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Effects of practice schedule and task specificity on the adaptive process of motor learning

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ABSTRACT

This study investigated the effects of practice schedule and task specificity based on the perspective of adaptive process of motor learning. For this purpose, tasks with temporal and force control learning requirements were manipulated in experiments 1 and 2, respectively. Specifically, the task consisted of touching with the dominant hand the three sequential targets with specific movement time or force for each touch. Participants were children (N = 120), both boys and girls, with an average age of 11.2 years (SD = 1.0). The design in both experiments involved four practice groups (constant, random, constant–random, and random–constant) and two phases (stabilisation and adaptation). The dependent variables included measures related to the task goal (accuracy and variability of error of the overall movement and force patterns) and movement pattern (macro- and microstructures). Results revealed a similar error of the overall patterns for all groups in both experiments and that they adapted themselves differently in terms of the macro- and microstructures of movement patterns. The study concludes that the effects of practice schedules on the adaptive process of motor learning were both general and specific to the task. That is, they were general to the task goal performance and specific regarding the movement pattern.

1. Introduction

Task specificity has been considered a cause and consequence of the main models and theories of motor control and learning over the last century (Keetch, Lee, & Schimidt, 2008; Newell, 1989, 1991). A brief analysis of the history of the motor behaviour field shows that task specificity played a major role in its course and periods of crisis (Abernethy & Sparrow, 1992; Adams, 1987; Schmidt & Lee, 2011). For instance, task specificity was a key aspect in the controversy surrounding the task and process-oriented approaches (Pew, 1970). Whereas the former research focused on complex tasks related to industry and sport, in the latter, simple and artificial tasks were used to allow better inference of internal processes (e.g. attention and memory). In the case of the peripheral versus centralist debate, i.e. conflict between open and closed-loop theories (Adams, 1971; Schmidt, 1975), research emphasised slow versus fast and discrete tasks, respectively. Concerning the action versus motor theories confrontation (Meijer & Roth, 1988; Schmidt, 2003; Summers, 1998), it is possible to verify that research related to the former emphasised tasks of a phylogenetic nature and with cyclical and rhythmic characteristics, whereas investigations related to motor theory addressed tasks with strong cognitive involvement.

Studies about task specificity were originally influenced by Henry's hypothesis of motor specificity (Henry, 1958, 1959;

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Henry & Rogers, 1960), and they continue to be the focus of important issues in the motor behaviour field, including the effects of practice schedule on motor learning (e.g. Coelho, Nusbaum, Rosenbaum, & Fenn, 2012; Graydon & Griffin, 1996; Healy & Wohldmann, 2012; Keetch, Schmidt, Lee, & Young, 2005; King & Newell, 2013; Moradi, Movahedi, & Salehi, 2014; Proteau, Tremblay, & DeJaeger, 1998; Ranganathan & Newell, 2013; Shea & Kohl, 1990). However, in general, results on this concern remain inconclusive (see Keetch et al., 2008, for a revision). For instance, in experiment 1 by Keetch et al. (2005), experienced basketball players performed a set of shots (free throw) in a varied schedule by considering seven distances from the basket (9, 11, 13, 15, 17, 19, and 21 ft). In experiment 2, the task was modified by uncovering or covering the floor marks. In experiment 3, the type of task was modified, that is, the athletes performed the jump throw instead of the free throw. Results from experiments 1 and 2 showed better performance for throws performed at the foul line. Considering the free throw is performed from only one distance in a game (15 ft), the authors' conclusions were contrary to the hypothesis that practice variability elicits skill generalization. For them, the extensive practice related to the players' experience could have provided some benefits for learning a specific value (parameter) of the free throw. It seems there was specificity within a class of movement, that is, specificity within generality.

However, unlike previous experiments, no difference was observed in experiment 3. This result gives rise to the question if the specificity (or the way it interacts with generality) would also be dependent on the type of task. This is because the same reasoning from previous experiments could also be applied here, since the jump throw was also performed in a condition extensively practiced previously, perhaps even more than free throw. Throughout the game of basketball, players perform the jump throw countless times from different locations (Elliott & White, 1989; Erčulj & Štrumbelj, 2015; Miller & Bartlett, 1993, 1996). Thus, it is possible that the point is not just the massive practice itself, but also the difference between the tasks. Therefore, the fact of no specificity within the task in experiment 3 suggests the existence of specificity between tasks. Other questions have also emerged in relation to when or how much a motor skill would be different from another, i.e. what would be a movement class (Ranganathan & Newell, 2013; Schmidt, 2003). Moreover, it is important to highlight here that the study by Keetch et al. (2005) did not manipulate the constant practice schedule as a control group, i.e. in only one condition (distance) but with the same amount of trials. This implies further studies in order to get consistency to infer about variability of practice and task specificity.

