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The Effect of Over-learning and Off-line Different Periods on Stabilization-based Consolidation Process and Proactive Interference in Explicit Motor Memory

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Abstract
This study attempted to investigate the effect of over-learning and off-line different periods on stabilization-based consolidation process and proactive interference in explicit motor memory. Previous experiences can affect future performance. However, it is not clear how much exercise is needed to stimulate these effects, and what is the best offline period between workouts to prevent interference? In this research, the performance of 40 female students, who were between 20-30 years old and had been called to attend in the test voluntarily, was studied in two offline Periods of 5 minutes and 24 hours between the first (forehand) and the second (backhand) strokes. Data were analyzed using a variance analysis test with repeated measurement tests and a Tukey follow-up test. Two main findings emerged from the study. Firstly, it was determined that offline period (5 minutes and 24 hours) are not effective on the learning of the second task. The second finding was that overlearning performed consolidation in both of the offline Periods (24 hours and 5 minutes) and the learning of backhand stroke became resistant to anterograde interference. These results suggest that learning can play an important role in explicit motor memory, but offline period cannot make learning resistant to interference.

Keywords: Anterograde interference, consolidation, explicit motor memory, offline periods, over-learning

Introduction

Previous experiences can affect future actions. Not only can these experiences make appropriate changes in motor output, they can also balance the amount of change that occurs (Sing & Smith, 2010). Studies have shown that after initial acquiring of new skills, memories are fixed through consolidation processes and require a temporal interval after acquisition to allow them to occur (Lugassy et al., 2018). However, it is not clear how much practice is needed to stimulate these effects to the extent that consolidation becomes viable. In addition, the best interval for offline periods to prevent interfering events and complete memory consolidation between offline periods has not been determined. The distances are different and if they are not observed appropriately, it is possible for the memory to confront with anterograde and retrograde interference processes while performing first and second remembering tests.

It is more than a century that consolidation process has been the main point of attention in researches related to memory and learning. Once the skill or memory has been acquired, it must be consolidated before it may interfere with subsequent learning. It is clear that there are many points which may interfere with learning, the effect of anterograde interference (in which old information prevent presenting new information) was

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chosen to be studied here because it has significant effects which have not received as much attention as retrograde interference (in which new information prevent presenting existing information). This is surprising because retrograde interference has a relatively small (10-20%) increase in the performance of the studies reported in it; while anterograde interference has a considerable greater effect; in fact, several studies on interference have been specifically designed to minimize the effects of retrograde interference because it has been seen as a cover for anterograde interference. Achieving a better understanding of the underlying mechanisms of retrograde interference is very important, not only to provide more insight into the effects of anterograde interference, but also because of the phenomenon of spontaneous learning as the main cause of interference during motor learning (Sing & Smith, 2010).

Declarative (explicit) memory is a system that includes our memory of facts, events of personal nature and the world around us; it also includes knowledge that we are consciously aware of-even, we recover them (Edwards, 2010). As the researchers conducted on this domain show, explicit motor memory emerges fast is created rapidly as it rapidly declines (Sing & Smith, 2010). In addition, it has been found that explicit learning is more affected by retrograde interference than the implicit one (Ghilardi et al., 2009).

The idea of this research originated from three different sources: (1) Sing and Smith (2010) have shown that the created retrograde interference becomes resistant to interfere after repeating the second task for 40 times; (2) Krakauer (2005) believed that retrograde interference, unlike the anterograde one, is not affected by more time intervals (offline periods); and (3) Goedert and Willingham (2002) acknowledged that retrograde interference does not happen with more offline periods. Therefore, this research tried to answer the following questions: Is the overlearning of the first task facilitative or does it create more interference? and How much does learning the first task affect the acquisition and learning of the second task? Another aim of this research was studying the role of offline periods in looming of retrograde interference.

The present research, using two tasks of forehand and backhand strokes, probed on these two questions: "Is offline learning beneficial to the performance of learning the second task?" and "What is the effect of first and second task overlearning on anterograde interference and consolidation of the second task?"

