TEL AVIV UNIVERSITY

The Gershon H. Gordon Faculty of Social Sciences
School of Psychological Sciences

Learning motor skills by Passive Movement training

The paper was submitted as the thesis for M.A. degree by

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The thesis was carried out under the supervision of
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Abstract

Previous research has demonstrated that passive limb movement can result in significant performance gains. What is common to such studies is that the trained limb is passively moved by an external source – either a robotic device or physiotherapist/experimenter. Therefore during training, there is no causal link between limb movement and subject's volition. Recently, and for the first time, we used a novel device that allowed us to re-introduce this causal link during passive training, and to generate passive movement from self. By using a unique device, we yoke finger movement of one hand to passively follow active voluntary finger movements of the other hand. In the current thesis, we directly compare learning of a motor skill (sequence of finger movements) when the source of passive movement is self or external.

Sixty participants were randomly divided to 3 groups; self- generated passive movement (SPM), externally-generated passive movement (EPM), and training by cross education (CE). All groups exhibited significant performance gains across 3 days of training, however we did not find significant differences in performance between the SPM and EPM training methods. Our results have implications for the question whether training by a physiotherapist, or robotic treatment, have an advantage over passive movement driven by self-movement.

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Introduction

Motor movement plays an important role in our lives since we were born. That's one of the reasons why many researchers are interested in developing this field of learning new motor skills. Although physical training is optimal for learning, alternative types of training have been shown to introduce significant performance gains on various tasks: passive movement, observation, cross education. Each of the alternative type of training would be explained in the following.

Passive movement

It is a common view that repetitive, voluntary physical movement enhances performance and learning of motor movement skills (Wolpert, Diedrichsen & Flanagan, 2011). A number of studies indicate enhancement of motor performance not only following voluntary physical movement but also following passive movement training. Passive limb movement by an external source (i.e. experimenter / physiotherapist, or robotic device) can also enhance subsequent performance of the trained movement. For instance, in a study by Wong and colleagues, the participants were asked to reproduce both the time-varying position and velocity of novel, complex hand trajectories (either a circle at constant velocity or a handwritten word) (Wong et al., 2012). Subjects were divided to three training groups that received visual feedback of hand position in real time during motor learning: 1- passive movement + visual input, 2- visual input only, 3- active movement + visual input. The group of participants that received passive movement by a robot showed greater improvements than the group that only received visual information. Interestingly, performance gains following passive training were similar to those following active movement. Passive movement, by an external source, has been shown to advance the learning process of motor skills on multiple tasks such as drawing (Wong et al., 2012), reaching movement to an unseen target (Bernardi et al., 2015) and golf swinging (Kummel et al., 2014).

Passive movement has been shown to have beneficial effects not only in unimanual but also in bimanual tasks. In a study by Beets and colleagues three groups practiced for four days on a complex bimanual coordination pattern while receiving visual feedback in the form of Lissajous plots (this feedback promotes the integration of both movements into a unified form, also called 'motor binding'). The three groups were: 1) passive training; 2) active training; 3) no training (control). It was revealed that passive as compared to active training resulted in equally successful acquisition of the frequency ratio between hands, but active training was more effective for acquisition of the new relative phasing between the hands in the presence of augmented visual feedback (Beets et al., 2012).

These results support the notion that training by passive movement facilitates acquisition of motor skills, and that performance gains can result even in the absence of voluntary drive or active movement.

Observation

There is much to be gained from visual input in motor learning. Passive observation of someone else performing a motor task, even in the absence of physical training, is also sufficient for introducing significant performance gains (Bird et al., 2005; Kelly et al., 2003; Mattar & Gribble, 2005; Ossmy & Mukamel, 2016a).

For example, in a recent experiment in our lab during fMRI scans, healthy subjects learned to perform sequences of finger movements by passively observing right or left virtual hand performing the same sequences in egocentric view. During the experiment subjects' real hands were immobile. Performance levels on the sequence of finger movements were evaluated before and after training. At the behavioral level, left and right hand performance gains were significant in both training conditions, demonstrating significant learning by observation (Ossmy & Mukamel, 2016a).

Previous studies investigated the behavioral and neural consequences of training with manipulated visual feedback (Halsband and Lange, 2006). Mainly, unimanual training with mirrored visual feedback (as if the opposite, immobile hand, is training) has been found to increase transfer to the opposite hand and increase excitability of primary motor cortex (M1) ipsilateral to the physically trained hand (Garry et al., 2005; Hamzei et al., 2012; Nojima et al., 2012). Thus training with such incongruent visual feedback results in higher subsequent performance gains in the non-physically trained hand (Ossmy & Mukamel 2016b).