Furthermore, contrary evidence to this study has emerged. For instance, while Keetch et al. (2005) showed that the specificity of practicing the task at the foul line was not related to the visual information of the markings on the court, Moradi et al. (2014) revealed that the effects of practicing the same task were specific to the visual conditions. In this study, participants of two groups practiced the basketball free throws under two conditions: full vision or seeing only the target. After that, they performed two transfer tests (immediate and delayed) by practicing the task in the two previous conditions. Results showed that both groups had their performances deteriorated when they performed the test in the condition different of the acquisition.

In sum, notwithstanding the developments provided by the foregoing studies, their findings still present some apparent contradictions. To the best of our knowledge, it seems that the main challenge is not to explain the results *per se* but in adopting a theoretical model that explains the effects of a practice schedule by considering the apparently contradictory phenomena of generality and specificity as coexisting in the same control structure (Keetch et al., 2008). In the present study, we aimed to advance the existing knowledge about the relationship between task specificity and practice schedule effects based on an emerging alternative model of the adaptive process of motor learning (Tani et al., 2014).

This adaptive model advances those current ones (e.g. Fitts & Posner, 1967; Jacobs & Michaels, 2007; Kostrubiec, Zanone, Fuchs, & Kelso, 2012; Newell, 1996; Schmidt, 1975; Schöner, Zanone, & Kelso, 1992) in relation to three main aspects: *first*, it characterizes a non-equilibrium model of motor learning. The current models are equilibrium-oriented, since they explain the motor learning as a stabilization process, i.e. their focus is on the pattern formation. To put it in another way, such models explain the motor learning as a process constrained by negative feedback mechanisms (diminishing of discrepancies/errors), which unfolds by phases and ends with the functional patterning of the motor skill (see Tani et al., 2014 for a revision). For instance, automation (Fitts & Posner, 1967), skilled optimization of control (Newell, 1996), and information-for-learning (Jacobs & Michaels, 2007) have been proposed as the last motor learning phases in some of the current models.

The problem here is not the acquisition of stability by itself, even because it is an important phenomenon for life, but what happens after that. In other words, the current models are limited in explaining how the acquired stability is transformed in order to make the learning a continuous process. For this purpose, any model or theory needs to consider the learner's nature as a non-equilibrium open system. This is because only far from equilibrium, a system have energy for changing, i.e. adapt itself (von Bertalanffy, 1950; Jantsch, 1980; Kauffman, 1995; Prigogine & Stengers, 1984, 1998).

What is adaptation in terms of motor skills and how it takes place refers to the *second* differential aspect of the adaptive process model. Generally, motor learning studies change the learning task after the acquisition phase (functional stabilisation) in order to apply a transfer test. This is a type of test is concerned with the assessment of the robustness of learning by separating it from the transitory effects of performance, i.e. accessing the transfer of functions (Cormier & Hagman, 1987; Fischman, Christina, & Vercruyssen, 1982). Differently, the adaptive process is proposed as a phase of motor learning whose core is the changes in the structure of motor skill, i.e. alteration of components and/or their interaction modes. In experimental terms, this implies a design involving the phases of stabilization and adaptation in order to show how adaptation takes place.

In sum, when considered in terms of an adaptive process, motor learning is characterised as a process marked by continuous cycles of acquisition and break of stability, i.e. stabilisation and adaptation as learning phases, respectively (Fig. 1A) (Corrêa, Correia, & Tani, 2016; Corrêa et al., 2015; de Paula Pinheiro, Marques, Tani, & Corrêa, 2015; Tani et al., 2014). The stabilisation phase involves the spatiotemporal patterning of the action, i.e. reduction of inconsistency and incorrect responses through negative feedback mechanisms. This process is characterised by functional stabilisation of the task, that is, the interaction between the task components becomes stable and the task goal is consistently achieved.