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The role of speed-based strategy instruction on learning and transfer of motor sequences in a complex task

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Abstract

Study aim: The purpose of this study was to investigate the impact of speed-based strategy instruction on motor sequence learning and transfer.
Material and methods: Male participants (n = 30, 18 to 24 years old) were assigned to one of the groups based on instruction. Motor sequence learning was examined using the complex dynamic arm movement task. Two sets of speed and control instructions completed ten blocks of 100 trials in the acquisition phase followed by the retention and transfer test after 24 hours.
Results: Mixed analysis of variance (2×10 and 2×4) and the independent samples t-test were used to examine the data. The results demonstrated that element response time and error of prediction in both groups were significantly improved in the acquisition phase ($P < 0.05$), but in the 24-hour retention test, the speed group had a significantly better element response time than the control group ($P < 0.05$). Furthermore, the findings of the independent samples t-test in the transfer test revealed that element duration and error rate were significantly better in the speed group than the control group ($P < 0.05$).
Conclusions: According to the data, when compared to the conventional technique, in which participants were not given any special instructions, the speed-based instruction resulted in greater acquisition of the acquired motor sequence and better transfer of a new sequence.

Keywords: Sequnce learning – Speed – Accuracy – Instruction – Complex task

Introduction

Motor sequence learning is one of the aspects of motor learning [33, 34]. Motor sequences are a particular category of implicit motor memory, which is described as the skill acquisition to create motor sequences efficiently and precisely while requiring little effort and focus. The two phases of the sequence learning process are learning the order of elements in the sequence and the capability to perform the sequence with appropriate speed and accuracy. A sequence's elements are created slowly and asynchronously when it is initially performed by a person [19]. When a sequence is generated initially, its components are executed individually, and then the time of sequence production decreases through practice. Future practice will cause the individual to become less dependent on external inputs, which will lead to being able to predict the subsequent step in the sequence and, in a sense, progressively acquire its related knowledge [10]. As sequence-related knowledge is acquired, one performs its elements with higher speed, accuracy and coordination [30].

Therefore, the goal of several studies in this area has been to identify crucial and efficient variables that encourage the acquisition of sequence knowledge to enhance its components more rapidly and precisely [5]. The kind of instruction is one of the most prevalent elements [17]. Originally, the majority of studies only employed explicit and implicit instructions, concentrating on strengthening the cognitive processes involved in comprehending the relative order of the elements of a sequence [15]. However, the motor processes that produce the response, such as speed, have received little study [5]. As several ideas and studies in this area demonstrated, speed is a key factor in sequence learning [5].

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According to Verwey [47], the chunking process of a sequence takes longer when a sequence is executed slowly or with a delay to maximize accuracy and reduce errors. Motor chunk is defined as the performance of two or more parts of a sequence simultaneously. A subsequence is created by performing a collection of independent components as a single unit. They emphasize that the aforementioned procedure is crucial for structuring and, consequently, sequence retention [47]. According to Howard and Howard [16], retarded motor execution impairs motor learning by interfering with cognitive processing processes [16]. Conversely, according to Barnhoorn et al. [5], individuals who execute the sequence more rapidly during the acquisition phase score better on the retention test when in a discrete sequence task [5]. Vieweg et al. [50] reported that one of the most significant influencing variables in how old and young individuals learn motor sequences is the difference in the speed at which the sequences are executed, with the elderly performing the motor sequences more slowly than the young [25]. Furthermore, Verwey [48] noted that a crucial aspect of learning motor sequences is the creation of linkages between the elements of a sequence. As a result of the interruption to the co-activation process and the lack of sequence generation-related development of representations, they claim that performing a sequence slowly, and thereby extending the time between the proper accomplishments of its components, causes people's performance to be degraded.

The influence of speed in learning the motor sequence is thus, in light of the subjects discussed, a significant difficulty in this discipline. According to the related literature review, this factor's contribution to learning the motor sequence has not yet been examined in any studies. According to Barnhoorn et al. [5], one of the primary causes of the paucity of research on the function of various educational instructions, such as speed in this field, is the different types of tasks used to study the acquisition of motor sequences, particularly complex tasks [52]. Contrarily, according to Burstyn et al. [6], the complexity of the task lengthens the time it takes to complete a sequence and reduces its accuracy [8]. Therefore, it is crucial to find a way to increase speed because it is a critical element of sequence learning [5]. According to Shea et al. [38], this problem is one of the key causes of the absence of a discrete framework in the field of sequence learning [38].

