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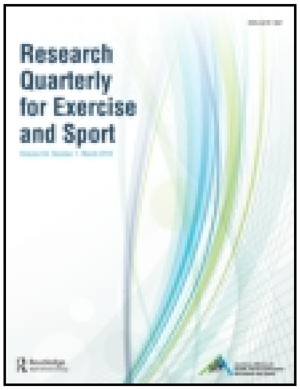

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Self-Controlled Practice Enhances Motor Learning in Introverts and Extroverts

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Self-Controlled Practice Enhances Motor Learning in Introverts and Extroverts

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Purpose: The purpose of the present study was to investigate the effects of self-controlled feedback on the learning of a sequential-timing motor task in introverts and extroverts. **Method:** Fifty-six university students were selected by the Eysenck Personality Questionnaire. They practiced a motor task consisting of pressing computer keyboard keys in a specific spatial and temporal pattern. The experiment consisted of practice, retention, and transfer phases. The participants were distributed into 4 groups, formed by the combination of personality trait (extraversion/introversion) and type of feedback frequency (self-controlled/yoked). **Results:** The results showed superior learning for the groups that practiced in a self-controlled schedule, in relation to groups who practiced in an externally controlled schedule, $F(1, 52) = 4.13$, $p < .05$, $\eta^2 = .07$, regardless of personality trait. **Conclusion:** We conclude that self-controlled practice enhances motor learning in introverts and extroverts.

Keywords: autonomy, competence, extraversion, feedback

An important motor-learning variable that has been extensively studied recently is self-controlled practice (Wulf, 2007). Self-controlled practice, in general, is a situation in which learners have possibilities of participating more actively in the process of learning, as they have the freedom to make decisions about some of its aspects. The benefits of self-controlled practice, when compared with an externally controlled condition (yoked groups) have already been shown for a range of different factors affecting learning, such as model observation (Wulf, Raupach, & Pfeiffer, 2005), order of multitask-learning trials (Keetch & Lee, 2007; Wu & Magill, 2011), use of assistive devices (Chiviacowsky, Wulf, Lewthwaite & Campos, 2012; Hartman, 2007; Wulf & Toole, 2001), and provision of feedback (e.g., Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Huet, Camachon, Fernandez, Jacobs, & Montagne, 2009; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997; Patterson & Carter, 2010).

Self-controlled feedback has consistently received more attention in the literature on self-control compared with the other practice factors, with studies investigating not only its effects on different tasks and populations, but also with the purpose of shedding light on the reasons for the benefits of self-controlled practice on motor learning. In self-controlled feedback manipulations, specifically, learners are usually provided with freedom to choose when and how frequently they want to receive feedback information during a practice session. Freedom of choice is considered an example of an important condition of autonomy support on learning contexts, in the same vein as using noncontrolling language, providing meaningful rationales, and acknowledging negative feelings (Su & Reeve, 2011).

It has been argued that self-controlled feedback benefits learning because learners have the possibility of asking for feedback according to their own needs or preferences, with perceptions of success playing an important role in this

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process (Chiviacowsky & Wulf, 2002, 2005; Chiviacowsky, Wulf, & Lewthwaite, 2012). Besides the important function that learners' needs can play in the self-controlled feedback schedules, investigations about the effects of this variable as a function of individual preferences/characteristics have not yet been considered. Individual differences may influence learners' choices regarding feedback schedules to fit needs or preferences, with direct consequences on learning. For example, in two experiments, Chiviacowsky, Godinho, and Tani (2005) and Chiviacowsky, Wulf, Medeiros, Kaefer, and Wally (2008) observed the effects of different self-controlled practice schedules on motor learning of adults and children, respectively. Comparing different schedules chosen by self-control participants, the authors found that adults who chose to request more feedback on the second half of the practice phase and less on the first half showed superior sequential-timing task learning compared with adults who chose the opposite schedule (Chiviacowsky et al., 2005). Also, a group of children who requested higher feedback frequency (39.3% on average) during the practice phase of a beanbag-throwing task showed superior learning than did a group who requested lower feedback frequency (8.4% on average; Chiviacowsky, Wulf, Medeiros, Kaefer, & Wally, 2008). These results suggest a possibility that certain individual characteristics may interact with self-controlled practice effects and may not always result in optimal learning for certain individuals.

