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ORIGINAL RESEARCH

Motor Skill Retention Is Modulated by Strategy Choice During Self-Controlled Knowledge of Results Schedules

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Investigations into the strategies that are used by participants when they control their knowledge of results (KR) schedule during practice have predominantly relied on multiple-choice questionnaires. More recently, open-ended questions have been used to allow participants to produce their own descriptions rather than selecting a strategy from a predetermined list. This approach has in fact generated new information about the cognitive strategies used by learners to request KR during practice (e.g., Laughlin et al., 2015). Consequently, we examined strategy use in self-controlled KR learning situations using open-ended questions at two different time points during practice. An inductive thematic content analysis revealed five themes that represented participants' unique strategies for requesting KR. This analysis identified two dominant KR strategies: "establish a baseline understanding" in the first half of practice and "confirm a perceived good trial" in the second half of practice. Both strategies were associated with superior retention compared with a yoked group, a group that was unable to engage in KR request strategies because KR was imposed rather than chosen. Our results indicate that the learning advantages of self-controlled KR schedules over yoked schedules may not only depend on what strategy is used, but also when it is used.

Keywords: motor learning, information processing, feedback, thematic analysis, strategies

Knowledge of results (KR) is a category of augmented feedback that informs learners about the outcome of their motor response relative to the task goal. Self-controlling one's KR schedule, defined as self-selecting when to receive or not to receive KR during motor training, has been shown to facilitate learning compared with conditions wherein the KR schedule is imposed on learners without any choice (i.e., a yoked condition; see Sanli, Patterson, Bray, & Lee, 2013, and Wulf, 2007, for reviews). This superior motor learning has been suggested to result from self-controlled KR schedules allowing participants to tailor their KR schedule to their

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individual needs on a trial-to-trial basis relative to yoked conditions (Chiviacowsky & Wulf, 2002). As such, Chiviacowsky and Wulf (2002) concluded that independent of the reasons why KR may be requested for a particular trial, its presentation would be more useful for participants in a self-controlled group because they receive KR when they actually need it, whereas in a yoked group, KR is essentially provided to the participants in a random fashion.

Motor learning scientists have predominantly examined the reasons why participants in self-controlled groups choose to receive KR during practice using multiple-choice questionnaires (e.g., Carter & Patterson, 2012; Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010). For example, after all practice trials were completed for a four-digit key-pressing sequence, Chiviacowsky and Wulf (2002) administered a KR questionnaire to participants in the self-controlled group as well as to those in the yoked group. Participants in the self-controlled group were asked to select the option that best captured their reason for requesting KR during practice. The options referred to whether KR was requested after participants thought they had a good trial, after a poor trial, after good and poor trials equally, or randomly. In contrast, participants in the yoked group were asked to reflect on whether they felt they received KR after the right trials; if they felt they did not, they were asked to identify when they would have wanted to receive KR by choosing one of the previously identified strategies. The questionnaire data for the self-controlled group revealed a strong preference for participants requesting KR predominantly after they thought they had a good trial. The majority of the participants in the yoked group reported that they did not receive KR after the right trials, and most of these participants stated that, if given the choice, they would have preferred to receive KR mostly after what they thought were good trials. This led Chiviacowsky and Wulf to conclude that self-controlled KR schedules are advantageous for motor learning because they are more congruent with the needs and preferences of the learner than yoked KR schedules.

Although the data from these KR strategy questionnaires provided valuable insight regarding how participants use KR when afforded control over their schedule, a limitation of multiple-choice questionnaires is that participants select a strategy from a predetermined list that is supposed to represent their "own" strategy. (It should be noted that these questionnaires have included an "other" option in which participants could write their own response; however, the general finding has been that most participants do not select this option.) More recently, researchers have begun to introduce open-ended questions into their experiments to further our understanding of strategy adoption during practice with a self-controlled feedback schedule (e.g., Aiken, Fairbrother, & Post, 2012; Fairbrother, Laughlin, & Nguyen, 2012; Laughlin et al., 2015). For example, Laughlin et al. (2015) asked participants to elaborate on their reasons for using four different types of instructional assistance, one of which was KR, while learning a three-ball juggling task. The authors identified three themes for requesting KR: (a) confirm success or improvement, (b) connect technique to performance, and (c) foster confidence or set goals. The confirm success or improvement strategy was the most popular of the three strategies, which parallels the data found in previous studies using multiple-choice questionnaires (e.g., Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010). The finding that some participants used KR to connect technique to performance and to foster confidence or set goals represents strategy information that has not been captured in previous self-controlled KR experiments, presumably because of the use of the multiple-choice questionnaires.