According to Shea et al. [39], the majority of earlier studies employed keyboard-required activities (such as serial reaction time, discrete sequence production, Tower of Hanoi, finger tapping, etc.). They argued that because most studies only required little processing, the role of error in analyzing sequence learning had been overlooked. In addition, the mechanisms involved in responding with the keyboard are very straightforward, cognitive, and evident. However, since these tasks are weak in motor components, they are not appropriate for examining the function of efficient strategies in sequence structure, particularly motor strategies such as speed [20]. The distinction between the processing requirements of simple and complex activities, and how their outputs cannot be extended to one another, is crucial in this context. Nevertheless, many scholars have overlooked this problem [28, 29]. According to Heitz [14], task complexity causes a sequence to take longer to execute and reduces accuracy.

To comprehend the sequence in complex tasks faster, it is important to offer a solution [14]. In light of the aforementioned rationales, it is not surprising that sequence structuring has recently begun only by increasing the amount of practice [1]. Therefore, the researcher utilized a dynamic arm movement task to investigate motor strategies such as speed. Due to the usage of hand bending and opening actions, the aforementioned task has higher motor requirements than the other types of assignments and is ideal for measuring motor learning [28, 29]. Additionally, this task is continuous, in contrast to earlier discrete tasks [21]. As a result, taking into account the discrepancy in the prior studies as well as the differences in the task's nature and the style of educational instructions compared to the previous research, the researchers analyzed motor learning based on the type of instruction in a challenging implicit sequence task as well as a novel method of providing knowledge for improved learning efficacy. Finally, the majority of prior studies have examined sequence learning using a retention test, although the transfer is considered by Müssgens and Ullén [27] as a crucial element in a more in-depth investigation of sequence learning. Transfer, which is the use of newly acquired skills in a different setting, is a crucial result in the study of motor learning [27]. Accordingly, little is known about whether the type of instruction enhances the transfer of skill acquired in the sequence task, in addition to the uncertainty concerning the function of effective practice techniques in motor sequence learning. Therefore, based on the information provided, researchers are attempting to determine whether a certain sort of instructional training enhances the retention and transfer process in a challenging sequential task.

Material and methods

Participants

The research sample size included 32 volunteers in the age range of 18–21 years (19.37±1.22) who were randomly selected based on the G POWER software (0.95 power and 0.20 effect size) [11]. During the research process, one participant of the speed instruction group was removed from the research due to not following the principles of the speed instruction and one person from the control group due to not attending the retention test on time. Finally, the number of participants in each group was 15. The criteria for entering the research include the age range of 18–21 years, being right-handed according to the Edinburgh Hand Dominance Questionnaire (Oldfield, 1971), having good general health status according to the Goldberg General Health Questionnaire (Goldberg, 1972), not having movement restrictions in the upper limbs based on the Box and Block Test (Mathews et al., 1985), not taking special drugs and not having physical and neurophysiological disorders and behavioral problems, not having previous experience in the desired task and having normal or modified natural eyesight. If the mentioned criteria were not met, the people did not fulfil the necessary criteria to participate in the research [3, 17]. The participants entered the research procedure by signing the informed consent form after confirming their mental and cognitive health and fulfilling the requirements of the study. The Ferdowsi University of Mashhad's ethics committee for biological research has given the study procedure approval under the reference number IR.MUM.FUM.REC.1400.262.

Apparatus

The apparatus was the Dynamic Arm Movement Task (DAMT), which was adapted from the Park and Shea task [17] to evaluate motor sequence learning. The apparatus consists of a horizontal lever and monitor (43 inches). The axle of the lever rotated freely in ball-bearing supports, allowing the lever to move in the horizontal plane over the table surface. At the distal end of the lever, a vertical handle was attached. The position of the handle could be adjusted so that the participant rested their forearm on the lever, with their elbow aligned over the axis of rotation and could comfortably grasp the handle (palm vertical). The location of the participants' hands on the lever was adjustable to their hands' length [7, 39]. The horizontal movement of the lever was monitored (1000 Hz) by an increment rotary encoder, which was attached to the end of the axle of a lever and stored for later analysis on the computer. A pointer was attached to the end of the lever extended so that it could be positioned within the targets on the monitor. Also, to reduce the noise, nine optical sensors were used on the main body of the apparatus under the lever to precisely elaborate the movement. Another pointer was attached vertically under the lever to make a connection with the optical sensors. The distance between the pointer and the monitor was 20 cm and the distance between the participants and the monitor was approximately 80 cm [17].