Method

The present study adopted a pre-test/ post-test design. The subjects answered some questions about age, level of education, regularity of sleeping, precedence of neurological or psychiatric diseases, damage to the skull, precedence of anesthesia, sleep disturbance, hearing, kinesthetic, visual, and cognitive or memory loss, consumption of cigarette or alcohol, psychological and memory disorders and taking hormonal drugs (Shamsipoor, 2014).

The performer sent the ball, from its own right (forehand stroke) and left (backhand) sides, diagonally towards the goal on the other side of the table. In the right corner of the table, two squares were drawn to determine the score: a large 75 ×75 cm square and a small one right in the middle of the large one with dimensions of 25 × 25 cm (Figure 1). The balls that hit the smaller square received 3 points; hitting the large square had 2 points and the balls that hit the outside of the square or on the table received 1 point. In addition, the balls that hit outside the opposite table did not receive any point (scoring for forehand and backhand strokes were the same) (Asgari, Abdoli & Aslankhani, 2012). After getting familiar with the ball, rocket and table, as well as the training needed to acquire the forehand stroke (the first task) in the pretest phase, subjects performed two blocks of ten attempts of forehand and backhand skills and, based on this test, were randomly grouped into four experiment groups. Then, the subjects of the groups that did not have skill overlearning, performed 20 blocks of 10 attempts, and the subjects of the groups of those who had skill overlearning performed 60 blocks of 10 attempts of the desired task. The subjects received instruction on the performance of the second task (backhand stroke) after performing the first task (forehand stroke). In the acquisition phase of the last two blocks of the last session of the first task (forehand) and the first two blocks of the first session of the second task (backhand), the first session of the second task (forehand stroke) was recorded. In addition, two blocks of the last session of the second task (backhand) and two blocks of the retention phase of the second task (backhand) were recorded. The balls were thrown through an OUKEI table tennis robot with a frequency of 20 balls per minute and without ant turning (Asgari, Abdoli &Aslankhani, 2012). After the acquisition phase of the forehand, the acquisition stage was performed 5 minutes or 24 hours later. During the acquisition phase, the subjects were asked to hit the balls that were being thrown towards them, according to the instructions proposed to them (Table 1).

Participants

Participants included 40 female students of the Azad University of Shahr-e-Quds Branch, aged 20 to 30, who were voluntarily invited. After becoming familiar with the research process and receiving full explanations about its steps, they completed a consent form for participation in the research. None of the subjects were aware of the purpose of the experiment. After their having of entrance criteria was approved, the participants were randomly assigned to 4 groups (10 subjects in each group).

Instruments

The instruments used in the present study were as follows:

1. Sleep Quality Questionnaire: Those subjects who had sleep disorders were determined; using sleep quality questionnaire (with the reliability rate of 0.89), and excluded from the study.
2. Goldberg Mental Health Questionnaire: The subjects' mental health was measured using the Goldberg Mental Health Questionnaire (with a reliability of 0.865). In addition, subjects with developmental, psychiatric, sleep, and neurological problems were excluded from the study too.
3. Wexler Memory Test: The third-generation Wexler Memory Test (WMS_III), with reliability rate of 0.74, was used to evaluate the memory function of the subjects.
4. Ant’s Hand Superiority: Participants' hand superiority was also determined using Ant's hand superiority questionnaire (with a reliability of 0.68).

The tested tasks were backhand and forehand strokes of table tennis. Standard tennis table and rocket, 100 tennis balls with a diameter of 40 mm and OUKEI table tennis robot (08-2800-TW Model) were designed for performing and assessment of these two tasks.

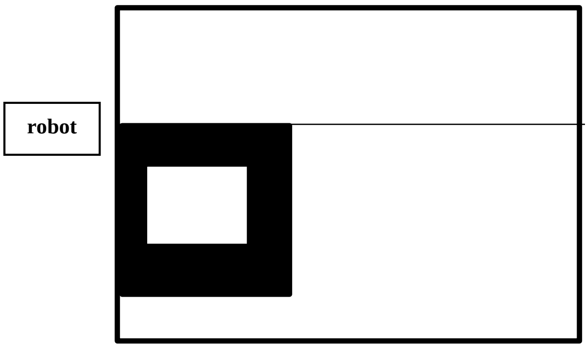

Figure 1.
Place of Ball landing and How to Score in the Retention Test Stage

Table 1.
Explanation of Tested Groups

Number	Stroke	acquisition Session Paradigm	Retention Test Paradigm
1	Forehand (A) and Backhand (B)	A→24h→B→24h→	A→5′→B
2	Forehand (A) and Backhand (B)	A→5′→B→24h→	A→5′→B
3	Forehand (A) and Backhand (B)	AAA →24h→BBB→24h→	A→5′→B
4	Forehand (A) and Backhand (B)	AAA →5′→BBB→24h→	A→5′→B