A personality trait is a type of personal characteristic that may distinctively affect the performance and learning of motor skills. Personality traits have been mainly explained based on the cortical activation level of individuals, with introverts presenting higher activation levels and trying to avoid excessive stimulation sources and the opposite being observed in extroverts (Eysenck, 1967). The relationship between cortical activation and personality traits has been receiving support in a series of experiments carried out in the neurobehavioral level of analysis (Johnson et al., 1999; Kumari, Ffytche, Williams, & Gray, 2004; Mathew, Weinman, & Barr, 1984). Johnson et al. (1999) described brain activation associated with extraversion. Whereas their results showed an increased blood flow in the frontal lobes and in the anterior thalamus in introverts, they showed an increased blood flow in the anterior cingulate gyrus, temporal lobes, and posterior thalamus regions in extroverts. In the study by Kumari et al. (2004), using functional magnetic resonance imaging (fMRI), a negative relationship was observed between the extroversion level and resting fMRI signal; that is, the greater the extroversion score, the lower the level of resting cortical arousal. These results support the differences in personality proposed by Eysenck (1967), showing that the cortical arousal system, modulated by reticulothalamic-cortical pathways, is chronically more active in introverts than in extroverts. A similar approach of extraversion is based on a motivational dopamine system that facilitates behavior (Depue & Collins, 1999; Wacker, Chavanon, & Stemmler, 2006). In this view, extroverts present a more reactive behavior facilitation system than that of introverts and reach this state more easily, with weak incentive stimuli being sufficient to induce behavioral facilitation for these individuals (Hutcherson, Goldin, Ramel, McRae, & Gross, 2008).

Differences in personality can possibly lead individuals to present different reactions to the same stimulus or situation. In fact, motor performance differences between introverts and extroverts have been observed in some studies. For example, Doucet and Stelmack (1997) and Stelmack, Houlihan, and McGarry-Roberts (1993) examined participants' reaction times and movement times (MTs) in tasks involving releasing and depressing buttons after the appearance of a target stimulus. They found that extroverts have quicker MTs than do introverts. Meira, Perez, Maia, Neiva, and Barrocal (2008) found that extrovert children made fewer errors than introvert children while performing a saloon dart-throwing task. In the study by Thompson and Perlini (1998), while introverts showed superior learning than extroverts in a short-term memory task, they did not differ in their responses to positive and negative feedback. These results suggest that some factors that affect motor learning have the potential to present different effects in both personality traits.

Considering the different characteristics of introverts and extroverts, it is still unknown whether the already observed benefits of self-controlled practice for motor learning can be generalized for both extremes of the extraversion trait. Results of previous studies, showing the benefits of self-controlled schedules of practice, suggest this kind of practice provides participants with the chance to choose their own strategies (Wulf & Toole, 1999), according to their preferences, characteristics, or needs (Chiviacowsky & Wulf, 2002, 2005), with the potential to overcome eventual personality differences. In this way, we expect to find superior learning results for both introvert and extrovert self-controlled groups when compared with their yoked counterparts. Moreover, considering the proposition of Eysenck (1967) that introverts, unlike extroverts, seek to avoid excessive stimulation sources, and taking into consideration that feedback can constitute a source of stimulation, it is expected that: (a) Extroverts will choose to ask for more feedback during the acquisition phase to raise the activation level, whereas introverts will ask for less feedback to reduce the activation level; and (b) both self-controlled groups (introverts and extroverts) will achieve a level of activation that facilitates learning through the control of stimulation source (feedback) in comparison with the groups that do not have control over it.

In addition, because extroverts do not differ from introverts in their responses to positive and negative feedback (Thompson & Perlini, 1998) or in valuing nonsocial rewarding feedback (Fishman & Ng, 2013), and because the need for competence has been considered as

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universal and innate for all individuals (Deci & Ryan, 2000), we expect that both introverts and extroverts will ask for feedback mainly after good trials, in agreement with previous literature results (Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010), even with individual differences having the potential to affect the degree in which individuals can experience perceived competence satisfaction.