Cross-Education

The phenomenon of cross-education or intermanual transfer is the increase in performance of an untrained limb following unilateral training of the opposite homologous limb. It has been reported as early as 1894 (Scripture et al., 1894). Investigations of cross education have shown that subjects can transfer acquired motor skills from one hand to the other. Various studies have established the cross education (CE) phenomenon, and supported the contribution of unilateral training for the performance of the opposite side (Carroll & Gandevia 2006; Lee & Carroll 2010; Ruddy & Carson 2013; Ossmy & Mukamel 2016b). For example, in one of these studies, healthy subjects practiced ballistic (fastest possible) abduction of the index finger with the hand pronated and the forearm resting on a desk. Pre-training and post training assessment of ballistic task performance for both hands showed that training with the right hand produced a rapid improvement in performance that generalized to the untrained, left hand (Lee & Carroll 2010).

Recently, we combined the three types of training as discussed above (passive movement, observation and CE). Subjects trained to perform a sequence of finger movements with their right hand while visual feedback and passive left hand movement was manipulated. Results showed that physical training with the right hand while receiving visual feedback of left virtual hand movement, together with passive left hand movement, results in significant left hand performance gains that were higher than any other form of training that did not involve voluntary left hand physical movement (Ossmy & Mukamel, 2016b).

As mentioned earlier, what is common in the traditional literature of passive movement is that the trained limb is passively moved by an external source –either a robotic device or physiotherapist/experimenter. Therefore during training, there is no causal link between limb movement and subject's volition. The novel device allowed us to re-introduce this causal link during passive training, and to generate passive movement that is self-generated – namely, passive movement in one limb is generated by active movement of the subject's opposite limb (Ossmy & Mukamel, 2017). Thus the learning hand was passively moved while subject's volition was maintained (Ossmy & Mukamel, 2016b). Since in the previous studies we found that the combination of passive movement and manipulated visual input is best, we continue this design in search of an optimal training scheme.

Although in a recent study in the lab, we found significant performance gains following self-training on a finger opposition task (Ossmy & Mukamel, 2016b), it is not known how these performance gains compare with those resulting from traditional passive movement by an external source. Such a comparison is important and bares clinical relevance. During the rehabilitation process, patients suffering from hemiparesis undergo physical therapy which includes passive movement of the affected limb by the physiotherapist. A direct comparison of performance gains in healthy subjects following training by passive movement by an external source vs. self-generated passive movement (SPM) will help inform future directions in motor skill learning and rehabilitation. In order to fill the gap in the literature regarding the difference between the two mentioned methods, we compare the traditional learning by passive movement generated by an external-generated (EPM), and self-generated passive movement (SPM). While the previous study conducted in the lab examined within-session performance gains (Ossmy & Mukamel 2016b), the current study also extends previous results to provide information on acquisition of skills through passive motor movement on a long term practice period (3 days).

We hypothesize that voluntary control during passive movement plays a significant role in motor skill learning; therefore the aim of the current study is to manipulate voluntary control during passive movement and compare performance gains between self-generated passive movement and traditional passive movement. Higher performance gains following passive training by an external source, would suggest that self-generated passive movement involves inter-hemispheric interference interactions due to active movement of the opposite hand. Higher performance gains following passive training by self, would suggest that volition directed to the active moving hand facilitates training by passive movement. Since the 'self' condition involves cross-education that is absent in the 'other' condition, we also examine the size effect of cross-education in the absence of passive movement as control.

.

Method

Subjects. Sixty subjects participated in the study. 16 men and 34 female, mean age 25.1 years, range 21-44 years old. Subjects were randomly assigned to one of three groups. All subjects were healthy right handed young adults, with no reported cognitive deficit or neurological problems, and normal/corrected to normal vision. All subjects were naïve to the purpose of the experiment and gave their written informed consent to the experimental procedure. The study conformed to the guidelines approved by the Ethical Committee of Tel-Aviv University.