Method

The participants were chosen based on the research criteria, and the examined groups were divided into two categories based on age and results from the Box and Block Tests, with one group receiving speed instruction and the other receiving no instruction (control). The acquisition session consisted of 10 blocks of 100 trials (10 sequences with 10 repeat) with a minute of rest in between each block [26]. Except for the first, fifth, and ninth blocks, which were random, the target appeared in a preset pattern and order. The sequences were employed in the acquisition and retention stage in the following order: 1, 7, 4, 10, 4, 7, 1, 4, 7, and 10, with identical angles of 13.34° between the elements. The distance between the targets was fixed in random blocks, similar to patterned sequences [28, 29]. The test sessions were conducted immediately following the acquisition phase and 24 hours later [9, 26]. The participants were exposed to a novel sequence (10 elements) during the acquisition phase followed by the transfer test, which was conducted 24 hours later [17, 32].

Procedure

People faced the monitor while seated in a chair with a height-adjustable back for the test. The participant's arm was positioned on the chair such that it was around 60° away from his forearm in the starting position. The participants' range of motion was 0°–80° (elbow angle, which was 60° in the starting position for the participants, was considered equal to zero angle). Information on how to use the dynamic arm to complete the task was supplied to each participant. The participants positioned the pointer in the targets displayed on the monitor by bending and opening their arms while standing 80 cm in front of the monitor [22]. When viewed from the middle of the targets, the diameter of the targets was equal to around 2° of elbow flexion or extension. On the monitor screen, there were ten targets, but only four targets were active (1, 4, 7, 10). The aims' general outline was initially visible, showing that a block is active. Participants were instructed to set the lever in the start position before each block (black circle). As soon as the beginning location was determined, a target outline with the first point 20° from the starting position appeared on the screen. Other targets were 6.67° apart from one another. To familiarize themselves with the task, participants completed a random preparatory session at the start of the training session, which presented 10 targets separated by 500 milliseconds, which then the acquisition phase initiated. The main block began with a brief sound, which was simultaneously presented with the initial stimulus [17]. The only variation between the groups' practices of the identical sequence was how the instructions for the process were delivered. The speed instruction group instructed the participants to strive to complete the training attempts in each block as quickly as they could without thinking about the error rate. However, before the start of the acquisition phase, the participants in the control group were merely taught how to use the device and react to the target. Like many studies on this field, they received no explicit instructions before or during the break in training blocks. However, when there was a rest interval between training blocks in the acquisition phase and the total duration of the speed group's training block was 2.5% faster than the total time of the previous training block, instructions should have been given to them. When this did not occur, the sequence block's total execution time was the same as the block before it, and they were informed that "your speed is fixed, attempt to improve it". Finally, a warning indication was shown on the screen concerning not following the speed instruction when the overall execution time of the training block was longer than the duration of the prior block. The person would be removed from the study process if this happened a third time [5].

Data analysis

For data analyses, the MATLAB software (Math works, R2014a) was utilized and SPSS 22 was used as used for statistical analysis (at the 0.05 significance level). The research variables included element response time and error of prediction. The element response time was computed as the elapsed time from hitting (crossing the target boundary) the currently illuminated target to hitting the next illuminated target. The error of prediction was indicated when a reversal movement was made away from the intended target in a sequence. Four amplitudes and four reversals make up the required pattern and assuming no extra movements resulted in motor corrections or sequence repeat, all but one of the sequences spontaneously formed with at least eight predictions. Any extraneous prediction in the movement route that resulted in more than eight default direction changes was considered an error. Each inaccuracy shows that the participant selected the right stimulus based on a flawed prediction.