METHOD

Participants

Fifty-six adults (college students, $M_{age} = 21.6$ years, $SD = 3.4$ years) participated in the study. They were quasirandomly assigned to one of four groups, with seven men and seven women in each group, according to the personality trait, assessed by the Eysenck Personality Questionnaire (EPQ). All individuals participated as volunteers, and written informed consent was obtained from each participant prior to the experiment. The study was approved by the university ethics committee.

Apparatus and Task

The EPQ (Eysenck & Eysenck, 1991) was used as a tool for identifying participants' personality traits. The questionnaire, validated for Portuguese (Tarrier, Eysenck, & Eysenck, 1980), is composed of 88 questions with objective answers (yes or no), with relevant items to the dimensions of extraversion, neuroticism, psychoticism, and a lie scale, to detect individuals who are fudging the answers. The questionnaire provides scores for each key dimension in which every answer is an added point in its index. For the purposes of this study, an index greater than or equal to +1 standard deviation (SD) above the sample mean was considered extraversion, and an index equal to or lower than −1 SD below the population mean was considered introversion. The other traits were controlled, with scores between −1 SD and +1 SD from the sample mean indicating normality in neuroticism and psychoticism.

The following exclusion criteria were applied: scores at either 1 SD below or above the mean in neuroticism or psychoticism, scores greater than 1 SD from the sample mean in the lie scale, and scores within 1 SD above or below the mean in extraversion. The mean score of the extraversion trait in the present study was 12.84. Participants who achieved a score equal to or greater than 17 and less than 9 were considered extroverts and introverts, respectively. The mean score of the present study is in line with the value found by Caruso, Witkiewitz, Belcourt-Dittloff, and Gottlieb (2001; $M = 12.32$, $SD = 3.12$), who conducted a reliability generalization study of EPQ scores utilizing data from 69 samples of 44 different studies. However, it is slightly higher than the value found in the Tarrier et al. (1980) study ($M = 10.02$, $SD = 3.84$), in which participants of different age groups ranging from 16 to 75 years old were represented. Out of a sample of 227 participants (Figure 1), 80 met the inclusion criteria, but only 56 participants, the more extremes in the continuum of extraversion traits, were chosen. The mean scores and standard deviations on the EPQ for the self-controlled extrovert and introvert groups were, respectively, 17.36 (0.49) and 7.57 (1.28), while the yoked extrovert and introvert groups scored 17.21 (0.42) and 7.0 (1.51). Participants excluded from the experiment were told the selection was based on certain aspects of personality.

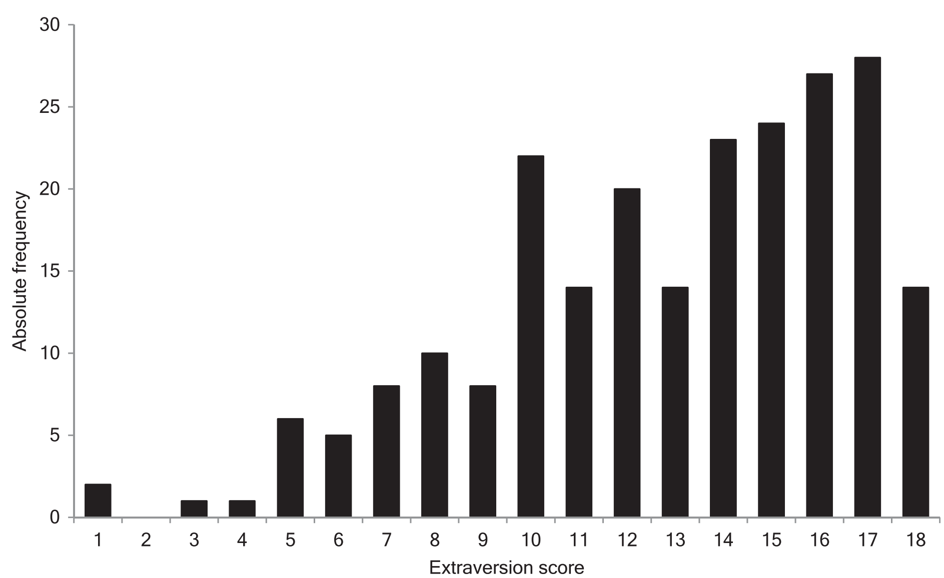

FIGURE 1 Distribution of participants, in absolute frequency, on each extraversion dimension score of the Eysenck Personality Questionnaire (EPQ).