Although Laughlin et al. (2015) have shown that open-ended questions can identify new KR strategies, they provided very little detail about their qualitative analysis. For example, it is unclear how the themes were identified (e.g., inductively or deductively), and no measure of interrater reliability was reported. Nevertheless, a key contribution of Laughlin et al. is that querying participants about their strategies with open-ended questions can be used to identify new reasons for requesting KR, thereby increasing our understanding of why participants request KR when they have control over its scheduling in practice. Similar to Laughlin et al., we opted to use open-ended questions to query participants on their reasons for requesting KR during practice.

The KR strategy data presented in this article are from a secondary analysis of the practice and learning data that have been reported elsewhere as a function of experimental group (see Carter, Carlsen, & Ste-Marie, 2014). In that experiment, the work of Chiviacowsky and Wulf (2005) was revisited to further investigate the interaction between having control over one's KR schedule and the temporal locus of the KR decision. One self-controlled group made their KR decision before a trial (self–before), one made their decision after a trial (self–after), and another made a decision before a trial but could then decide to stay or change their original choice after a trial (self–both). A corresponding yoked group for each of these self-controlled groups was also included. The results revealed superior motor learning in the self-controlled groups that were able to complete their KR decision after a trial (i.e., the self–after and self–both) compared with their yoked counterparts and the self–before group. Interestingly, making the decision before a trial afforded no learning advantage because the self–before and yoked–before groups did not differ significantly on a delayed retention test. It was concluded that a self-controlled KR schedule is only effective for motor learning when the decision is made after a trial because one's self-evaluation of performance can subserve the KR decision, which would maximize the informational value of the KR received (i.e., reduce any uncertainty because information would be transmitted; Fitts & Posner, 1967; Guadagnoli & Lee, 2004; Marteniuk, 1976). Thus, the specific strategies used by participants when deciding to request KR may have a strong influence on the usefulness of the KR received and subsequent learning. Along this line, it was recognized that completing the KR decision before motor execution prevents participants from being able to request KR based on a perception of the just-completed motor response (e.g., after a perceived good performance); therefore, participants in the self–before group were unable to engage in similar strategies to participants in the self–after and self–both groups. On the basis of this inherent difference in strategy affordance and because the self–before group gained no self-controlled learning advantage over their yoked counterparts, it was determined that the self–before group would not inform our research question, and it was therefore excluded from the final analyses in this article.

In the present article, two phases of analyses were conducted. In Phase 1, an inductive thematic content analysis (Braun & Clarke, 2006) was performed on the responses from the open-ended questions to identify emergent themes that represented the participants' unique strategies for requesting KR during the first and second halves of practice. Inductive thematic analysis is a bottom-up data-driven process that involves coding participants' responses without trying to fit them into preexisting theoretical notions (Braun & Clarke, 2006). In this sense, by using an inductive approach, participants were given a voice to discern their own specific strategies for requesting KR that were guarded against preconceptions held by the researchers. In Phase 2, a quantitative analysis was conducted to determine whether motor learning, as measured in a delayed retention test, was differentially affected by strategy adoption. Specifically, we were interested in whether the dominant strategy of a given practice half, as identified in Phase 1, was more effective for retention than the other identified strategies (collapsed across each other) and not being able to request KR (i.e., a yoked group). On the basis of past research (Laughlin et al., 2015; Patterson & Carter, 2010), we expected that a dominant strategy would be requesting KR after trials that were perceived as good by the learner. We also expected to see a shift in the dominant strategy used between the two halves of practice because it has been shown that participants in a self-controlled KR group adopt different strategies on the basis of their stage in practice (e.g., Carter & Patterson, 2012). Similar to Laughlin et al. (2015), we also expected that the use of open-ended questions would reveal strategies for requesting KR that have yet to surface in previous self-controlled KR experiments.

Phase 1

It is important to note that the data collection procedures are identical to those reported in Carter et al. (2014), and the reader is directed to that article for specific details not included here.

Method

Participants. Data from 16 participants (10 women; $M_{age} = 21 \pm 0.82$ years) were included in the analysis in Phase 1. Written informed consent was obtained from all participants, and the study was approved and conducted in accordance with the ethical guidelines set by the university's Research Ethics Board.