Online learning, motor sequence learning (retention), and transfer of a new motor sequence were included in the data analysis. General improvement, or analyzing the first to the tenth blocks of the acquisition stage, is a part of concurrent learning. Blocks 2 and 10 (the first and last sequential blocks of the first session), Block 11 (the immediate retention phase block), and Block 12 were compared for motor sequence learning (retention) (24-hour retention phase block). The new block with 10 elements (block 13) was finally compared in two groups during the transfer phase. Considering the scores of Goldberg's General Health Questionnaire, the Edinburgh Handedness Inventory, the Box and block test, the manual dexterity test, as well as the scoring scale of such variables, both groups' participants were right-handed, in good health (M = 19.72, SD = 2.45), had adequate upper limb function and manual dexterity (86.5 ± 80.84), and no significant difference existed between the two groups in these variables ($P \geq 0.05$).

Results

The mean element response time and error of prediction in 13 blocks (blocks 1 to 10 of the acquisition phase, block 11 of the immediate retention phase, block 12 of the retention phase after 24 hours, and block 13 of the transfer phase) are provided in two groups (speed and control) prior to drawing any statistical inferences (Figure 1). Additionally, the Box test ($P \geq 0.05$) does not rule out the hypothesis that the covariance matrices for the variables "element response time" and "error of prediction" are similar for the groups in the 2×10 and 2×4 mixed variance analyses. Greenhouse-Geisser's epsilon has been used to adjust the degrees of freedom in mixed variance analysis since Mauchly's test ($P < 0.05$) indicates that the assumption of sphericity of the covariance matrix error is rejected.

Element response time

Online learning (general improvement) in the acquisition phase

The results of the 10×2 mixed variance analysis indicated that the intragroup effect (blocks 1 to 10) is significant, i.e., a significant difference existed between the mean element response times in 10 blocks ($P < 0.001$ and $F_{3,87} = 115.07$). Except for blocks 3 with 5, 4 with 6, 9 with 7, and 8 with 10, there is a significantly decreasing trend in the mean response time of the blocks, as shown in Figure 1 and by Bonferroni's post hoc test, and as a consequence, a general improvement has occurred in the acquisition phase. Additionally, the block impact between the two groups differed significantly ($P < 0.001$ and $F_{3,87} = 15.714$) due to the interaction effect of block and group. The eta square coefficient indicates that the speed instruction had a 35.9% effect on general learning during the acquisition stage.

Sequence learning

The findings of the 4×2 mixed variance analysis revealed a significant intra-group effect (blocks 2, 10, 11, and 12), i.e., a significant difference existed between the mean element response times in 4 blocks ($F_{1,42} = 75.828$, $P < 0.001$). For block 2, the mean element response time was much longer than for blocks 10, 11, and 12, and for blocks 10 and 11 it was much longer than for block 12 (blocks 10 and 11 did not have a significant difference). Accordingly, the retention phase involved learning the motor sequence. Additionally, the interaction between the effects of block and group was significant ($F_{1,42} = 10.686$, $P = 0.001$) since it affected the sequence learning differently in the experimental (speed) and control groups. The eta square coefficient indicates that the rate of this interaction was 27.6%.