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The task (the same used in several motor-learning experiments, e.g. Chiviacowsky & Wulf, 2002, 2005) required participants to depress four keys (2, 4, 8, and 6) on the numeric computer keyboard, with the index finger of their right hand, in a sequential way. The goal MTs for the three segments were 200 ms, 400 ms, and 300 ms (total MT = 900 ms) for the practice and retention phases, and 300 ms, 600 ms, and 450 ms (total MT = 1350 ms) for the transfer phase. The relative timing for the three segments (in percentage) in all phases of the experiment was 22.2–44.4–33.3.

Procedure

After being informed about the nature, risks, and steps of the study and agreeing to participate, the participants signed the informed consent and responded to the EPQ. The participants who met the criteria for composition of the sample were invited to participate. To verify the effects of self-controlled feedback in different personality traits, the 56 participants were divided into four groups, with an equal number of participants in each group: self-introverts, yoked introverts, self-extroverts, and yoked extroverts.

The participants received verbal instructions about the task before the first practice trial. The preferred hand was defined by questions about the hand used to write. The practice phase consisted of 60 trials of practice. The retention and transfer phases were performed 24 hr after the practice phase and consisted of 10 trials each, without feedback.

Participants who received self-controlled frequency of feedback were told that they would be able to request information by pressing the Enter key when they needed it. Those who received an externally controlled feedback frequency (yoked) were told that while they would not be able to request information when desired, they would sometimes receive it and sometimes not. All participants received the instruction that further tests would be carried out the next day without feedback. During practice, they sat at a table in front of the computer keypad and monitor. To indicate the keys to be pushed, as well as the time intervals between them, a graphic representation of the task was used during instruction. Feedback, when presented, was composed of the actual segment MTs as well as the goal segment MTs and was displayed in the computer screen for 8 s. A square appeared on the computer screen for 5 s after each trial to regulate intertrial intervals, and participants were instructed to start the next trial only after the square had disappeared. The experimenter demonstrated the task's spatial sequence once to familiarize participants with the procedure and with how the feedback was presented on the computer screen. A room especially reserved for the experiment was used, with only the presence of the experimenter and one participant at a time.

Data Analysis

The independent variables of the study were the type of feedback provision (self-controlled or yoked) and personality trait (extraversion/introversion). The dependent variables were the partial errors in absolute and relative timing obtained in each block of trials. For the practice phase, comparisons of means were performed with the data arranged in six blocks of 10 trials. The retention and transfer phases consisted of one block of 10 trials each.

Absolute error, a measure to assess absolute-timing performance, was computed by taking the absolute difference between the overall goal MTs and the actual overall MTs. The sum of the absolute differences between the goal proportions and the actual proportions for each segment was computed and used to measure relative-timing performance, resulting in the absolute error in relative timing. Absolute- and relative-timing performance were analyzed in 2 (personality trait: introversion, extraversion) × 2 (feedback type: self, yoked) × 6 (blocks of 10 trials) analyses of variance (ANOVAs) with repeated measures on the last factor for the practice phase. Separate 2 (personality trait: introversion, extraversion) × 2 (feedback type: self, yoked) ANOVAs were used for the retention and transfer tests. Bonferroni post-hoc test was used for follow-up analysis.

To determine whether self-control participants chose feedback mainly after good or poor trials and the schedule received by the yoked participants regarding trial type (good, poor), we calculated the average error on feedback and no-feedback trials for the practice phase in 2 (personality trait) × 2 (trial type) ANOVAs, separately for the self and yoked groups.