Task and equipment. The goal of the task was to push and release a low-friction slider along a fixed horizontal rail to a target distance of 133 cm. Propelling the slider along the rail required participants to grasp the handle of the slider and then to slowly flex about the elbow joint, then quickly extend their arm and let go of the slider's handle when ready. This task can be likened to a force production task because participants need to learn the correct amount of force to exert for the slider to stop as close as possible to the goal distance. Participants completed this task in the absence of vision (i.e., opaque goggles were worn during all experimental phases) and using their nondominant hand as assessed using the Edinburgh Handedness Inventory (Oldfield, 1971). End position data of the slider on each trial was captured using a Vernier Motion Detector 2 (Vernier, Beaverton, OR; ultrasound frequency of 50 kHz with an accuracy of ±2 mm within a range of 0.5–6 m) that was located at the opposite end from where the participant sat. The motion detector was connected to a Vernier LabPro that transmitted the position data of the slider to a data collection computer. A customized LabVIEW program (National Instruments Corp., Austin, TX) was created to control the Vernier Motion Detector 2 and the Vernier LabPro and the timing of all experimental stimuli and to capture and store the end position data for offline analysis.

Procedure. Participants were randomly assigned and practiced in one of two self-controlled groups: self–after and self–both. Both groups were told they were free to choose when they would receive KR during practice, but with the restriction that they only had three requests per block of 10 trials and that in each block all three requests had to be used. This procedure is identical to that used by Chiviacowsky and Wulf (2005). More important, this ensured that all participants practiced with a relative KR frequency of 30%, which was necessary to avoid any potential learning differences resulting from differences in KR frequency. On the basis of their self-controlled group assignment, participants were also informed about when they would be required to complete their KR decision (i.e., they were told they would be asked either after a trial or both before and after a trial). When KR was provided to the participants, it consisted of the target distance (133 cm), the distance of their attempt (e.g., 140 cm), and their constant error score (e.g., 7 cm).

All participants completed 60 practice trials on Day 1. On completion of the third and sixth practice block, the self-controlled participants completed the open-ended question regarding strategy use which asked them to briefly describe "when/why did you ask for feedback during the previous three blocks of practice trials?" Participants required 1–2 min to write their answer on the provided sheet of paper, and thus no follow-up questions were asked on the basis of participants' descriptions. Motor learning was assessed using a delayed 24-hr no-KR retention test.

Data analysis. An inductive thematic content analysis was used to identify, analyze, and report themes within the data (Braun & Clarke, 2006). For this analysis, the primary coder first read through all participants' responses to the open-ended question and made notes based on the content of the responses. This step in the analysis allowed the primary coder to become immersed in the data and familiar with the depth and breadth of its content. Next, the open-ended responses were analyzed line by line and broken down into codes consisting of words, sentences, or entire paragraphs that shared the same idea or related to the same topic. For example, the response "If I felt I was getting bad/lazy with my movement" was a segment of text that was considered a code because it represented a single idea. Similarly, the response "I asked when I felt I had undershot or overshot to see by how much" was also considered a code because it represented a single idea. The next step involved assigning a tag to each code that was relevant to its content. For instance, the code "If I felt I was getting bad/lazy with my movement" was given the tag "Participant asked for feedback because their movement was poor," and the code "I asked when I felt I had undershot or overshot to see by how much" was given the tag "Participant believed they were off target." Once tags were assigned to each code, they were examined for similarities and grouped together, forming higher order themes. For example, the tags "Participant asked for feedback because their movement was poor" and "Participant believed they were off target" were similar and therefore grouped together to form the higher order theme of "Confirm a perceived 'poor' trial," which could also include any other similar tags. The operational definition of each higher order theme, an example of a participant's response for each theme, and the number of responses per theme can be found in Table 1. These themes represented participants' unique strategies behind requesting KR during practice.

Table 1 The Five Knowledge of Results Strategy Themes, Their Operational Definitions, and an Example of a Participant's Response

Strategy Themes		Count[a]
Establish a baseline understanding		9–6
Definition	Feedback was requested to obtain a reference for future trials on the basis of how the slider responded to exerted force.	
Example	"I asked for feedback on the first trial to gauge the force required to push the object towards the goal distance and to understand how much I needed to adjust" (Participant 19).	
Evaluate a change in (motor) strategy		5–4
Definition	Feedback was requested when purposefully changing force or arm configuration to see whether a new technique was more successful than the previous trial they received feedback on.	
Example	"I would ask for more feedback about two tries later [after a baseline strategy request] to see how effective my attempted corrections were" (Participant 14).	
Confirm a perceived "good" attempt		5–7
Definition	Feedback was requested because they felt their attempt was successful and wanted to see whether they were correct.	
Example	"I relied on the way it felt to judge how far I was pushing it. When it felt like I was pushing it the right amount of distance, I would ask for feedback to see if I was getting close" (Participant 16).	
Evaluate a perceived "poor" attempt		2–1
Definition	Feedback was requested because they felt their attempt was unsuccessful and wanted to see their amount of error.	
Example	"If I felt I was getting bad/lazy with my movement" (Participant 5).	
Schedule feedback based on trial		6–6
Definition	Feedback was requested in a way that did not consider force, technique, or accuracy, and instead requests were determined by the spacing of trials.	
Example	"I staggered the feedback based on trials to see if I would be more consistent with my throws" (Participant 5).	