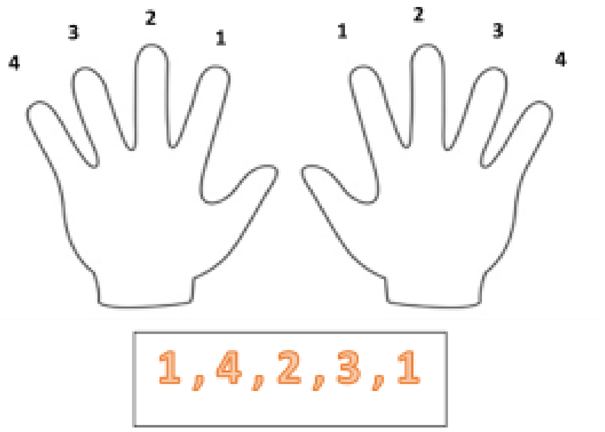
Apparatus and experimental procedure.

- *Motion sensitive gloves:* In order to track finger movement, the subjects wore specialized gloves with 5 flex sensors (*Neurodigital GloveOne),* providing for each finger the degree of flexure between 0 and 1 (1 - fully extended, and 0 fully flexed).
- *HTC Vive:* a virtual reality head-mount display for visual input. Through the display, the subjects saw a virtual room with a desk and two virtual hands with palms facing down. The hands were embedded in a particular position in space – corresponding to the location where the subjects would expect to see their real hands if they were not wearing the head-mount display.
- *Passive finger movement device:* This device accommodates two hands. When the device is turned on, voluntary finger movement of one hand (the active hand), activates motors that result in corresponding passive finger movement of the other hand (the passive hand) (Ossmy & Mukamel, 2016; Ossmy & Mukamel 2017).

Procedure. Subjects were randomly assigned to one of three training groups: Self-generated passive movement (SPM), Externally-generated passive movement (EPM), and Cross Education (CE). Subjects learned to perform a specific sequence of five finger flexion movements: 1, 4, 2, 3, 1 where 1 corresponds to the index finger and 4 corresponds to the little finger. The general experimental design is similar for all three training groups. Every day, for three days, the subjects underwent a left hand performance test, a train period (which depended on the experimental group), and another left hand performance test. Throughout the experiment, the subjects wore the gloves and head-mount display through which they saw a virtual room with table, and two virtual hands with palms facing down.

During the performance tests, subjects were asked to perform the sequence of finger movements repeatedly using their left hand - as accurate and as fast as possible for 30 seconds. Visual input of corresponding left virtual hand movement was provided (based on input from the left hand glove). During the training stage, the subjects' hands were strapped to the hand-movement device. The visual input from the head-mount display consisted of the same virtual room, with a right virtual hand fixed in place and a left virtual hand moving. Left virtual hand movement was controlled by the right hand glove and depended on the experimental group (see below). The training phase consisted of three runs. Each run contained seven 30-second long training blocks followed by 9 seconds of rest. During each training block, the subjects performed the sequence of finger movements repeatedly at self-pace. Each run was initiated by the subject when ready, following a rest period of at least 30 seconds between runs. During the inter-run rest period, the instruction slide with the finger sequence was presented (Figure 1a+b). At the end of the training phase, the subject's hands were removed from the hand-movement device, and another test-phase (identical to the first) was performed. In all 3 groups, the test-phase was performed with the left hand only. The outcome measure in each test-phase was the number (P) of correct full finger sequences and the number of errors.

a.



b.

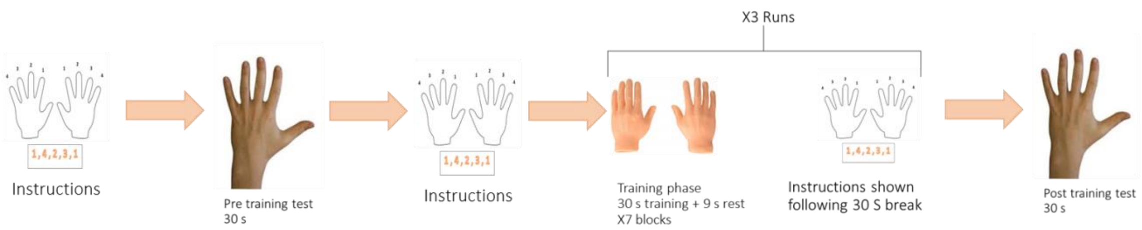


Figure 1. a. Experimental instructions. The instruction was displayed at the beginning of each stage (pre training test stage, training stage and post training test stage), and between runs (for at least 30 s). **b.** Time plot of the experiment.

Experimental groups.

Self-generated passive movement (SPM): during the training phase, both hands of the subjects were strapped to the hand-movement device and the subject wore both gloves. The subjects actively performed the finger-sequence with their *right* hand at self-pace while the device was turned on. Thus the source of passive left-hand movement was the subject's real right hand. In addition, movement of the left virtual hand was controlled by the subject's real right hand (through input from the right hand glove).