RESULTS

Practice

Frequency

Participants of self-controlled feedback groups requested feedback on 31.62% of the practice trials. Extrovert participants requested feedback on 30.95% of the trials (18 on average), 50.61% (9) of them in the first half of practice and 49.39% (9) in the second half. In turn, introverts requested feedback on 32.3% of the trials (19 on average), 51.54% (10) of them in the first half and 48.46% (9) in the second half.

Absolute Timing

Absolute-timing errors decreased across the practice phase (Figure 2). The main effect of the block was statistically significant, $F(5, 260) = 11.53$, $p < .01$, $\eta^2 = .18$. Post-hoc tests confirmed differences between Block 1 and all the other blocks, $p < .01$. There were no other differences between blocks. The main effects of "trait" and "feedback type," $Fs\ (1,\ 52) < 1$, and the interaction of Block × Trait × Feedback Type, $F(5, 260) = 1.46$, $p > 0.5$, were not statistically significant.

Relative Timing

Quite similar to the absolute timing, improvement was found from the first to the last block of practice (Figure 3). The main effect of the block was statistically significant, $F\ (5, 260) = 15.85$, $p < .01$, $\eta^2 = .23$. Differences between Block 1 and all the other blocks, $p < .01$, and between Block 2 and Blocks 4 and 6, $p < .05$, were also confirmed by *post-hoc* tests. Other differences between blocks were not observed. No differences were detected on the factors "trait," $F(1, 52) = 1.30$, $p > .05$, or "feedback type," $F(1, 52) < 1$, $p > .05$, or on the interaction of Block × Trait × Feedback Type, $F(5, 260) = 1.49$, $p > .05$.

Feedback After "Good" or "Bad" Trials

To determine whether participants in the self-control groups (introverted and extroverted) requested feedback more frequently after good or bad trials, we calculated absolute-timing errors for the trials that were followed (or not) by feedback during practice. The analysis indicated that feedback trials showed statistically significantly fewer errors, $F(1, 26) = 5.15$, $p < 0.05$, $\eta^2 = .16$, compared with no-feedback trials. No main effects were found for the interaction of Trial Type × Trait, $F(1,\ 26) < 1$. For the yoked groups, no main effects were detected regarding trial type or the interaction of Trial Type × Trait, $Fs(1, 26) < 1$.

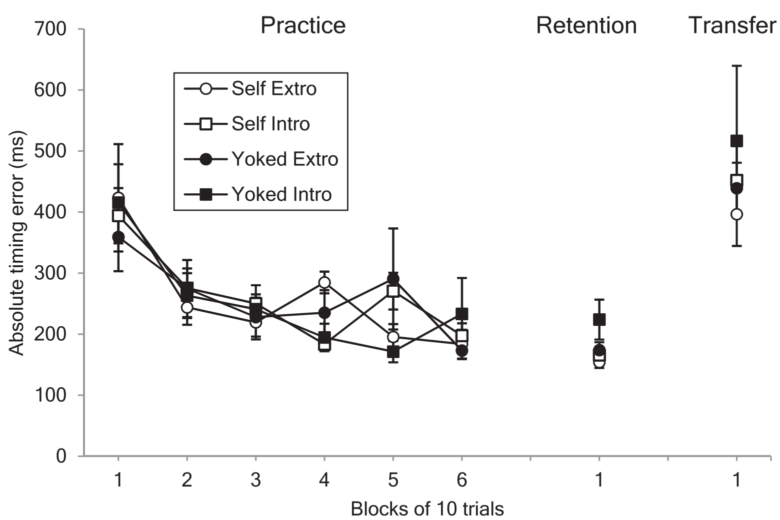

FIGURE 2 Errors in absolute timing, on blocks of 10 trials, during practice, retention, and transfer. Error bars indicate standard errors.

