Prior knowledge of final testing improves sensorimotor learning through self-scheduled practice

Flavio Henrique Bastos a,⇑, Welber Marinovic b,c, Aymar de Rugy c, Go Tani a

a Motor Behavior Laboratory, School of Physical Education and Sport, University of São Paulo, Brazil
b Perception Lab, School of Psychology, The University of Queensland, Australia
c Centre for Sensorimotor Neuroscience, School of Human Movement Studies, The University of Queensland, Australia

ABSTRACT

The elaboration of learning strategies has been considered a key factor to explain sensorimotor learning gains obtained in self-scheduled practice conditions. Nevertheless, the effect of prior knowledge of the testing context (i.e., the learning goal) on that process has been neglected. This study sought to determine whether: (a) learners in a self-controlled condition make different choices contingent on having or not having a learning goal; (b) providing a learning goal would modify the effects of a self-controlled practice condition, and (c) the effect of providing a learning goal would be due to the augmented cognitive effort or to the practice schedule resulting from the learning strategies. The results show that prior knowledge of a variable testing context affects the elaboration of learning strategies and improves skill acquisition in a self-scheduled practice condition. Furthermore, learning gains can be attributed to the self-imposed practice schedule resulting from the learning strategies, and not to the process of elaborating them.

1. Introduction

Baseball sportsmen are required to perform extremely accurate actions in order to hit a home run (Regan, 1992). A number of studies in the literature have sought to understand how such temporally accurate interceptive actions are performed (see Tresilian, 2004, 2005; Zago, McIntyre, Senot, &
Lacquaniti, 2008, 2009, for reviews). Although we can easily intercept falling balls with a bat within a time window of ±10 ms (McLeod, McLaughlin, & Nimmo-Smith, 1986) and quickly learn to deal with complex acceleration profiles (de Rugy, Marinovic, & Wallis, 2012), little is known about how to optimize the acquisition process of these sensorimotor skills. Learning how to deal with targets moving at various speeds is important as optimal preparation for anticipatory timing tasks depends on the accuracy of our temporal estimations (Marinovic, Reid, Plooy, Riek, & Tresilian, 2011). Here we sought to determine the role of learning goal on the acquisition of an anticipatory timing task.

A number of studies have shown that self-controlled practice improves sensorimotor learning (Wulf, 2007, for a review). An explanation for the positive effect observed in self-controlled practice schedules is that these conditions allow learners to elaborate and test strategies that would not be common in externally controlled practice conditions (Chiviacowsky & Wulf, 2002; Keetch & Lee, 2007; Wulf & Toole, 1999). Developing strategies is one of the cognitive processes related to what has been called ‘active involvement’ in the learning process (e.g., Wulf, 2007). This additional cognitive effort brought about by active involvement is believed to enhance sensorimotor learning (Lee, Swinnen, & Serrien, 1994).

Chiviacowsky and Wulf (2002) argue that learners can use current performance to develop learning strategies. In their study, learners that had the opportunity to self-regulate the delivery of augmented feedback used current performance to decide when to require it. The strategy developed by the learners consisted of requiring feedback mostly after trials they believed having performed well, in order to confirm their performance. Although learners can use current performance for the development of learning strategies in self-controlled practice conditions, a key element of this process has been neglected: the context in which the skill is performed. From a learner’s perspective, two different types of goals can be distinguished: the ‘task goal’, which merely refers to performing the sensorimotor task successfully, and the ‘learning goal’, which additionally includes the context in which the sensorimotor skill is to be performed with maximum success (e.g., final testing session). Both goals are not mutually exclusive, as learners with a learning goal should still seek to achieve the task goal on every trial. To clarify the distinction between these goals, imagine that two novice tennis players are instructed to practice their strokes using a robot launcher, and that this robot allows them to program beforehand the velocity of the balls for each trial. Both of them receive the same task goal: hitting the ball so that it lands on a specific region of their adversary’s court. However, one of them is also told that during a game, the adversary may vary the velocity of the ball and it would be appropriate to prepare for this during practice. This advance information that could affect, or guide, the way the learner organizes his set of practice trials, is classified as a ‘learning goal’.

Providing individuals with advance information has been shown to influence control strategies that optimize the use of visual feedback in discrete aiming task (Khan, Elliot, Coull, Chua, & Lyons, 2002) and adaptive behavior in interceptive actions (Tijtgat, Bennett, Savelsbergh, Clercq, & Lenoir, 2011). Nevertheless, it remains unknown whether it affects the way learners organize their practice in a self-controlled condition, i.e., whether it affects learning strategies.