Note. [a]Total number of responses for each theme as function of practice half (1st–2nd).

Validity. On the basis of the guidelines outlined by Yardley (2008), the technique of comparing researcher's coding was used during the inductive thematic content analysis to ensure that the identified themes that emerged from the data were not imposed by the primary coder. This technique is an external check of the research process that involves the triangulation of coding between two coders

(Yardley, 2008). Before the peer analysis occurred, the primary coder coded all responses into individual codes and grouped codes into five themes on the basis of similarity. Next, 52% of the codes were randomly selected and provided to the comparison coder. The comparison coder was also provided with a list of the five identified themes along with the operational definition of each theme. Finally, the comparison coder was instructed to label the codes presented to him to the best of his knowledge using the list of themes and definitions. The primary coder (SR) was an impartial sport psychology doctoral candidate whose area of expertise was in an area unrelated to motor learning (i.e., transformational leadership) and who also specialized in using mixed-methods research. An impartial primary coder was used to ensure the themes were inductively produced, rather than being influenced by predetermined notions or hypotheses based on the extant self-controlled feedback literature. The comparison coder was the first author of this article. A comparison analysis was performed to determine interrater reliability between the two coders, and a Cohen's kappa of .90 was calculated. Any value higher than .80 is considered to represent a strong interrater reliability (Hruschka et al., 2004); thus, the primary coder was deemed to be accurately portraying the data.

Results

Five themes were identified (see Table 1) that represented participants' unique strategies for requesting KR: (a) establish a baseline understanding, (b) evaluate a change in (motor) strategy, (c) confirm a perceived good trial, (d) confirm a perceived poor trial, and (e) schedule KR on the basis of trial. As can be seen in Figure 1, the dominant self-reported strategy for the first half of practice was "establish a baseline understanding," and least used strategy was "confirm a perceived poor trial." The other three strategies were used to a similar extent during the first half of practice. There was a decrease in the self-reported use of the "establish a baseline understanding" strategy from the first half to second half of practice. This decreased use of that strategy was replaced by an increase in the "confirm a perceived good trial" strategy, which became the dominant strategy during the second half of practice. The self-reported use of the "schedule KR based on trial" strategy also increased in the second half of practice compared with its use in the first half, with a concomitant decrease in both the "evaluate a change in (motor) strategy" and the "confirm a perceived 'poor' trial" strategy between the two practice halves.

Discussion

Similar to Laughlin et al. (2015), the use of open-ended questions in the present experiment also identified new strategies for requesting KR such as using KR to "establish a baseline understanding," to "evaluate a change in (motor) strategy," and also to "schedule KR based on trial" within a block, thus extending our current understanding of why participants choose KR during practice. We also noted a shift in the dominant self-reported strategy as a function of practice half, which is consistent with the findings of Carter and Patterson (2012). Specifically, in the second half of practice there was a shift from the "establish a baseline understanding" strategy to the "confirm a perceived 'good' trial" strategy. The identification