Externally-generated passive movement (EPM): during the training phase, the left hand of the subject and the right hand of the experimenter were strapped to the device. The experimenter actively performed the sequence of finger movements with the right hand, resulting in corresponding passive movement of the subject's real left hand. Since in this condition the experimenter wore the right hand glove, movement of the left virtual hand (and subject's real left hand movement) was controlled by the experimenter's right hand movement.

Cross-education (CE): during the training phase, the subject's hands were strapped to the hand-movement device but it was turned *off*. Thus subjects actively trained with their right hand while their real left hand was immobile. Through the head-mount display, subjects received visual input of left virtual hand movement that was controlled by their real right hand movement.

Throughout the training phase, SPM and CE groups performed the sequence at self-pace. For the EPM group, the experimenter performed the finger sequence at a pace that was determined based on the average pace of the other two groups.

For each subject, data was collected across 3 daily meetings of ~30-40 mins.

Design.

Independent variables (IVs):

a. A within-subject variable of two levels:
   - Test before training
   - Test after training
b. A between groups variable of three levels:
   - Self-generated Passive Movement (SPM; n=19)
   - Externally-generated Passive Movement (EPM; n=21)
   - Cross-education (CE; n=20)

In all three groups, subjects were provided with visual feedback of a left virtual hand performing the task. Left virtual hand movement was controlled in real-time by the active right hand.

Dependent variables (DVs):

Performance: In each test stage, we calculated subject's performance (P) by counting the number of correctly performed complete 5-digit sequences within 30 s. An index of performance gain (G) was calculated based on the difference in performance level between the post-training test of each day and the pre-training test stage of the first day, for each subject. Subject's performance gain was calculated using the formula below:

G= Ppost training-Ppre training of day 1

Where Ppost_training/Ppre_training correspond to the subject's performance in the post/pre training test stage respectively. Therefore, a positive G index reflects improvement in performance. We calculated the left-hand G index for each subject, in all 3 days of training.