Thus, if learning goals are used as a reference to develop learning strategies, we expected that learners in a self-controlled condition would make different choices, depending on receiving or not a learning goal. Additionally, we predicted that setting a learning goal would lead to greater involvement of the participants in the learning process, enhancing the positive effects of the self-controlled practice condition.

Prior knowledge of the variability present in the test following a period of practice was used as the learning goal in Experiment 1. Two groups were given complete control over the velocity a target would move in an anticipatory timing task, but only one group received the learning goal. Differences in the elaboration of learning strategies were inferred by means of the number of switches among velocities during practice. In Experiment 2, we analyzed whether the benefits of setting an explicit learning goal resulted from the cognitive engagement in the task or the differing self-imposed practice schedules.

### 2. Experiment 1

#### 2.1. Participants

Sixteen volunteers (12 men and 4 woman, age range 20–44; mean = 26 years) participated in this experiment. All participants reported having normal or corrected-to-normal vision and all gave their consent to participate in the study. Participants were not informed of the learning goal prior to entering the laboratory. They were asked to focus on hitting a target that moved horizontally across a screen placed in front of them. Participants were presented with a sequence of targets and were required to time their responses in order to hit the targets within a specified window. The task was repeated for 15 trials, and participants were informed of their performance after each block of trials. The learning goal was introduced after the participants had completed the first 15 trials, and participants were informed of their performance after each block of trials.

Please cite this article in press as: Bastos, F. H., et al. Prior knowledge of final testing improves sensorimotor learning through self-scheduled practice. Human Movement Science (2013), http://dx.doi.org/10.1016/j.humov.2012.11.008
written informed consent, which was approved by the local Ethics Committee of the School of Physical Education and Sport – University of São Paulo.

2.2. Task and apparatus

Participants were seated in front of a monitor screen in a chair positioned next to the table supporting the monitor. The participants were required to press with their index finger the space bar of a computer keyboard at the exact time they judged a moving red target (40 × 20 pixels) would make contact with a stationary red target (40 × 120 pixels), positioned at the right side of the monitor screen. The moving target traveled at a constant velocity from the left to the right side of a 17’’ LG Studioworks 710G monitor screen (85 Hz refresh rate, 1024 × 768 resolution) located 0.6 m away from the participant.

Participants could select the velocity of the moving target before the start of every trial. Targets moved with one of three possible velocities. Velocities (‘Velocity 1’ = 0.31 m/s, ‘Velocity 2’ = 0.41 m/s, and ‘Velocity 3’ = 0.50 m/s) were selected by pressing the numeric keys ‘1’, ‘2’ and ‘3’ on the computer keyboard. Pressing one of these keys immediately started the trial. The moving target took 1.6 s to reach the stationary target at Velocity 1 and 1.3 s and 1 s, respectively, at velocities 2 and 3. Visual stimuli were generated with Cogent 2000 Graphics (http://www.vislab.ucl.ac.uk/cogent_2000.php) running in MATLAB 7.5.

2.3. Procedures and design

The experiment consisted of three phases, named ‘Acquisition’ (AQ), ‘Immediate Transfer Test’ (ITT) and ‘Delayed Transfer Test’ (DTT). Before starting the experiment, participants were randomly assigned to one of two groups: Task Goal (TG, n = 8) or Learning Goal (LG, n = 8). In the acquisition phase participants performed 90 trials of the task described above – 30 trials for each of the three target velocities. Both groups were instructed to always strive to achieve the lowest possible error. They were also informed about the three velocities of the moving target and that they could choose any of them before each trial, not exceeding 30 trials per velocity. Before starting the AQ, participants in the LG group were told that at the end of the 90 trials they would take a test in which the three velocities of the target would be arranged randomly. They were instructed to select the velocities during AQ in order to prepare for this test. Participants in the TG group were instructed only to obtain the lowest possible error. The additional instruction related to the test, provided to the LG group before AQ, was the variable that distinguished LG and TG groups. Participants in the TG group were instructed about the test after the end of the AQ. Velocities in the ITT trials (24 total – 8 trials for each velocity) were pseudo-randomly arranged, so that one given velocity was not repeated in successive trials. The ITT was identical for both groups. DTT consisted of the same test (ITT), performed after a 15 min interval. Both groups were informed about the DTT only after the ITT. Participants were asked to browse the Internet during the interval between tests, to prevent them from mentally rehearsing the experimental task.