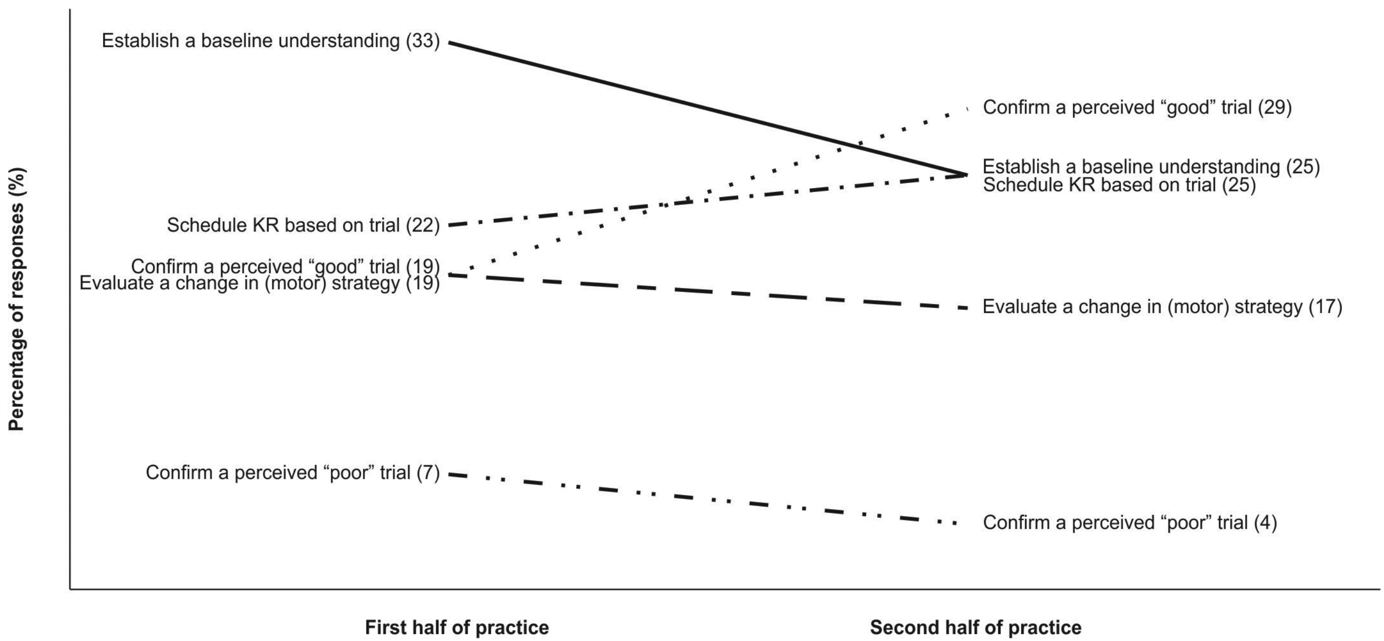

Figure 1 — Percentage of responses that were coded for each of the five themes for the first (left; Trials 1–30) and second (right; Trials 31–60) halves of practice. Note the shift in the dominant self-reported strategy (in bold) from "establish a baseline understanding" (solid line) during the first half of practice to "confirm a perceived 'good' trial" (dotted line) during the second half of practice. KR = knowledge of results.

of the "establish a baseline understanding" strategy is a novel contribution to the literature. We suggest that the propensity of most participants to adopt such a strategy in the first half of practice intuitively makes sense because KR could be used to help participants "get the idea of the movement" (Gentile, 1972, p. 5) that is required to propel the slider along the rail. Similarly, the "establish a baseline understanding" strategy may have helped familiarize participants with task-intrinsic feedback sources, which in turn is important for the development of a reference of correctness for the task (Schmidt, 1975). The use of the "confirm a perceived 'good' trial" strategy is commensurate with past research using both multiple-choice (Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010) and open-ended (Laughlin et al., 2015) questions. We suggest that this strategy may have served a reinforcement role that helped participants stabilize their performance around the task goal in the later stages of practice (Carter et al., 2014). Alternatively, it is possible that this strategy was used in a similar way to that reported by Laughlin et al., who found that KR was used to enhance motivation and to also set new goals.

The analysis also revealed that a fair number of participants reported requesting KR in a way that did not consider accuracy or technique and was instead scheduled on the basis of the spacing between trials within a block. It is conceivable that this strategy is a product of restricting the number of KR requests to three per block because the typical finding with self-controlled KR schedules is that participants fade their KR requests across practice blocks (e.g., Chiviacowsky & Wulf, 2002; cf. Laughlin et al., 2015). Last, the strategy of requesting KR after a perceived poor trial was the least reported strategy across practice halves, which is similar to those reported in past research (Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010) and suggests that most participants are quite capable of labeling trials as poor on the basis of task-intrinsic feedback sources.

Phase 2

The primary question of interest in Phase 2 was whether using the dominant KR strategy of a given practice half as identified in Phase 1 was associated with superior motor learning compared with not using the dominant strategy (i.e., using one of the other four identified strategies) and not being able to use any strategy (i.e., yoked group). On the basis of the learning results reported in Carter et al. (2014), we included the yoked–after group as our "no-strategy" control group in Phase 2 because this was the yoked group that had the most accurate performance on the delayed retention test; therefore, this group would provide the strongest contrast for our analyses than would using either of the other lower performing yoked groups.