Table 1 shows after the acquisition phase of the forehand, the backhand acquisition stage was performed 5 minutes or 24 hours later and the retention phase was completed 24 hours after the acquisition of the two tasks.

Procedure

This study was performed in two phases; the first phase was the difference in the acquisition phase of the first task (forehand) and the second task (backhand) in order to study the effects of overlearning the first task on the acquisition of the second task; the second phase also tried to determine the effects of overlearning the second task on its retention. The analysis of the collected data was calculated in the descriptive statistics section of the central distribution indicators. To test statistical hypotheses, Shapiro-Wilk Test test (to check the normality of the data) analysis of variance with repetitive measures 2 factors of overlearning (overlearned, not overlearned) and 2 factors of offline periods (24 hours 5 minutes) and 2 steps (acquisition, retention) were used while observing presupposition of Mauchly's Sphericity Test ($p<0.05$) and variance analysis test. Significance levels were considered for all variables as ($p\leq0.05$). The Tukey test was also used to determine the significance of the test. Data analysis was performed with SPSS statistical software version 22 and the graphs were plotted with Excel software.

Findings

The findings can be classified into two phases:

Phase 1 of the experiment: The difference between the last two blocks of the acquisition of the first task (forehand) and two initial blocks of the acquisition stage of the second task (backhand) showed that overlearning factor in the acquisition stage of the backhand caused the difference between the groups ($p = 0.030$), with the effect of 0.125. having in mind the significance of the main factor of the block ($p= 0.000$) with the effect of 0.938, interactive effect of block in overlearning ($p=0.000$) with the effect of 0.290 (Table 3) and also the difference in the mean scores of the 4 groups (Table 2 and Figure 2), it can be inferred that the overlearning of the first task (forehand) causes a decrease of performance in the acquisition of the second task (backhand) and leads to intervention. However, it was found that factor of offline periods did not cause a significant difference in the groups. The results of the Tukey follow-up test showed that there was a significant difference between the overlearned, 24-hour group and overlearned 24-hour and 5-minute groups. In addition, it was also determined that there was a significant difference between the overlearned 5-minute group and not-overlearned 24-hour group.

From these results, it can be inferred that overlearning of the first task (forehand) caused the performance of the second task (backhand) to decrease-especially in the case of 24 hour offline periods.

Table 2.
Descriptive Statistics of Group Scores with Offline Periods of 5 minutes and 24 hours

Group	Number	Forehand Acquisition Average	Backhand Acquisition Average	Forehand Acquisition SD	Backhand Acquisition SD
Not Overlearned-24 Hours	10	12.3	4.6	2.21	1.71
Not Overlearned-5 Minutes	10	12.6	4.2	2.22	1.03
Overlearned-24 Hours	10	13.8	2.4	2.65	1.07
Overlearned-5 Minutes	10	13.9	2.9	2.07	1.19

Table 2 shows the difference in the mean scores task (forehand) and the second task (backhand) of the 4 groups. The highest score is related to the Overlearned-5 Minutes forehand task and the worst score is related to the Overlearned-24 Hours backhand task.