Prior to the AQ phase, each velocity of the moving target was shown to the participants once. The number of trials performed at each velocity was displayed to the participants before every trial. After each trial, participants received feedback about their timing performance. No feedback was provided during ITT or DTT.

2.4. Data analysis

With regard to the AQ, the mean absolute temporal error of the first trial performed in each velocity was used as an indicative of participants’ initial performance (baseline). Absolute temporal error (AE), defined as the absolute value of the difference between the key press and the time the moving target arrived at the designed location, and variable temporal error (VE), defined as the standard deviation of the temporal error over 15 trials (90 total – 6 blocks of 15 trials), were the dependent measures of interest. The mean absolute and variable temporal errors in the AQ were submitted to two-way ANOVA (2 groups × 6 blocks) with repeated measures on the second factor. Additionally, the number of
times that participants switched among velocities and the percentage of each velocity per block of trials were also considered.

Both transfer tests (ITT and DTT) were analyzed in two blocks of 12 trials each. AE and VE were the dependent measures of interest. The mean absolute and variable temporal errors, in ITT and DTT, were submitted to a two-way ANOVA (2 groups × 2 blocks) with repeated measures on the second factor. The same analysis was used to assess differences between the baseline and the AE obtained in the first block of ITT. The differences between LG and TG groups were further assessed through pairwise t-tests using the FDR (False Discovery Rate) correction (Benjamini & Hochberg, 1995). AE was transformed by its inverse in order to obtain a normal distribution (Shapiro Wilk’s test) and homogeneity of variance between groups (Levene’s test).

$\text{t}-$Tests for independent samples were used to assess differences between groups regarding the number of velocity switches and the baseline performance.

The data were organized and analyzed using R, a language and environment for statistical computing (R Development Core Team, 2011).

2.5. Results

The groups showed no difference in the baseline measure, $t(14) = -0.65, p > .5$, indicating that they had similar skill level at the beginning of the AQ. In addition, repeated measures ANOVA on the baseline and the first block of the ITT showed that there was significant improvement of performance by both groups with practice, indicated by the main effect of blocks, $F(1,14) = 18.26, p < .01$. 
2.6. Velocity choices

It was expected that with the instruction about the test (Learning Goal), participants in the LG group would perform more velocity switches during the AQ, compared to the TG group. The $t$-test on number of velocity switches confirmed this prediction, $t(14) = 3.07$, $p < .01$. The LG group performed an average of 42.6 ($SD = 17.5$) switches, while the TG group performed 13.7 ($SD = 6.8$).

Fig. 1 suggests that the LG group chose the three velocities in a balanced manner throughout the AQ, while the TG group tended to choose them by their numerical ascending order (i.e., ‘Velocity 1’ was more frequently chosen in the first blocks, followed by velocities 2 and 3).

2.7. Acquisition

We found a significant interaction effect between groups and blocks in the AQ for the AE, $F(5,70) = 2.67$, $p < .05$. Post-hoc comparisons revealed that the LG group showed better performance in the first block of trials, $t(14) = 2.84$, $p < .05$. We also found a significant interaction between groups...
and blocks for the VE, $F(5,70) = 2.55, p < .05$. Nevertheless, post hoc comparisons failed to determine the locus of differences. The mean absolute error of the 30 trials on each velocity was submitted to a one-way ANOVA to verify whether velocities were associated with different difficult levels of the task. This analysis revealed no significant differences among velocities for the TG, $F(2,14) = 3.45, p > .05$, or LG, $F(2,14) = 2.41, p > .05$, groups.

2.8. Immediate and delayed transfer tests

As can be seen in Fig. 2a, the LG group showed lower AE in both ITT, $F(1,14) = 5.07, p < .05$, and DTT, $F(1,14) = 7.68, p < .05$, indicating better performance for this group concerning the magnitude of the temporal timing error.

There was an interaction effect between groups and blocks in the ITT for the VE, $F(1,14) = 5.05, p < .05$, indicating that performance became less consistent between the ITT blocks for the TG group, which did not occur to the LG group (Fig. 2b).

Participants in the LG group showed different strategy elaboration in relation to the TG group, as revealed by the greater number of switches during the AQ and the avoidance of using the numerical designations given to the velocities to decide about which velocity should be performed.

