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# Nominal and functional task difficulty in skill acquisition: Effects on performance in two tests of transfer ☆

Elizabeth A. Sanli *, Timothy D. Lee

*Department of Kinesiology, McMaster University, Canada*

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A B S T R A C T

The influence of nominal and functional task difficulty during the acquisition of a motor skill was examined in two tests of transfer of learning. The task involved a ballistic, target-directed, finger action. Nominal task difficulty was defined as the distance of the target from the home position. Functional task difficulty was created by manipulating the progression of target distances during practice. Based on the challenge point framework (Guadagnoli & Lee, 2004), we predicted that practice with a set of targets farther away from the performer would benefit from less functional task difficulty, while practice with a closer set of targets would benefit from more functional task difficulty. In single-task transfer tests, learners who practiced using the high nominal task difficulty targets benefitted in terms of persistence of performance over time. In dual-task transfer tests, groups with an intermediate combined (nominal and functional) task difficulty performed with greater persistence over time on tests of transfer than those who practiced with the highest or lowest combined difficulty. Together these findings suggest that the influences of nominal and functional task difficulty during acquisition are weighted differentially depending upon the transfer test context. The challenge point framework does not accurately capture this complex relationship in its current form.



☆ This manuscript is based on data from the first author's doctoral dissertation.

* Corresponding author at: Department of Kinesiology, Brock University, 500 Glenridge Ave., St. Catharines, Ont. L2S 3A1, Canada.

*E-mail address:* elizabethannsanli@gmail.com (E.A. Sanli).

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## 1. Introduction

In a given practice context, there are many conditions to be considered in the attempt to maximize learning benefits (e.g., practice scheduling, provision of feedback, etc.). However, the effects of these conditions depend upon, and are interdependent with a number of other factors, such as the skill level of the learner and the complexity of the task itself (Wulf & Shea, 2002). We describe an experiment that tests predictions based on the "challenge point framework" (Guadagnoli & Lee, 2004) concerning a specific interaction of these factors.

### *1.1. Task complexity*

The classification of task complexity (or difficulty) has been addressed through various classification systems and continua, each of which describes task difficulty for specific tasks in a unique way (Gentile, 2000). A single task characteristic or system is unlikely to be sufficient for classifying the wide variety of motor tasks used in research and daily life (Wulf & Shea, 2002).

The challenge point framework (Guadagnoli & Lee, 2004) approaches the issue of task difficulty through two broad, descriptive categories. *Nominal task difficulty* refers to the absolute constraints of the task; it is the most general description of how difficult it is to perform a task. In contrast, *functional task difficulty* refers to the challenge presented by a task relative to the conditions in which the task is performed and the skill level of the learner (Guadagnoli & Lee, 2004). For example, what might be *nominally*, a moderately-difficult task might *functionally,* be easy or very difficult for two people of different skill levels, or for the same person under gentle vs. harsh practice conditions.

The nominal and functional difficulty for a given task can differ independently. One example of how nominal task difficulty has been quantified in the control of manual aiming is the "index of difficulty" (or ID; Fitts, 1954), which takes into account the size of a target and the distance to be covered to reach the target – the larger the amplitude for a given target width or the smaller the width for a given amplitude, the higher the index of difficulty. Fitts quantified ID for manual aiming task as $\text{Log}_2\,(2A/W)$ (where $A$ is the amplitude to the target and $W$ is the width of target).

Fitts' Law describes the relationship between movement time and task difficulty, which is typically characterized as a linear function, where $\text{MT} = a + b\,(\text{ID})$. According to the challenge point framework, the ID would be considered the nominal difficulty of the task. However, many factors could affect the functional difficulty, resulting in changes to the $y$-intercept (a) and slope (b) of the linear function – such as the mass of the limb or object being moved to the target, the age of the performer, etc.

Functional task difficulty is less likely to be quantified by researchers, however some have done so. Akizuki and Ohashi (2013) used a probe reaction time technique to measure the functional task difficulty of three variations of a stride-length-matching task in which the nominal task difficulty and participant experience level was kept constant. Those who practiced in a random schedule (frequently switching between variations), often considered to elevate functional task difficulty and to involve greater cognitive effort, had longer probe reaction times than those who practiced in a blocked schedule (completing all trials of one variation before moving on to the next).

### *1.2. Testing challenge point framework predictions*

Guadagnoli and Lee (2004) made predictions specific to contextual interference (CI), modeled information in practice, and the provision of feedback, such that increased task and environment complexity, and the resulting potential information would be of benefit as a function of a learner's experience with the task. Here we will focus on those predictions specific to the scheduling of practice trials (CI). For example, they predicted that "For individuals with differing skill levels, low levels of CI will be better for beginning skill levels and higher levels of CI will be better for more highly skilled individuals" (p. 219). Guadagnoli and Lee (2004) also made predictions regarding the interaction between nominal task difficulty and CI – defining functional task difficulty. For example, Guadagnoli and Lee