Table 3.
Results of Variance Analysis with Repetitive Measures for Groups with 5 Minutes and 24 Hours of Offline Periods

Variation Source	Total Roots	Freedom Level	Roots Average	F Value	Amount of P
Block's original Effect	1852.81	1	1852.81	549.20	*0.000
Block's Interactive Effect on Overlearning	49.61	1	49.61	14.70	*0.000
Block's Interactive Effect on Offline Periods	0.113	1	0.113	0.033	0.856
Overlearning Original Effect	30.62	1	30.62	18.96	*0.030
Offline Periods' Original Effect	0.312	1	0.312	0.087	0.769

*Significance in the level of $p\leq0.05$

Table 3 reveals that overlearning factor in the acquisition stage of the backhand caused the difference between the groups ($p = 0.030$). Having in mind the significance of the main factor of the block ($p= 0.000$), it shows the interactive effect of block in overlearning ($p=0.000$)

Table 4.
Tukey Test to Compare Pairs of Groups

Paired-comparison of Groups		Average of Differences	Amount of P
Not-overlearned/24 Hours	Overlearned/24 Hours	2.20	*0.003
	Not-overlearned/ 5 Minutes	0.400	0.898
	Overlearned/ 5 Minutes	1.700	*0.026
Overlearned/24 Hours	Not-overlearned/24 Hours	-0.2.20	*0.003
	Not-overlearned/ 5 Minutes	-1.800	*0.017
	Overlearned/ 5 Minutes	-0.500	0.820
Not-overlearned/ 5 Minutes	Overlearned/24 Hours	-0.400	0.898
	Not-overlearned/24 Hours	1.800	*0.008
	Overlearned/ 5 Minutes	1.300	0.125
Overlearned/ 5 Minutes	Overlearned/24 Hours	-1.70	*0.026
	Not-overlearned/24 Hours	0.500	0.820
	Not-overlearned/ 5 Minutes	-1.300	0.125

As Table 4 indicates, the results of the Tukey follow-up test there was a significant difference between the overlearned, 24-hour group and not-overlearned 24-hour and 5-minute groups. In addition, it was also determined that there was a significant difference between the overlearned 5-minute group and not-overlearned 24-hour group.

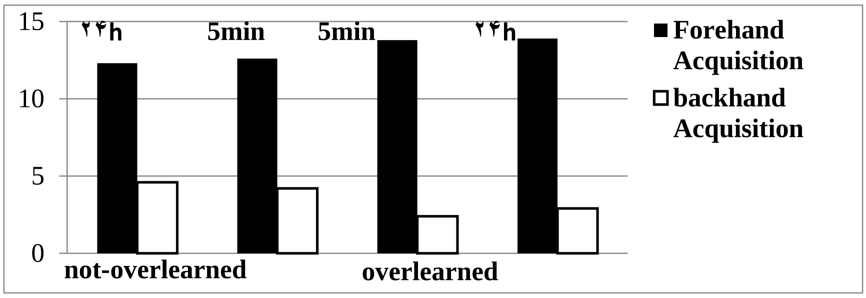

Figure 2.
Average Scores of Overlearned and Not-overlearned Forehand Groups with Offline Periods of 24 Hours and 5 Minutes

Second Phase of the Experiment

The difference between the acquisition and retention stages of the second task (backhand) showed that the overlearning factor causes the difference between the groups (p = 0.000); with the effect of 0.379. Having in mind the significance of the main factor of the block (p=0.000), effect of 0.316, interactive effect of block in overlearning (p=0.000) with the effect of 0.589 (Table 6) and the difference between averages in 4 groups (Table 5 and Figure 3), it can be inferred that overlearning of the second task (backhand) erased the effect of anterograde interference. However, the factor of offline periods did not cause any significant changes.

The results of the Tukey follow-up test (Table 7) showed that the overlearned groups of 24 hours and 5 minutes were significantly different from the not-overlearned groups of 24 hours and 5 minutes.

According to the results, it can be said that the worst performance belongs to non-overlearned groups especially that of 5 minute offline periods. Therefore, it is possible to infer that the overlearning of the backhand task prevents interference.

Table 5.

Descriptive Statistics of Group Scores with Offline Periods of 5 Minutes and 24 Hours

Group	Number	Forehand Acquisition Average	Backhand Acquisition Average	Forehand Acquisition SD	Backhand Acquisition SD
Not Overlearned-24 Hours	10	10.9	9.5	1.72	1.64
Not Overlearned-5 Minutes	10	10.5	9	1.58	1.49
Overlearned-24 Hours	10	12.4	12.5	1.95	2.17
Overlearned-5 Minutes	10	12.4	13.1	2.03	1.79

Table 5 shows the difference in the mean scores task (forehand) and the second task (backhand) of the 4 groups. The highest score is related to the Overlearned-5 Minutes backhand task and the worst score is related to the Not Overlearned-5 Minutes backhand task.