Results from the AQ suggest that performing more velocity switches did not impair the performance of the LG group. Additionally, the mean AE and VE, in the ITT and the DTT, indicate that strategies developed by the LG group benefited learning. A possible explanation for the beneficial effect observed is the ‘intention superiority effect’ (e.g., Badets, Blandin, Bouquet, & Shea, 2006). In short, delayed intentions would have a privileged place in memory, being held in an augmented state of activation. Thus, one could suppose that the LG group would have held the sensorimotor skill in a heightened state of activation, due to the intention of performing the task after the AQ. Nevertheless, the modified state of activation is supposed to disappear once the intended action is fulfilled. In other words, in order to bear on this hypothesis, a drop in performance should have been observed in the DTT, since the intention of performing the task was fulfilled in the ITT. Thus, this effect is not suited to explain our results, since the learning improvement observed in the LG group remained in the DTT.

Two alternative hypotheses could account for our results. The first is that a greater cognitive effort was undertaken by the LG group, as they had to deal not only with the goal of the task, but also with the preparation for the test (cognitive effort effect). The second is that the practice schedule – resulting from the choices made by the group – could have led to superior performance in the transfer tests (practice schedule effect).

In an attempt to further investigate this issue, a second experiment was designed to control for the cognitive effort related to dealing with both task and learning goals, while retaining the practice schedule employed by the participants in Experiment 1. Specifically, in Experiment 2, participants of both groups were mirrored, so that the practice schedule resulting from their choices were performed by new participants – yoked groups.

3. Experiment 2

3.1. Participants

Sixteen volunteers (12 men and 4 woman, age range 20–36; mean = 25 years) participated in this experiment as volunteers. All participants reported having normal or corrected-to-normal vision and all gave their written informed consent, which was approved by the local Ethics Committee of the School of Physical Education and Sport – University of São Paulo.

3.2. Procedures

The task and procedures were identical to Experiment 1, except that both groups in Experiment 2, Learning Goal Yoked (LGY) and Task Goal Yoked (TGY), were not allowed to choose the velocity they performed in each trial. Each participant from the LG group from Experiment 1 was paired to a
participant in the LGY group, so that the order of velocities presentation was the same for both groups. The TG and TGY groups were paired in the same way. The number of trials performed at each velocity was not displayed to the participants before every trial, only the total number of trials. The reason for this was to avoid that participants tried to find some pattern in the way velocities were performed. Both groups were instructed to always strive to achieve the lowest possible error and were not given prior knowledge of the testing context (learning goal).

Data analysis were the same used in Experiment 1, except that none of the temporal error measures needed transformation to satisfy the parametric assumptions of normality and homogeneity of variance.

3.3. Results

The groups showed no difference in the baseline measure, $t(14) = -1.34, p > .1$, indicating that they had the same skill level at the beginning of the AQ. Repeated measures ANOVA on the baseline and the first block of the ITT revealed a main effect of blocks, $F(1,14) = 7.75, p < .05$, indicating practice improved performance for both groups.

![Fig. 3.](image)

Fig. 3. Absolute temporal error (a) and variable temporal error (b) of the LGY and TGY groups. A1–A6 refer to the blocks of trials of the acquisition, ITT1 and ITT2 to the blocks of trials of the immediate transfer test and, DTT1 and DTT2, to the blocks of trials of the delayed transfer test. Error bars represent the ±SEM. *Indicate where groups differed significantly ($p < .05$).
3.4. Acquisition

There was a significant main effect of group, $F(1,14) = 7.66, p < .05$, indicating that the LGY group performed better during the AQ than the TGY group. Additionally, there was a significant main effect of block for the AE, $F(5,70) = 4.36, p < .05$, and for the VE, $F(5,70) = 2.86, p < .05$ – Mauchly’s test indicated that the assumption of sphericity had been violated ($W = .1, p < .05$), thus Greenhouse–Geisser estimates of sphericity were used for both the AE ($e = .55$) and the VE ($e = .76$). Post-hoc comparisons failed to reveal the locus of differences between blocks.

3.5. Immediate and delayed transfer tests

Fig. 3a displays the mean AE of both groups, in both transfer tests. The repeated measures ANOVA on the AE showed a significant main effect of group for both ITT, $F(1,14) = 16.54, p < .01$, and DTT, $F(1,14) = 11.48, p < .01$, indicating a better performance of the LGY group in both tests, in terms of the magnitude of the timing error.