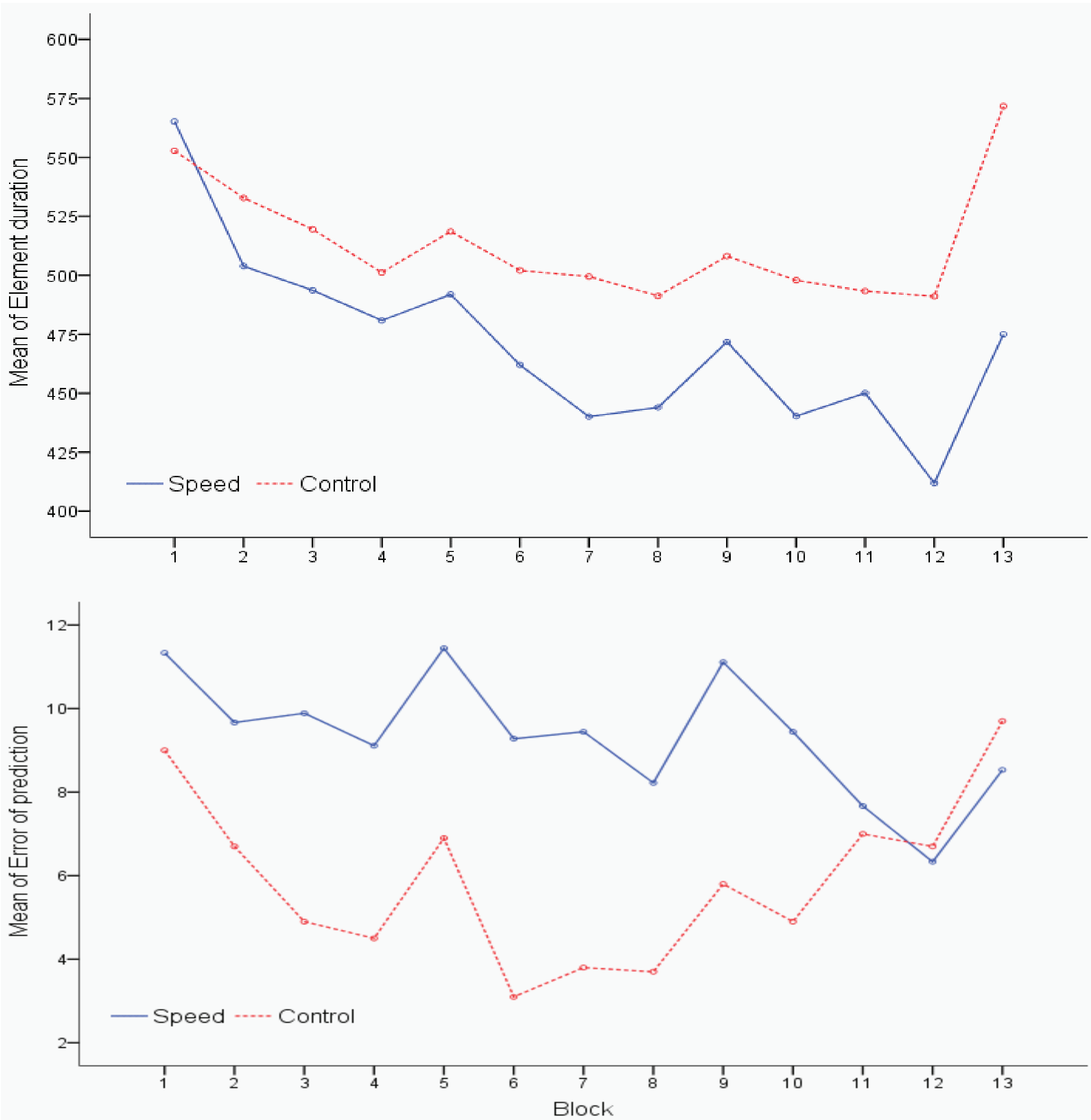

Figure 1. Mean element response time and error of prediction in 13 blocks in terms of two experimental (speed) and control groups

New sequence transfer

The findings of the independent samples t-test demonstrated that after 24 hours, the response times for blocks 13 in the two experimental groups (speed) were significantly slower than those in the control group (t_{28} = 26.625, $P < 0.001$). Therefore, according to the eta square coefficient, the speed instruction had an impact on the transfer of the new sequence, with a rate of 96.2%.

Direction change error

General learning in the acquisition phase

The findings of the 2×10 mixed variance analysis revealed a significant within-group effect (blocks 1 to 10) since a significant difference existed between the mean error of predictions in the 10 blocks ($F_{4,124}$ =14.629, $P < 0.001$), indicating that the mean error of prediction of several blocks has significantly decreased, as shown Figure 1 and Bonferroni's post hoc test. As a result, the acquisition phase has shown an overall improvement. Additionally, the block effect showed a significant difference between the two groups due to the interaction effect of block and group ($F_{4,\ 124}$ = 2.650, $P = 0.032$). Therefore, the eta square coefficient indicates that the speed instruction had an 8.6% impact on general learning during the acquisition phase.