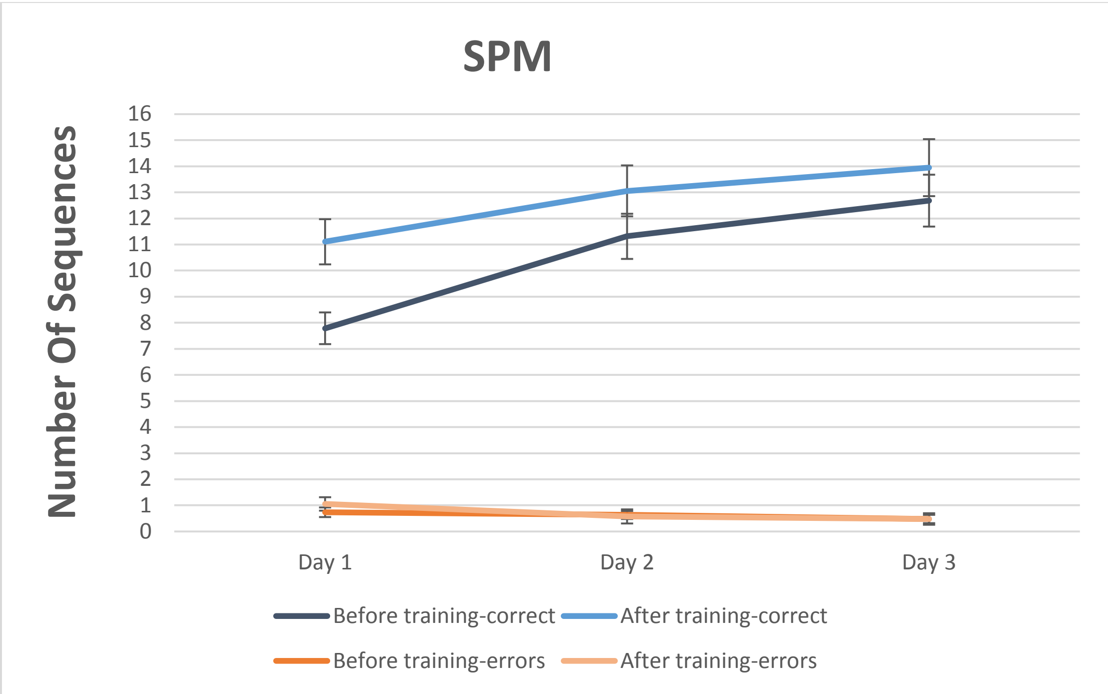
Results

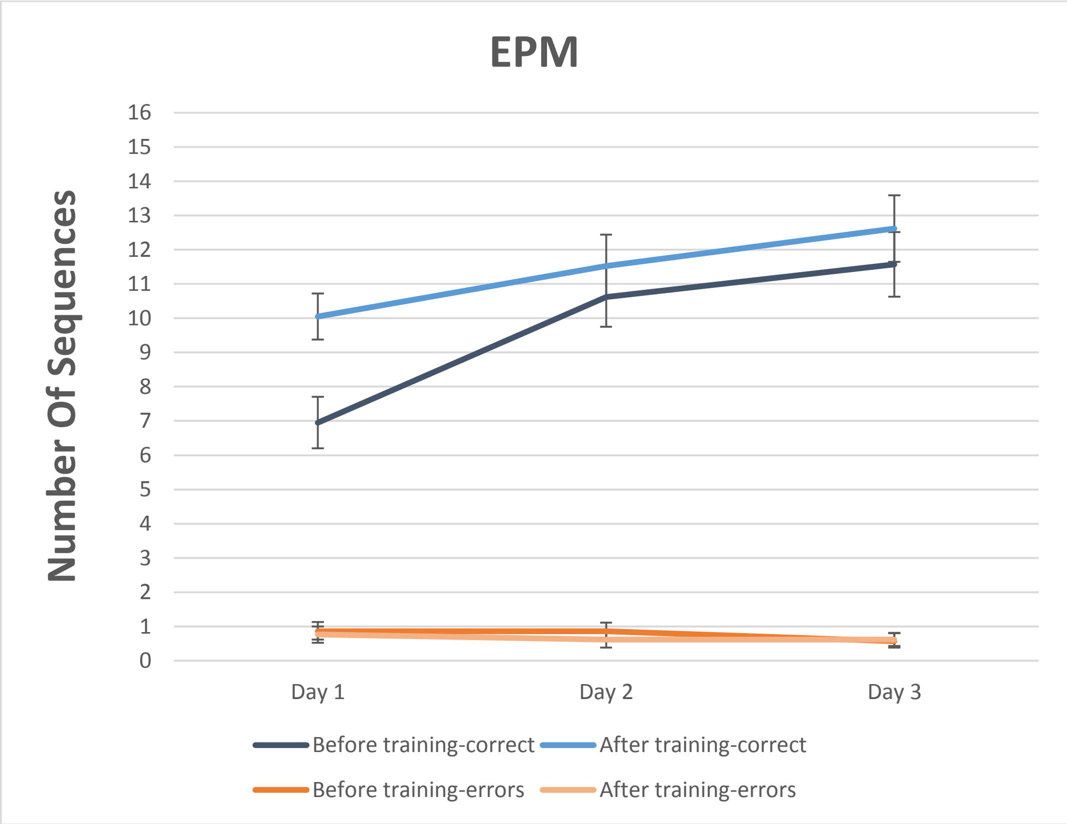
83 subjects were recruited to the study. Ten subjects dropped out for personal reasons, and data from additional 4 subjects were discarded due to technical errors. Seven subjects were discarded due to failure in following task instructions. Finally, when examining the pre-training performance level from the first day evaluation stage, 2 subjects were outliers (over 2 standard deviations from the group mean), and were excluded from further analysis. After exclusions, a total of 60 subjects (16 male and 34 female, mean age 25.1, range 21-44 years old), successfully finished the 3-day experiment (SPM group N = 19, EPM group N = 21, and CE group N = 20).

First, we compared the performance (number of successful sequences of finger movements) in the initial pre-test on day 1 between the groups. The average performance for the SPM group (*M= 7.79, SD*= 2.66), EPM group (*M= 6.95, SD*= 3.43), and CE group (*M= 6.9, SD*= 3.67) was not statistically different (F (2, 57) = 0.44, p= 0.64, one-way ANOVA). Similarly, the number of error sequences in the pre-test of the first day was not statistically different across groups: the average errors for the SPM group (*M= 0.74, SD= 0.81*), for the EPM group (*M= 0.86, SD= 1.24*), and the CE group (*M= 0.9, SD= 0.97*), (F (2, 57)= 0.13, P= 0.88, one-way ANOVA) (see figure 2 below).