Fig. 3b displays the mean VE of both groups, in both transfer tests. The repeated measures ANOVA on the VE showed a significant interaction between groups and blocks in ITT, $F(1,14) = 5.52, p < .05$, indicating a performance decrement of the TGY group between blocks 1 and 2. A main effect of group in the DTT, $F(1,14) = 6.56, p < .05$, indicates that participants in the TGY group showed inconsistent performance compared to those in LGY group, after an interval without practice.

Results obtained in this experiment suggest that both yoked groups behaved like their counterparts in Experiment 1, supporting the previously mentioned ‘practice schedule effect’ in detriment of the ‘cognitive effort effect’. To further assess similarities between yoked groups in Experiment 2 and their counterparts in Experiment 1, the mean AE and VE were submitted to three-way ANOVA including two practice conditions (self-scheduled and yoked), two groups (LG-LGY and TG-TGY) and 2 blocks (ITT1, ITT2 and DTT1, DTT2), with repeated measures on the third factor. None of the interactions involving conditions, groups and blocks of trials were significant – ITT-AE: $F(1,28) = .02, p = .83$; ITT-VE: $F(1,28) = .04, p = .83$; DTT-AE: $F(1,28) = .39, p = .53$; DTT-VE: $F(1,28) = .0001, p = .99$. These results corroborate the qualitative analysis between experiments, giving support to the hypothesis that the practice schedule, resulting from the choices made by the LG group, led to superior performance in the transfer tests.

4. General discussion

The main goal of the experiments we report here was to determine whether providing a learning goal would lead learners self-controlling their practice to make different choices (compared to those not receiving one) and whether this would induce a learning advantage in relation to groups without it. Additionally, a second Experiment was carried out to investigate whether the cognitive effort, involved in dealing with the learning goal, was responsible for the observed learning gains.

In relation to the first goal, the results clearly indicated that receiving a learning goal induced different strategy elaborations (e.g., practice schedule). In Experiment 1, the learning goal consisted of preparing for the test participants would be submitted to after the AQ. Participants in the LG group were informed that the test consisted of responding to randomly arranged velocities of the moving target. Thus, as they were given control over the order those velocities would be performed during the AQ, we hypothesized that participants in the LG group would perform more velocity switches than the TG group, in an attempt to prepare for future performance. Some authors have found evidence that current performance is used to guide the development of learning strategies. In the study of Chiviacowsky and Wulf (2002) performance was used by participants to decide which trials they should require augmented feedback. However, although learners can use their current performance to guide the elaboration of learning strategies (organize the practice order), this seems to be insufficient. Receiving only the task goal, participants in the TG group used the numerical denomination given to the velocities (‘Velocity 1’, ‘Velocity 2’ and ‘Velocity 3’) as a reference to organize their practice. Specifically, they used the ascending order of the numbers, so that most of their trials in ‘Velocity 1’ were
performed prior to trials in ‘Velocity 2’ and, finally, those in ‘Velocity 3’. Critically, the same was not observed in the LG group. Keetch and Lee (2007) reported that movement sequences were chosen by learners, in a self-controlled condition, based on the alphabetical order of the letters labeling them (A, B, C, etc.). Nevertheless, as suggested by the results reported here, this “tendency” to choose according to the order of the labels does not indicate a characteristic of learners in a self-controlled condition, but the lack of a learning goal.

One could argue that participants without the learning goal (TG group) would select velocities according to necessity rather than their numerical designations. Particularly, they would select easier velocities (e.g., slower speeds) early in practice so as to prepare for more difficult speeds later (e.g., higher speeds). To test this possibility, we compared the mean AE involving all the trials on each velocity, in the AQ. This analysis revealed no differences for the TG or LG groups, indicating that velocities were not related to different difficult levels of the task. Therefore, we believe it is unlikely that velocity choice was associated with a particular strategy to select easier or harder velocities during the AQ. Furthermore, descriptive statistics of the TG group indicate that the ‘Velocity 1’ was the one yielding greater errors, followed by velocities 2 and 3. The mean absolute error for velocities 1, 2 and 3 for the TG group were 32, 31 and 25 ms, and 25, 26 and 21 ms for LG group, respectively. Thus, if participants in the TG group had selected velocities according to their performance level or due to the task difficult, the order of the velocities chosen by the TG group should be reversed in relation to the one observed in Experiment 1 – i.e., participants would start with Velocity 3.