Table 6.

Results of Variance Analysis with Repetitive Measures for Groups with 5 Minutes and 24 Hours of Offline Periods

Variation Source	Total Roots	Freedom Level	Roots Average	F Value	Amount of P
Block's original Effect	5.51	1	5.51	16.60	*0.00
Block's Interactive Effect on Overlearning	17.12	1	17.12	51.55	*0.000
Block's Interactive Effect on Offline Periods	0.313	1	0.313	0.941	0.338
Overlearning Original Effect	137.81	1	137.81	21.93	*0.000
Offline Periods' Original Effect	0.112	1	0.112	0.018	0.894

*Significance in the level of $p \leq 0.05$

Table 6 reveals that overlearning factor in the acquisition stage of the backhand caused the difference between the groups (p = 0.000). Having in mind the significance of the main factor of the block (p= 0.000), it refers to the interactive effect of block in overlearning (p=0.000) . The factor of offline periods did not cause any significant changes.

Table 7.

Tukey Test to Compare Pairs of Groups

Paired-comparison of Groups		Average of Differences	Amount of P
Not-overlearned/24 Hours	Overlearned/24 Hours	0.450	0.941
	Not-overlearned/ 5 Minutes	-2.25	*0.036
	Overlearned/ 5 Minutes	-2.55	*0.014
Overlearned/24 Hours	Not-overlearned/24 Hours	-0.450	0.941
	Not-overlearned/ 5 Minutes	-2.700	*0.008
	Overlearned/ 5 Minutes	-3.00	*0.003
Not-overlearned/ 5 Minutes	Overlearned/24 Hours	2.25	*0.036
	Not-overlearned/24 Hours	2.70	*0.008
	Overlearned/ 5 Minutes	-0.300	0.981
Overlearned/ 5 Minutes	Overlearned/24 Hours	2.55	*0.014
	Not-overlearned/24 Hours	3	*0.003
	Not-overlearned/ 5 Minutes	0.300	0.981

Table 7 shows that the results of the Tukey follow-up test the overlearned groups of 24 hours and 5 minutes were significantly different from the not-overlearned groups of 24 hours and 5 minutes.

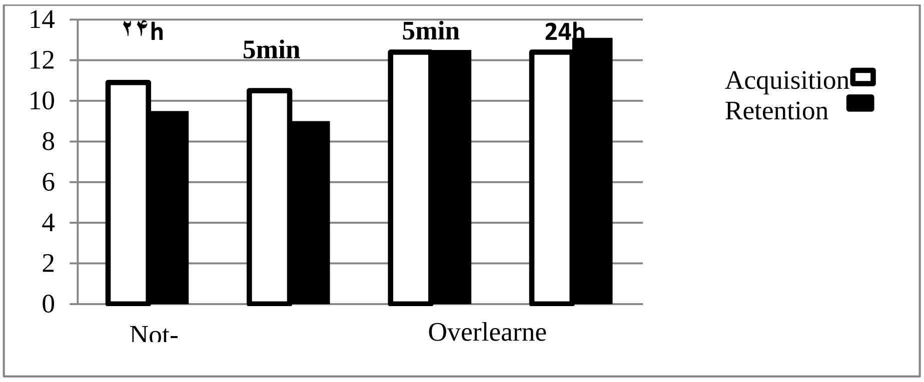

Figure 3.
Average Scores of Overlearned and Not-overlearned Backhand Groups with Offline Periods of 24 Hours and 5 Minutes

Discussion and Conclusion

Learning a task may interfere (anterograde) with subsequent learning. We thus examined the effect of acquiring the first task in learning the backhand task (the first phase). Having in mind the anterograde interference, it can be said that the second hand task has been affected after learning of the first one.

