI is present (Porter, Landin, Hebert, & Baum, 2007). In addition to the typical blocked/random CI effects, studies have included a serial order of trials to manipulate a moderate level of CI compared to the high and low CI from blocked and random practice (Hebert, Landin, & Solmon, 1996). Results are mixed, some show that blocked practice is more beneficial for novices during retention; others found no differences (Jones & French, 2007). Porter and Magill (2010) conducted a study that provided systematic increases in CI compared to the traditional studies and the results showed that including moderate CI trials provided novice learners more time to correct errors and develop problem solving strategies to benefit performance.

It is plausible that the results from the blocked/random practice schedule literature are influenced by where attention was focused during skill development. For example, and in line with the forgetting hypothesis (Lee & Magill, 1983), when participants shift from one task to another during random practice, participants 'forget' how to perform the previously learned skill. Thus, random practice facilitates learning through solution generation (see Cuddy & Jacoby, 1982). Alternatively, it is possible that shifting from one task to another compels performers to focus on skill execution to 'relearn' the skill, but allows performers to behave more reflexively and focus attention away from skill execution during retention tests. Motor learning literature has studied this phenomenon through dual-task methodology (Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock & Carr, 2001). These studies are designed to explore the de-automatization of skills hypothesis (see Castaneda & Gray, 2007; Gray, 2004). This hypothesis posits that attention directed toward skill execution (deemed 'skill-focus' attention) will cause a disruption in proceduralized knowledge compared to attention directed toward an irrelevant aspect in the environment (deemed 'extraneous' attention). In line with this, participants who have high levels of experience in a task would be particularly affected by a skill-focus manipulation, as they would be required to switch from an automatic, global mode of control to a more localized mode of control that focuses on a single component of the skill. However, those with less-skill may actually benefit when attention is directed toward skill execution until the motor movements become more automatic. It is argued that dual-task methodology is more challenging than attentional manipulation through instruction (Castaneda & Gray, 2007), and is the type of paradigm we believed would best answer our research questions. Specifically, we were interested in the interaction between practice type and attention while learning a new motor task in a challenging dual-task environment.

The purpose of the present study is to extend the current motor learning literature by examining how practice scheduling and attentional focus interact while learning a new task under challenging conditions. To our knowledge, only a single study has investigated the interrelationship of practice scheduling and focus of attention to show how they contribute to performance and learning (Modaberi & Nehbandanian, 2013). This study, however, manipulated attention through instruction, and we hoped to further our understanding of attention and practice scheduling by incorporating a more challenging (i.e., dual-task) environment. To do this, we required participants to complete a novel key-pressing task while attention was manipulated through a secondary task. Based on current consensus in the literature regarding optimal practice conditions and dual-task conditions, the three hypotheses were made. First, the combination of random practice and skill-focused attention would lead to superior skill retention relative to all other conditions. This hypothesis is based off of the contextual interference literature that has reliably showed the beneficial effects of a random compared to blocked practice schedule (Magill & Hall, 1990; Shea & Kohl, 1990), and the dual-task literature that has demonstrated novice performance enhancement when using a skill-focused mode of attention relative to an extraneous focus of attention (see Beilock & Carr, 2001; Gray, 2004). Our second hypothesis stated that significant improvements from baseline to retention would be exhibited for those engaging in random practice and skill-focused attention. Our third hypothesis stated that significant improvements from baseline to retention would be exhibited for those engaging in random practice with extraneous attention. Similar to the first hypothesis, the second and third hypotheses were developed from the contextual interference literature that show enhanced learning effects when a random practice schedule is utilized (Magill & Hall, 1990; Shea & Kohl, 1990). However, since the dual-task literature typically looks at transitory performance (e.g., Castaneda & Gray, 2007) we were unsure how this would influence learning. We suspected that, during a random practice schedule, performance would increase from baseline to retention for both types of focus (skill focused and extraneous).

2. Methods

2.1. Participants

Forty-nine students participated in this experiment (M age = 21.54 \pm 3.25 years). All participants were recruited from the local university community via verbal communication and flyers posted around campus. The study was approved by the

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