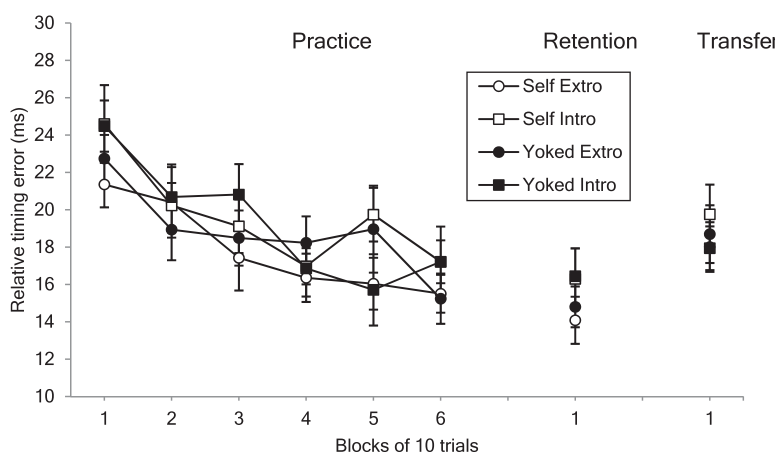

FIGURE 3 Errors in relative timing (%), on blocks of 10 trials, during practice, retention, and transfer. Error bars indicate standard errors.

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Retention

Absolute Timing

The groups' main effects were detected on the factor "feedback type": Self-controlled groups performed better, $F(1, 52) = 4.13$, $p < .05$, $\eta^2 = .07$, compared with externally controlled groups (Figure 2). Neither differences were detected on the factor "trait," $F(1, 52) = 2.59$, $p > .05$, nor on the interaction of Feedback Type × Trait, $F(1, 52) = 1.00$, $p > .05$.

Relative Timing

The main effect of groups did not indicate any differences on the factors of "feedback type," $F(1, 52) > 1$, or "trait," $F(1, 52) = 1.94$, $p > .05$, or on the interaction between them, $F(1, 52) < 1$ (Figure 3).

Transfer

Absolute Timing

There were no significant main effects among groups (Figure 2) on either factors of "feedback type" or "trait," Fs$(1, 52) < 1$. The same happened on the interaction of Feedback Type × Trait, $F(1, 52) < 1$.

Relative Timing

No main effects were found whatsoever among groups (Figure 3) regarding feedback type and trait factors, Fs$(1, 52) < 1$, or on the interaction between them, $F(1, 52) < 1$.

DISCUSSION

The purpose of this study was to investigate the effects of self-controlled feedback on the learning of a sequential-timing motor task in introverts and extroverts. The findings confirmed the main hypothesis and showed that self-controlled frequencies of feedback are more effective than externally controlled frequencies regardless of personality trait. Both introverts and extroverts presented better learning when provided with freedom of choice, when compared with participants who did not have the chance to choose their own feedback schedule, as the absolute-timing results show. Introverts and extroverts could likely similarly benefit from the autonomy generated by this kind of practice, even presenting differences regarding cortical arousal and activation levels (Eysenck, 1967; Johnson et al., 1999; Kumari et al., 2004; Mathew et al., 1984) or dopamine transmission levels (Depue & Collins, 1999; Wacker et al., 2006). According to the Yerkes-Dodson Law (Yerkes & Dodson, 1908) or the principle of the inverted U, performance is maximized at an optimal level of activation, which cannot be too low or too high for a determined task. Thus, introverts and extroverts may have reached a favorable level of activation through self-controlled practice, with learning being similarly benefited when compared with introvert and extrovert participants of the yoked groups. This result reinforces the generalization of the benefits of self-controlled practice for learning, particularly of self-controlled feedback, as already demonstrated in previous studies (Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Janelle et al., 1997; Janelle, Kim, & Singer, 1995; Patterson & Carter, 2010).

Also worthy of consideration is the observed superiority of the "self" groups in absolute timing but not in relative timing and on retention but not on the transfer test, when compared with the yoked groups. The former finding is in agreement with previous studies that used a similar task (Chiviacowsky & Wulf, 2002; Patterson & Carter, 2010), while the second only partially agrees with them, with both indicating a dissociation between dependent variables. This fact can demonstrate that the benefits of self-controlled feedback do not always impact parameters and program learning or task consolidation and generalization to novel task requirements, in the same way, when considering individual differences. The different results found in relative- and absolute-timing measures in retention can strengthen the evidence for a dissociation of generalized motor programs and motor schemata, mechanisms respectively responsible for controlling invariant (relative timing) and variant (absolute timing) aspects of an action (Schmidt, 1975). Alternatively, it can simply reflect the fact that feedback was provided only in the form of absolute and not relative MT, making it more difficult for the participants to form a basis for changes in the last aspect.