Accordingly, in the four groups that learned the second task, the performance of the subjects decreased in the first blocks of the second task after the first task was acquired. This decrease was more palpable in groups that had undergone the overlearning of forehand. Therefore, one of the harmful effects of the acquisition of forehand (first task) is the existence of interference in the second task which is palpable in all the four groups. The results showed that even after 24 hours, there was a definite effect of forehand stroke's acquisition on learning backhand stroke (interference in groups 1 and 2).

The results of this hypothesis are consistent with the findings of Sing and Smith's (2010) research. They found that the amount of anterograde interference observed in learning the second task increased with the duration of the first task. It was also found that rapid processes are affected more than slow ones by anterograde interferences. Interestingly, they found that a multi-rate model of motor adaptation, consisting of two distinct but reciprocal adaptive processes, made it possible to predict several key features of anterograde interference patterns (Sing & Smith, 2010).

Ghilardi et al.'s (2009) research on learning motor sequences also supports the results of this hypothesis. Leow et al. (2014) also showed that repeated stimulation of the motor cortex in primary learning causes subsequent learning disruption along with increased anterograde interference. According to Stephens and Overmns' (2018) experiments, decreasing information recognition in memory reduces the effects of anterograde interference. The reported modeling and empirical results are consistent with the claim that associated information can be generated through the general destruction of information stored in memory. Therefore, the results of our research show that the information of the first task (forehand) are stored in the memory because of overlearning and prevent the fully acquisition of the second task (backhand).

Frith et al. (2018) in a study conducted to determine the reduction of anterograde interference showed that the second task should be conducted before the encryption of the first one in order to reduce the effects of anterograde interference. Therefore, the results of the current research show that the second task (backhand) has been conducted after the first task (forehand) leading to anterograde interference. These results show that memory remains from the first task, which leads to a more difficult acquisition of the second task and creates an interference that persists even after 24 hours.

By overlearning the second task (second phase), this harmful effect, which is the anterograde interference, disappeared; however, there was no significant difference between two groups of offline periods of 24 hours and 5 minutes. These results are consistent with those of Krakauer and Ghilardi (2005) which had claimed that resistance to anterograde interference disappears by overlearning.

Researches of Goedert and Willingham (2002) also showed that if there is a severe anterograde interference in a group, they will never learn the second skill adequately. Anterograde interference existed in his experiment during learning movement B (Second Task) 5 minutes after movement A (First task), however, the anterograde interference disappeared after 5 minutes and 24 hours. As it is expected, the level of anterograde interference is reduced by extensive training in the case of the second task. This reduction existed in all the groups which had learned movement B.

The results of Ghillardi et al.'s (2009) research showed that explicit learning is prone to retrograde interferences while implicit learning is prone to anterograde one; it was also shown that both of these interferences become resistant to interference by overlearning. The aforementioned results are in line with those of the current research.

The results of Sosic-Vasic et al.'s (2018) studies showed that the amount of interference depends on the closeness of the learning and interference cases during coding. The shorter the interval between the two ones, the greater their competition when recovering. Interference is also related to the type of intervening material. If the two types of material are more similar, the degree of interference will be greater. The negative impact of repeated calls for information from previous material makes it more difficult for new learners to learn new material, but with repeated practice (overlearning), harmful effects of anterograde interference are reduced too. These results are also in line with those of the current research.

Smith (2010) examined the formation of motor system capacity for anterograde interference in the adaptive control of arm access movement by determining the amount of interference after the duration of exposure to task A (first task). They found that although the amount of interpersonal interference in learning task B (second task) increased with the duration of task A (first task), this increase did not continue for an indefinite period of time.; instead, the interference after appeared from task A (first task) after 15-40 attempts tangentially.

Shibata et al.'s (2017) study showed that using maximum stabilization may lead to efficient learning paradigms. This is consistent with the results of our research, because by learning the second task in the acquisition phase, retention the second task became resistant to interference and consolidated.

Borragana et al. (2015) also found that offline periods after intervention are also effective on preventing anterograde interference. In their study the beneficial effect of sleep was significant for consolidating motor activity; however, this fact is not consistent with our results because the current research shows that anterograde interference does not disappear even after 24 hours of offline periods. The researchers contribute this inconsistency to differences in types of tasks and tools used, individual differences, time and number of training efforts, time of phase implementation or skill acquisition/test, arousal level of subjects, temporary tiredness or lack of motivation in the subjects, research methodology and type of the studied memory.