Method

Participants. Data from 24 participants (15 women; $M_{age} = 21.5 \pm 1.25$ years) were included in the analysis in Phase 2. Written informed consent was obtained from all participants, and the study was approved and conducted in accordance with the ethical guidelines set by the university's Research Ethics Board.

Task, equipment, and procedure. The task, equipment, and procedures were identical to those reported in Phase 1 but with the addition of the yoked–after group to represent the no-strategy condition. The participants in the yoked–after group were paired with a self–after counterpart and replicated their KR schedule without any choice during practice.

Data analysis. To determine whether the dominant KR strategy in each practice half, as identified in Phase 1, was associated with superior motor learning compared with all other strategies (collapsed across each other) and a yoked group, two one-way analyses of variance were conducted on retention performance with strategy (dominant vs. all others vs. yoked) as the between factor. Differences with a probability of less than .05 were considered to be significant, and partial eta-square (η_p^2) is reported to provide an estimate of effect size. Post hoc analyses were performed using Fisher's Least Significant Difference to determine the locus of any significant differences (Carmer & Swanson, 1973; Saville, 1990).

Results

First Half of Practice

The dominant strategy for the first half of practice was the "establish a baseline understanding" strategy. As can be seen in Figure 2A, the "establish a baseline understanding" strategy group ($n = 9$) was more accurate on the delayed retention test than the group of participants who did not use this strategy ($n = 7$) and those in the yoked group ($n = 8$), which was supported by a significant main effect, $F(2, 21) = 7.061$, $p = .005$, $\eta_p^2 = .402$. Post hoc comparisons indicated that using the "establish a baseline understanding" strategy ($M = 7.45 \pm 5.22$ cm) resulted in significantly less error than the "all other strategies" group ($M = 17.83 \pm 14.19$ cm) and the no-strategy yoked group ($M = 24.88 \pm 8.61$ cm).

Second Half of Practice

The dominant strategy used during the second half of practice was the "confirm a perceived 'good' trial" strategy. As can be seen in Figure 2B, there was less error in the "confirm a perceived 'good' trial" strategy ($n = 7$) group than among the participants who did not use this strategy ($n = 9$) and the yoked group ($n = 8$), which was supported by a significant main effect, $F(2, 21) = 6.217$, $p = .008$, $\eta_p^2 = .372$. Post hoc analyses revealed that the "confirm a perceived 'good' trial" group ($M = 6.87 \pm 5.02$ cm) resulted in significantly less error than the yoked group ($M = 24.88 \pm 8.61$ cm), but was not statistically different than the "all other strategies" group ($M = 15.96 \pm 13.11$ cm).

Discussion

The analysis revealed that motor learning, as measured using a delayed no-KR retention test, was differentially influenced by not only the specific KR strategy adopted by the learner but also the timing of when a particular KR strategy was implemented. Specifically, it was found that the dominant "establish a baseline understanding" in the first half of practice was more effective for skill retention than using any of the other strategies or than being in a yoked group. For the second