The results also showed that both extroverted and introverted participants requested feedback in a similar amount (around 31% of the trials) and mainly after the more successful trials during the practice phase. Although this frequency could be considered low, as the participants received feedback on only one third of the practice trials on average, it is in accordance with the results of previous self-controlled feedback studies (e.g., 35% in Chiviacowsky & Wulf, 2002; 7% in Janelle et al., 1995; 11% in Janelle et al., 1997). Thus, it seems that feedback information in a self-controlled schedule of practice does not constitute a source of stimulation that must be avoided by introverts to decrease sources of stimulation and thus reduce its level of activation. Also, it does not seem that extroverts request more feedback to seek sources of stimulation to raise their level of activation, as indicated in Eysenck's (1967) proposition. Both groups required the same amount of information for this type of task, with this amount not constituting an overload source of information for introverts or insufficient to extroverts. The fact that participants requested feedback mainly after the perceived good trials is also in line with the results of previous studies (e.g., Chiviacowsky & Wulf,

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2002; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Patterson & Carter, 2010; Patterson, Carter, & Sanli, 2011), and this suggests that both personality traits seemed to similarly benefit from the possibility of confirmed successful trials. This result can find support in the fact that the extraversion trait is considered to present predisposition to experience positive affect (Larsen & Ketelaar, 1989), and it confirms the importance of positive feedback as a strong motivational variable that is able to affect motor learning (for a review, see Lewthwaite & Wulf, 2012) in introverts and extroverts.

It has been proposed that self-controlled practice facilitates motor learning because it enables participants to test different movement strategies (Wulf & Toole, 1999), to manage practice strategies according to their needs, mainly to confirm successful performance (Chiviacowsky & Wulf, 2002, 2005; Chiviacowsky et al., 2012), and to perceive themselves as more autonomous during the learning process (Lewthwaite & Wulf, 2012). In fact, providing individuals with a more autonomous context had been demonstrated to be associated with more creative learning and engagement (Cordova & Lepper, 1996; Roth, Assor, Kanat-Maymon, & Kaplan, 2007; Zhou, 1998), lower stress and higher well-being (Weinstein & Ryan, 2011), and greater energy and vitality (Ryan & Frederick, 1997) between other aspects, because it may satisfy a basic psychological human need (Deci & Ryan, 2000, 2008). The present findings are in agreement with this proposition for extroverts as well as for introverts, showing that both personality traits benefited from an autonomous context of practice.

In conclusion, the results of this study seem to confirm that self-controlled practice can satisfy the different characteristics and needs of extrovert and introvert learners and that they benefit individuals with different personality traits in the same way. To our knowledge, this is the first study demonstrating that the positive effects of self-controlled practice can be generalized to motor learning in introverts as well as in extroverts. It would be fruitful if other studies were performed with the same variables, using different tasks and developmental levels.

WHAT DOES THIS ARTICLE ADD?

Self-controlled feedback has shown to be a factor that facilitates motor learning and investigations about the effects of this variable as a function of individual preferences/characteristics had not yet been consistently considered in the literature. In the present study, introvert and extrovert adults practiced a sequential-timing computer task. Their learning was compared in self-controlled and yoked frequencies of feedback, with the findings confirming previous results—that is, introverts and extroverts benefited similarly from self-controlled practice. To our knowledge, the present study is the first to demonstrate that the benefits of self-controlled practice can be generalized to motor learning in populations with different personality traits, despite their different characteristics. These findings have not only theoretical but also practical importance, because self-control protocols present the potential to meet introverts' and extroverts' needs, therefore benefiting their motor-learning process during practical sessions. Future studies could be performed using more ecologically valid tasks, as well as different variables controlled by the learners such as, for example, use of assistive devices or quantity of practice.

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