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Self-controlled knowledge of results: Age-related differences in motor learning, strategies, and error detection

Michael J. Carter [a,*], Jae T. Patterson [b]

[a] School of Human Kinetics, University of Ottawa, 125 University Ave., Ottawa, Ontario, Canada K1N 6N5
[b] Department of Kinesiology, Brock University, 500 Glenridge Ave., St. Catharines, Ontario, Canada L2S 3A1

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ABSTRACT

Research has demonstrated that a self-controlled KR schedule is advantageous for motor learning; however, the usefulness of a self-controlled KR context in older adults remains unknown. To address this gap in knowledge, we examined whether (1) the learning benefits of a self-controlled KR schedule are modulated by the age of the learner; (2) practicing in a self-controlled KR context concurrently strengthens the learner's error detection mechanism, and (3) the KR strategy during acquisition changes as a function of practice trials completed and age. As a function of age, participants were quasirandomly assigned to either the self-control or yoked group resulting in four experimental groups (Self-Young, Yoked-Young, Self-Old, and Yoked-Old). The results revealed the Self-Young group: (1) demonstrated superior retention performance than all other groups ($p < .05$); (2) was more accurate in estimating motor performance than all other groups during retention ($p < .05$), and (3) self-reported a switch in their strategy for requesting KR during acquisition based on the number of practice trials completed. Collectively, our findings suggest that older adults do not demonstrate the same learning benefits of a self-controlled KR context as younger adults which may be attributed to differences in KR strategies.

1. Introduction

Research has unequivocally revealed self-controlled practice to be a learning variable when performers controlled the frequency of observing a modeled demonstration, the use of physical assistive

* Corresponding author. Address: School of Human Kinetics, University of Ottawa, Montpetit Hall Room 403B, 125 University Avenue, Ottawa, Ontario, Canada K1N 6N5. Tel.: +1 613 562 5800x8849.
E-mail addresses: michael.carter@uottawa.ca (M.J. Carter), jae.patterson@brocku.ca (J.T. Patterson).

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devices, and the organization of practice repetitions (see Wulf, 2007 for a review). Similarly, a self-controlled knowledge of results (KR) schedule has proven more effective for motor learning compared to those not provided control (i.e., yoked group) for single task (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002, 2005; Patterson, Carter, & Sanli, 2011) and multiple task learning (Patterson & Carter, 2010).

The learning advantages of self-controlled practice are speculated to be the result of an increased *motivation* to learn (Boekaerts, 1996; Chiviacowsky & Wulf, 2002, 2005; Winne, 1995; Wulf, 2007), that practice conditions are *individualized* to the performers information processing capabilities (Chen et al., 2002; Chiviacowsky & Wulf, 2002; Keetch & Lee, 2007), and *task information* is requested only when necessary (Boekaerts & Corno, 2005; Chiviacowsky & Wulf, 2002; Winne, 2005; Wulf, 2007; Zimmerman, 1989). Learners also utilize *deliberate strategies* when provided the opportunity to control task-related information (e.g., KR after *good* trials: Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010).

The preference for KR after perceived good trials challenges theoretical accounts regarding the role of KR in resolving error; that is, minimizing the differences between the actual and the desired performance (Adams, 1971; Schmidt, 1975). The preference for feedback after good trials has been interpreted as a motivational factor during skill acquisition (Chiviacowsky & Wulf, 2002) and the perception that less cognitive effort is required to reproduce a successful response compared to the cognitive effort required to update a motor plan for an unsuccessful response (Chiviacowsky & Wulf, 2002, 2005; Koehen, Dickinson, & Goodman, 2008). The benefits of self-control have been primarily demonstrated in younger adults (see Wulf, 2007 for a review) and more recently in 10 year old children (Chiviacowsky, Wulf, Laroque de Medeiros, Kaefer, & Tani, 2008). In contrast, the usefulness of self-controlled practice in older adults has received minimal attention in the motor learning literature and consequently remains inconclusive (Patterson, Sanli, & Adkin, 2008).

Findings from the cognitive learning literature offer insight into the relationship between self-controlled practice and older adults. Compared to younger adults, older adults self-select practice strategies requiring minimal cognitive effort (e.g., recognition) for word association tasks and novel arithmetic problems compared to the cognitively effortful strategies (e.g., retrieval) considered advantageous for learning (D'Eredita & Hoyer, 2010; Hertzog, Touron, & Hines, 2007; Rogers & Gilbert, 1997; Rogers, Hertzog, & Fisk, 2000; Touron & Hertzog, 2004a, 2004b; Touron, Hoyer, & Cerella, 2004). Older adults' propensity to individualize a learning context that places low demands on their cognitive processes not only results in a less than favorable learning context but also suggests an explicit awareness of their age-related changes to information processing abilities and working memory capacity (Bäckman, Lindenberger, Li, & Nyberg, 2010; Bäckman et al., 2000; Fjell & Walhovd, 2010; Luo & Craik, 2008; Salthouse, 1996). In the motor skill learning literature, older adults have demonstrated similar learning advantages to their younger adult counterparts in learning contexts believed to place heightened demands on their information processing (i.e., cognitively effortful) (e.g., random practice: Jamieson & Rogers, 2000; Lin, Wu, Udompholkul, & Knowlton, 2010; reduced relative frequency of KR: Carnahan, Vandervoort, & Swanson, 1996; Guadagnoli, Leis, van Gemmert, & Stelmach, 2002). However, these practice contexts were externally determined by the researcher. For younger adults, a learner-controlled practice context has proven to positively impact motor skill acquisition. Yet for older adults, it currently remains unknown. The opportunity for the older adult to individualize their learning to match their changing information processing could in fact prove favorable for motor learning. However, based on the cognitive learning literature, the *effort* required by the older adult learner to individualize their learning context is perhaps a less than desirable method of facilitating their skill learning. For the present experiment, we were interested in determining if older adults would individualize a practice context that would place low demands on their information processing (i.e., frequent KR request) to the detriment of learning, *or*, individualize a learning context that optimally challenged their information processing abilities to the advantage of learning.

To address this gap in knowledge, the primary purpose of this experiment was to examine whether the learning advantages of a self-controlled KR schedule are modulated by the age of the learner. Based on the cognitive learning literature and age-related changes to information processing and working memory, we expected frequent KR requests during practice for older adults, at the expense of learning. We were also interested in examining the strategies for requesting KR as a function of