Sequence learning

The findings of the 2×4 mixed variance analysis revealed that the within-group effect (blocks 2, 10, 11

Table 1. 2×4 mixed variance analysis for sequence learning (blocks 2, 10, 11 and 12 in two groups)

Variable	Source of changes	Epsilon correction	Total squares	Degree of freedom	Mean squares	F	P	Eta square
Element response time	block	Sphericity supposition	73499.13	3	24483.04	75.728	<0.001	0.730
		Greenhouse-Geisser	73499.13	1.48	49473.35	75.728	<0.001	0.730
	Block × group	Sphericity supposition	10364.79	3	3454.93	10.686	<0.001	0.276
		Greenhouse-Geisser	10364.79	1.48	6981.44	10.686	0.001	0.276
	Error	Sphericity supposition	27157.55	84	323.30	–	–	–
		Greenhouse-Geisser	27157.55	41.57	653.31	–	–	–
Error of prediction	Block	Sphericity supposition	42.34	3	14.11	3.559	0.018	0.113
		Greenhouse-Geisser	42.34	2.29	18.51	3.559	0.029	0.113
	Block × group	Sphericity supposition	110.84	3	36.95	9.318	<0.001	0.250
		Greenhouse-Geisser	110.84	2.29	48.46	9.318	<0.000	0.250
	Error	Sphericity supposition	333.08	84	3.97	–	–	–
		Greenhouse-Geisser	333.08	64.04	5.20	–	–	–

and 12) is significant, i.e., a significant difference existed between the mean error of prediction in the 4 blocks ($F_{2, 64}$ = 18.512, P = 0.029); thereby, compared to blocks 10, 11, and 12, only mean error of prediction in block 2 was significantly higher. In addition, the block and group interaction effects were significant ($F_{2,64}$ = 9.318, P < 0.001), indicating that the motor sequence learning in the retention stage occurred differently in the experimental and control groups. Accordingly, the eta square coefficient indicates that the speed instruction affected sequence learning at a rate of 25%.

New sequence transfer

The findings of the independent samples t-test demonstrated that the error of prediction of block 13 was not significantly different between the experimental and control groups (t_{28} = –0.906, P = 0.373). As a consequence, the speed instruction had no impact on the new sequence transfer.

Discussion

The current study aims to investigate how a speed-based strategy affected the encoding, retention, and transfer of a new motor sequence. The Complex Dynamic Arm Movement Task was utilized to examine motor sequence learning. The participants in this study were divided into the speed instruction and the control groups, who, similarly to all other previous studies in this field, did not receive any instructions on how to carry out the sequence. In the acquisition phase, the experimental and control groups completed their exercises in ten practice blocks. After 24 hours, participants were asked to complete the sequences quickly and accurately in the retention and transfer areas without focusing on a particular factor or receiving instructions.

The results of the acquisition phase demonstrated that both the element response time and the error of prediction of the block effect were significant, indicating that training with the Dynamic Arm Movement Task significantly improved the performance of subjects in the speed instruction group as well as the control instruction group. Also, the mean element response time and error of prediction in sequential blocks have a downward trend from the start to the end, and even sequential blocks had faster and more accurate responses than random blocks. Indeed, individuals may perform the discrete elements in a sequence as a group and in the form of moving parts with correct and sufficient practice, which enhances their performance. They also learn the structure of the sequence [7]. The current finding supports the first stage of the discrete points theory of motor learning, which indicates that behavioral improvements in the task are discernible at this stage of intra-session learning and that in the early stages of practice, this improvement is very quick, even occurring within seconds and minutes [37].

A further finding of the research at this point is that the speed instruction group outperformed the control group by a large margin in the element response time, indicating that the interactive effect of block and group is significant both in the time factor and in the error of prediction. In contrast, when it came to the error of prediction factor, the control group outperformed the speed instruction group significantly. This result was attained following Fitts & Posner's theory [12]. They emphasized that the speed-accuracy trade off, which is a typical aspect in the execution of motor skills, is one of the most prevalent concepts that can be observed in everyday life. According to this hypothesis, speed increases at the expense of accuracy in tasks that call for both speed and accuracy [14]. It follows that a significant difference in acquisition phase speed and error of prediction between the experimental and control groups would be expected given the trade-off between speed and accuracy. The results of the current study compared to the retention stage showed that the block effect was not significant in the immediate retention stage, indicating that learning consolidation had already taken place at this point. In keeping with the consolidation model, the effects attained in the acquisition and practice phases have therefore been instantly maintained in the test phase. This model states that the initial stage of consolidation, or knowledge retention following training, begins within minutes of instruction, improvements to the consolidation and maintenance of skills, and typically lasts for the first five to six hours. Indeed, the stabilization stage enables performance to be maintained despite various interferences. Furthermore, the findings of the 24-hour retention phase revealed that the block effect was significant and that the subjects' performance in the 24-hour retention test was much higher than it had been during the acquisition phase. The interaction between the effects of the group and the block was also significant in this phase in such a way that the instruction group outperformed the control group in terms of speed, timing, and accuracy. These results are consistent with previous findings [5, 47, 49].