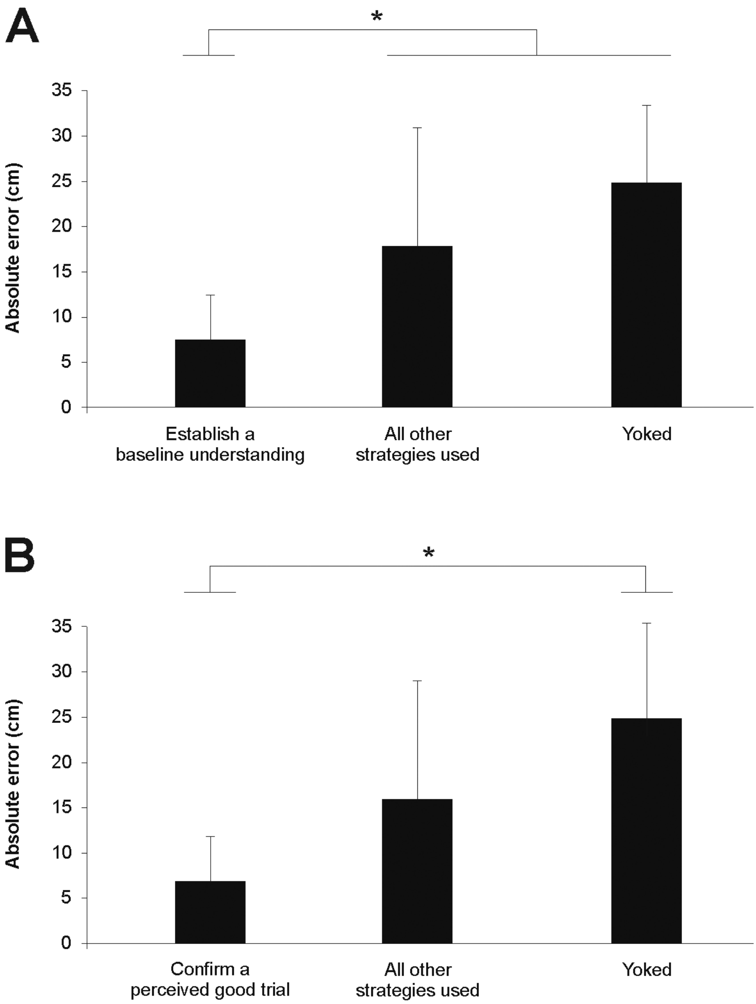

Figure 2 — Mean absolute error on the delayed retention test as a function of KR strategy use during the first (A) and second (B) halves of practice. KR = knowledge of results.

half of practice, the dominant "confirm a perceived 'good' trial" only resulted in significantly more accurate retention than practicing in a yoked group. It is important to note, however, that the difference between this strategy and using any of the other strategies did approach statistical significance (p = .08) for enhanced skill retention. Thus, it would appear that engaging in the "confirm a perceived 'good' trial" strategy during the later stages of practice did offer some magnitude of advantage over not using this strategy. These findings resonate with the fundamental view that motor learning is a dynamic process (Guadagnoli & Lee, 2004) and consequently the needs of the learner would be expected to vary as practice progresses. The fact that participants exhibited deliberate shifts in their strategy based on the amount of practice completed strongly suggests that self-controlled KR schedules allow participants to select strategies that maximize the usefulness of the KR received, which in turn has a beneficial effect on learning.

General Discussion

In the present article, we reported the findings from open-ended questions that asked participants in self-controlled KR groups to describe their strategies for requesting KR during the first and second halves of practice while learning a force production task. Previous self-controlled KR experiments have predominantly shared a common limitation of restricting participants to a single response to capture strategy choice, and the list of strategies to choose from were predetermined by the researchers (e.g., Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010). Similar to work by Fairbrother and his colleagues (e.g., Aiken et al., 2012; Fairbrother et al., 2012; Laughlin et al., 2015), we used open-ended questions to circumvent this limitation; thus, the qualitative approach used in Phase 1 is advantageous for two main reasons. First, using an inductive rather than a deductive thematic analysis provides participants with a voice, and therefore the themes that emerged from this analysis to represent KR strategies were derived from the content of their responses rather than having the researchers impose predetermined strategies. Second, the open-ended questions allow for the discovery of not only new reasons as to why KR was requested, but also strategies that may have been unique to the type of task used or the skill proficiency of the learner (e.g., Laughlin et al., 2015). In fact, our analysis not only confirmed previously identified strategies such as using KR to confirm both perceived good and poor trials (e.g., Chiviacowsky & Wulf, 2002), but it also identified new strategies that included using KR to "establish a baseline understanding," to "evaluate a change in (motor) strategy," and to "schedule KR based on trial" within a block. Moreover, the analysis in Phase 2 represents a novel contribution to the literature because it revealed that adopting certain strategies appears to be more effective for learning than other strategies as measured using a delayed retention tests.

The finding that participants predominantly wanted to use KR to "establish a baseline understanding" is much in line with researchers who have that proposed motor learning is a problem-solving process (e.g., Adams, 1971; Gentile, 1972; Guadagnoli & Lee, 2004; Higgins, 1991; Marteniuk, 1976; Schmidt, 1975). In the context of the task used in this experiment, participants needed to learn how much force was required to propel the slider, in addition to the optimal arm orientation to use, grasping style, or release point. Indeed, adoption of the "establish a baseline understanding" strategy resonates well with the informational role of KR for the development of a reference of correctness (Salmoni, Schmidt, & Walter, 1984; Schmidt, 1975; Schmidt & Lee, 2011) and what Gentile (1972) described as "getting an idea of the movement" (p. 5). We suggest this KR strategy would therefore be instrumental in helping participants in their search for an appropriate movement configuration (i.e., motor plan) to achieve the task goal because KR used in this way would be expected to help direct the learner's attention to the relationship between the task goal, their movement, and its associated outcome. Interestingly, the importance of forming a reference of correctness by knowing the result of their force output was evident in many of the participants' responses, for example, "For the first block I asked for feedback early on to get a sense for how far I was pushing the device" (Participant 6) and "[I] asked to gauge force required to push goal distance when first starting" (Participant 11).