It can be concluded that overlearning is useful in the sense that it overcomes anterograde interference. This role has not been described for overlearning, but its positive effect o has been on learning has been enunciated more than a century ago. In general, our results show that overlearning can support resistance to the interference mechanism. Based on the results of this study, which shows that overlearning plays an important role in explicit motor memory, it is suggested that this consideration is taken into account in primary education and the desired case is overlearned. This report is also very crucial for the patient with movement disorders.

It has also been shown that explicit and implicit memory work differently and are stabilized differently for the use of neural networks. Having in mind the fact that anterograde interference are an indirect indicator of the strength of the first task, it is best to reinforce the second task with overlearning; therefore it is desired to consolidate the second task by overlearning. Understanding the underlying mechanisms of anterograde interference can be effective on developing education and rehabilitation; leading to interference reduction.

Future studies should include larger samples and a more varied pool of initial assessments, as well as learning and memory tasks that are similarly novel to both children and adults, to enable a broader view of the findings.

References

Asgari, Z., Abdoli, B., & Aslankhani, M.A. (2012). Comparison of the effect of overt, deductive and exploratory learning on acquisition, learning and transfer of table tennis top spin skills. *Journal of Motion Behavior, 11*, 98-81.

Borragán, G., Urbain, C., Schmitz, R., Mary, A., & Peigneux, P. (2015). Sleep and memory consolidation: Motor performance and proactive interference effects in sequence learning. *Brain and Cognition*, *95*, 54–61.

Edwards, W. H. (2010). *Motor learning and control: From theory to practice.*

Frith, E., Sng, E., & Loprinzi, P. (2018). Randomized controlled trial considering varied exercises for reducing proactive memory interference. *Journal of Clinical Medicine*, *7*(6), 147-152.

Ghilardi, M. F., Moisello, C., Silvestri, G., Ghez, C., & Krakauer, J. W. (2009). Learning of a sequential motor skill comprises explicit and implicit components that consolidate differently. *Journal of Neurophysiology*, *101*(5), 2218–2229.

Goedert, K. M., & Willingham, D. B. (2002). Patterns of interference in sequence learning and prism adaptation inconsistent with the consolidation hypothesis. *Learning & Memory*, *9*(5), 279-292.

Krakauer, J. W. (2005). Adaptation to visuomotor transformations: Consolidation, Interference, and forgetting. *Journal of Neuroscience*, *25*(2), 473–478.

Leow, L. A., Hammond, G., & de Rugy, A. (2014). Anodal motor cortex stimulation paired with movement repetition increases anterograde interference but not savings. *European Journal of Neuroscience*, *40*(8), 3243–3252.

Lugassy, D., Herszage, J., Pilo, R., Brosh, T., & Censor, N. (2018). Consolidation of complex motor skill learning: Evidence for a delayed offline process. *Sleep*, *41*(9).

Shamsipoor, P. (2014). Effect of immediate, recent and remote explicit motor memory on reconsolidation process and retrograde effect. *Jcp*, *2*(3), 37–48.

Shibata, K., Sasaki, Y., Bang, J. W., Walsh, E. G., Machizawa, M. G., Tamaki, M., & Watanabe, T. (2017). Overlearning hyperstabilizes a skill by rapidly making neurochemical processing inhibitory-dominant. *Nature neuroscience*, *20*(3), 470-475.

Sing, G. C., & Smith, M. A. (2010). Reduction in learning rates associated with anterograde interference results from interactions between different timescales in motor adaptation. *PLoS Comput Biol*, *6*(8), e1000893.

Sosic-Vasic, Z., Hille, K., Kröner, J., Spitzer, M., & Kornmeier, J. (2018). When learning disturbs memory: Temporal profile of retroactive interference of learning on memory formation. *Frontiers in Psychology*, *9*, 82-95.

Stephens, J. D. W., & Overman, A. A. (2018). Modeling age differences in effects of pair repetition and proactive interference using a single parameter. *Psychology and Aging*, *33*(1), 182–194.

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