With regard to the AQ, results of Experiment 1 indicate that self-imposing more variations did not impair the performance of the LG group, compared to the performance of the TG group. Furthermore, results from Experiment 2 indicate that a more variable practice schedule, resulting from the attempt of the LG group to prepare for the test, led to a better performance of the LGY group on the AQ, compared to the TGY group. This result contrasts with those reported in studies investigating imposed practice variability, in which performance decrements are expected in the AQ, accompanying variations. It has been shown that participants plan to take advantage of sensory information when sensorial expectations are high, as occurs in constant practice schedule (Tijtgat et al., 2011). Thus, it seems reasonable to suppose that participants of the LG group chose to perform some consecutive trials on a given velocity, so as to optimize performance on that velocity, even though they were aware that they should vary among velocities to prepare for the test. The resultant combination of constant and variable practice yielded a practice schedule that enhanced the performance of the LGY group on the AQ.

With regard to the transfer tests, results of Experiment 1 indicate that providing a learning goal benefits learners self-controlling their practice. The better performance of the LG group, in both transfer tests, could be due to what has been called “intention superiority effect” (Badets et al., 2006). In this case, the superior performance of the LG group would be due to the desire to perform the motor skill in a delayed moment. This desire, triggered by the instruction about the test, is believed to induce the storage of the motor skill in a higher level of activation in memory. However, the activation level should decrease after the completion of the intention (Marsh, Hicks, & Bryan, 1999). Thus, if the better performance of the LG group in the ITT was due to the intention superiority effect, we should have observed a decrease in performance in DTT. The intention superiority effect is therefore unlikely to explain the learning gains observed in our study.

In order to further address the positive effect of providing a learning goal, a second experiment was carried out. Specifically, we hypothesized that dealing with both, task and learning goals, would demand higher cognitive effort, leading to an improvement in learning. This cognitive effort is related to what has been called ‘active participation’ of the learner in the learning process and has been used to explain the benefits of self-controlled practice conditions (Bund & Wiemeyer, 2004; Chiviacowsky, Pinho, Alves, & Schild, 2008; Wulf, 2007). If this cognitive effort accounts for the better performance of the LG group in the transfer tests of the Experiment 1, both yoked groups in Experiment 2 should show similar performance in the transfer tests, as they did not have to take into account the learning goal. However, our results indicate that both yoked groups performed as their counterparts in the transfer tests. This not only rejects the explanation related to the cognitive effort, but implies that the practice schedule alone, resulting from the learning strategies developed by participants in Experiment 1, accounts for the observed effects.
The fact that groups showing more variable practice schedules (LG and LGY) performed better in the transfer tests – both involving practice variability – raises questions concerning the specificity of practice hypothesis. Briefly, the specificity of practice hypothesis states that learning is beneficial when the practice condition resembles the test condition (e.g., Tulving & Thomson, 1973). In this context, one might wonder whether testing learners on a blocked condition would benefit the TG and the TGY groups, whose practice schedules showed less variability, compared to the LG and the LGY groups. An interesting possibility would be that the LG and the LGY groups show better performance with a test that includes parameters not experienced during practice. This pattern of results would rule out the specificity of practice hypothesis, while keeping the variability of practice hypothesis (Schmidt, 1975) as a potentially valid explanation. These issues, however, remain open and should be tackled in future studies.

5. Conclusion

In this report we have demonstrated that providing a learning goal in a self-controlled practice condition affects the elaboration of learning strategies in an anticipatory timing task. Additionally, strategies elaborated in the presence of a learning goal benefited skills acquisition. These results highlight the importance of a reference to guide learners in self-controlled practice conditions. Results from Experiment 2 allowed us to conclude that the improvement in learning can be attributed to the practice schedule resulting from the learning strategies, and not to the process of elaborating them.

Generalizing to real life contexts, while learners could be simply told how their practice schedules should be, it seems important to explain the reason their practice is organized in a certain fashion. When the practice condition resembles the test condition (e.g., Tulving & Thomson, 1973). In this context, one might wonder whether testing learners on a blocked condition would benefit the TG and the TGY groups, whose practice schedules showed less variability, compared to the LG and the LGY groups. An interesting possibility would be that the LG and the LGY groups show better performance with a test that includes parameters not experienced during practice. This pattern of results would rule out the specificity of practice hypothesis, while keeping the variability of practice hypothesis (Schmidt, 1975) as a potentially valid explanation. These issues, however, remain open and should be tackled in future studies.

References


Please cite this article in press as: Bastos, F. H., et al. Prior knowledge of final testing improves sensorimotor learning through self-scheduled practice. Human Movement Science (2013), http://dx.doi.org/10.1016/j.humov.2012.11.008