The effectiveness of the "establish a baseline understanding" strategy during the first half of practice was also supported by the quantitative analysis in Phase 2. It revealed that using this strategy in the first half of practice was associated with significantly less error on the delayed retention test than using one of the other four strategies and a yoked group. Thus, we not only identified a novel KR strategy in the present experiment, but we also demonstrated that the use of this strategy during the early stages of practice has a positive effect on long-term skill retention.

The emergence of the "confirm a perceived 'good' trial" strategy as the dominant strategy during the second half of practice is also similar to Carter and Patterson (2012), as well as the existing self-controlled KR literature when participants identified a KR strategy for practice as a whole (e.g., Chiviacowsky, 2014; Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010; Patterson, Carter, & Sanli, 2011). Despite the robustness of asking for KR after perceived good trials in the self-controlled KR literature, it is interesting that in the present findings this strategy only showed a strong trend ($p = .08$), albeit in the expected direction, for significantly more accurate retention performance than using one of the other four strategies during the second half of practice. To account for this finding, we suggest three alternative explanations.

First, although participants perceived they were requesting KR after good trials, their performance on these trials was in fact not more accurate than on trials when KR was not requested. Such a view is supported by our previously published data (Carter et al., 2014) in which the analysis of performance on KR trials versus no-KR trials was not significantly different (see also Carter & Patterson, 2012; Patterson & Carter, 2010); however, others have found performance to be significantly more accurate on KR trials than on no-KR trials (e.g., Chiviacowsky & Wulf, 2002, 2005; Fairbrother et al., 2012). Second, the opportunity itself to strategically request KR and the information-processing activities associated with this process were the key factors for learning compared with the yoked group, which was denied the opportunity to engage in KR request strategies. This notion is consistent with that put forward by Chiviacowsky and Wulf (2002), who suggested that independent of the actual KR strategy used, the KR received will always be more useful for participants in a self-controlled group because they receive KR when they actually need or want it. Last, if we consider that the typical performance (or learning) curve during the practice phase is a negatively accelerating curve, the largest improvements in performance occur in the early stages of practice (Bryan & Harter, 1897, 1899; Schmidt & Lee, 2011). From this perspective, the bulk of performance improvements had already occurred in the first half of practice, whereas performance improvements in later stages of practice are known to be more modest.

In the present experiment, the number of KR requests provided to learners was restricted to three requests in each block of the 10 trials. As stated in the introduction, this was consistent with the procedures of Chiviacowsky and Wulf (2005) and was important to ensure that any differences in learning could be attributed to differences in the amount of KR received during practice (Carter et al., 2014). However, it is possible that this restriction could have affected how KR strategies were adopted compared with situations in which participants are afforded control over KR on all practice trials. Unfortunately, the design of this experiment did not enable us to answer this question; however, Patterson et al. (2011) did report that the percentage of self-controlled KR trials afforded did have a differential impact on how participants requested KR. In that experiment, the majority of participants in the group with self-control on 100% of trials mostly asked for KR after perceived good and poor trials equally. In contrast, the majority of participants in the two groups with self-control on 50% of trials reported asking for KR mostly after perceived good trials only. Although these groups differed in their self-reported KR strategies, their degree of learning did not differ significantly.

In conclusion, the use of an inductive thematic content analysis in Phase 1 of the present experiment revealed the use of KR strategies during practice that not only confirmed those used in previous experiments (i.e., after perceived good or poor trials; Fairbrother et al., 2012; Patterson & Carter, 2010), but also brought to light new strategies related to the choice of requesting KR. These included the strategies of "establish a baseline understanding," "evaluate a change in (motor) strategy," and last "schedule KR based on the trial" within a block of trials. We have also provided novel evidence that motor learning is differentially affected by the strategy used during the first half of practice. Specifically, participants should use KR early in practice to "establish a baseline understanding" because this strategy is thought to help participants search for the optimal movement configuration to achieve the task goal. Together, the results of the present experiment and those reported by others (e.g., Aiken et al., 2012; Fairbrother et al., 2012; Laughlin et al., 2015) suggest that the use of open-ended questions is an effective way to identify new KR request strategies; thus, it may be fruitful to introduce open-ended questions into practice contexts in which learners have control over practice variables other than KR.

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