It is notable that the task utilized in this research was complex and required more processing power than other typical tasks in this area, such as discrete sequence production and serial reaction time, which were performed using the keyboard. Similarly, Heitz [14] argued that a task's complexity results in a reduced speed and an increase in errors. Verwey [48], however, asserts that learning motor sequences for complex activities requires a fast learning curve. However, prior studies revealed that this was less significant for simple keyboard tasks. However, Verwey [47] and Pfeifer et al. [30] claimed that speeding up the acquisition phase resulted in a decrease in the time delay in the execution of the components of a subsequence. Additionally, through the faster joining of subsequences, it reduces the time to reach the first element in a sub-sequence, and in this case, the chunking process in the sequence is better formed. By minimizing the time delay in the execution of discrete elements of a sequence and also by limiting the time available between sub-sequences, speed leads to better chunking and, as a result, higher improvement in motor learning [47]. Abrahamse et al. [1] reported that the strategies to prevent errors cause disruptions in the execution of a motor sequence, and by slowing down the performance of the sequence using these techniques, the response time between sequence elements is increased.

In addition, the present results are in line with previous findings [36, 45, 46]. According to Verneau et al. [45], the probability that a person will be able to apply information connected to closed-loop control feedback improves when the time to execute a sequence is increased. As a result, by lengthening the time a sequence is executed, the person acts more precisely, which enhances learning [31, 45]. According to Salthouse et al. [36], people's failure to assimilate information in the allotted time owing to quick sequences is one of the most critical problems impeding performance in complex tasks.

Therefore, they recommend that people execute sequences at a slower speed to enhance accuracy to improve sequence learning in complex tasks [35, 36]. Furthermore, the results of the task transfer test's independent samples t-test revealed a significant difference between the two groups' response times for the components in a novel, untrained sequence, favoring the speed group. Regarding the error of prediction, there was no significant difference between the groups. These results are consistent with the hypotheses that assert the importance of error during the acquisition stage [23, 24, 27, 42]. It is noteworthy that the speed group's participants made significantly more errors during the acquisition phase than those of the control group. However, this difference in the retention and transfer test was greatly reduced, and the speed group still outperformed the control group in these two stages of the test, although the difference was not statistically significant. According to the notion of contextual interference, learning is improved during the retention and transfer phase by activities and strategies that cause a person to make more errors during the acquisition phase. Making errors during the acquisition phase is therefore regarded as a crucial component of motor learning. According to Lee et al [24], more error during the acquisition phase is preferable for the expansion and development of sequence elements-related representations. Schmitt's schema theory views the process of variability and error-making as being crucial to learning the motor task's parameters. These findings, however, contradict the views that see the error as detrimental to motor learning. During the early phases of training, conscious thinking is believed by Fitts [13], Fitts and Posner [12], and Bernstein [6] to be detrimental to motor learning because it can lead to errors. They argued that individuals who train under settings that result in fewer errors have a good technique for motor learning [6, 12, 13]. According to Adams [2], a large error during the acquisition phase deprives a person of closed-loop control-based feedback, which disturbs that person's performance.

Conclusion

Therefore, compared to traditional tactics where the individual was not given any instructions throughout the acquisition phase, the speed-based strategy leads to improved learning and transfer. This is supported by the findings and the presented explanations in this study. The chunking process, which is a crucial and effective element in learning the motor sequence, is improved by speed instruction, which reduces the time delay formed between the sequence elements. However, the speed group that made more errors during the acquisition phase improved learning during the retention and transfer phase, supporting the assumptions regarding the significance of errors in motor learning that were previously put forward. The results of this research will help experts in the field of motor learning and behavior, especially in motor sequence learning, to use a speed-based strategy with greater variability in motor patterns during the acquisition phase to optimize learning and improve performance after training.

Finally, it is advised that researchers analyze the use of this instruction in complex sequences in future research, given that the sequence employed in the current research is simple in terms of the kind of sequence structure.

Conflict of interest: Authors state no conflict of interest.

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