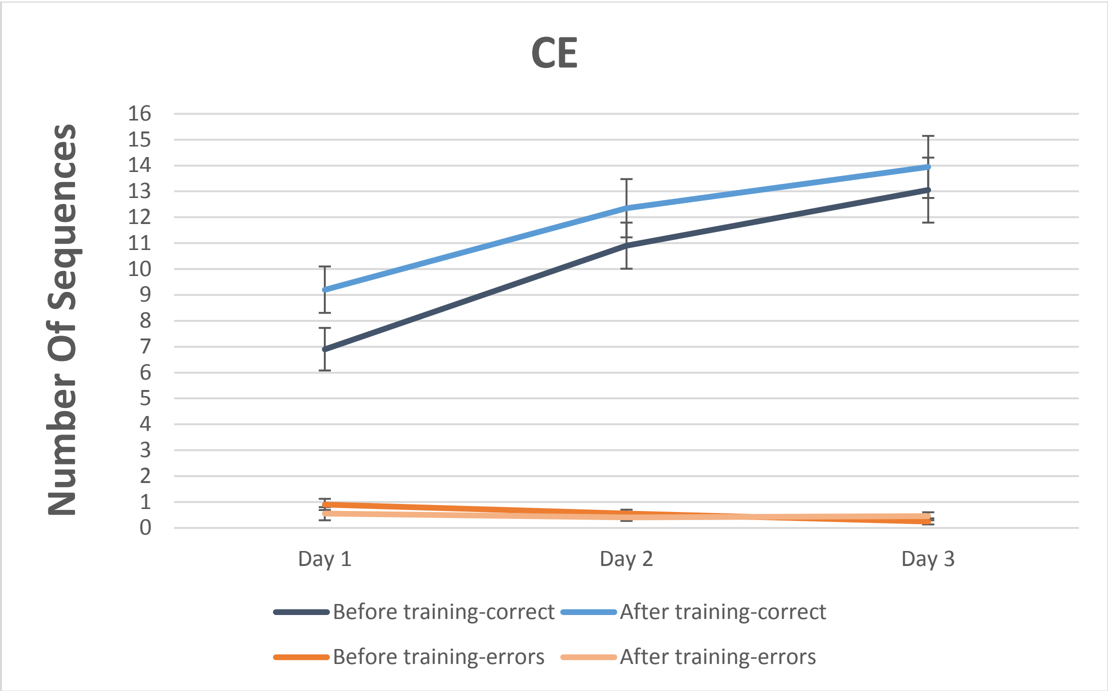
For each group, we calculated a daily gain index (G) based on the initial performance on day 1 (see Methods). We examined the G index using two ways repeated measures ANOVA with day as a within subject factor and group as a between subject factor. We found a significant *main effect of day (*first day*: M= 2.9, SD= 2.79;* second day *M= 5.09, SD= 3.89;* third day: *M= 6.29, SD= 4.59; F (2,114) = 51.22, P<0.05*). There was no significant main effect for group (SPM*: M= 4.91, SD= 2.73;* EPM*: M= 4.44, SD= 3.92;* CE: *M= 4.93, SD= 4.63; F* (2, 57) =0.12, *p*=0.89). When examining the interaction effect, we found a marginally significant effect between day and group (*F* (4, 114)= 2.23, *p*=0.07). Examining our three planned comparisons of G-index across days did not reveal a significant effect (day 1 (F (1, 57) = 0.6, p=0.44); day 2 (F (1, 57) = 0.05, p=0.82); day 3 (F (1, 57) = 0.24, p=0.88); see figure 3. Below). Similarly, analyzing the number of error sequences in each group across days, we found a significant *main effect of day (*first day*: M= 0.99, SD= 1.12;* second day *M= 0.53, SD= 0.75;* third day: *M= 0.51, SD= 0.21; F (2,114) = 5, p<0.05).* There was no significant main effect for group (SPM*: M= 0.7, SD= 1;* EPM *M= 0.67, SD= 1;* CE: *M= 0.67, SD= 0.81; F* (2, 57) =0.02, *p*=0.98). As opposed to the G index of the correct sequences, when examining the interaction effect for errors, we found no significant effect between day and group (F (4, 114)= 0.73, p=0.57).

2.a.





2. b.



2.c.

Figure 2. The average of correct sequences and error sequences for each group during the evaluation stages (pre-training correct in dark blue, and post training correct in light blue, pre-

training errors in dark orange, and post-training errors in light orange), for each day of training. Y axis is the number of correct sequences performed. A - SPM (group results, N= 19). B - EPM (group results, N= 21). C - CE (group results, N= 20). All groups exhibited significant improvement across days, and significantly decrease in number of errors. Error bars represent standard error across subjects.

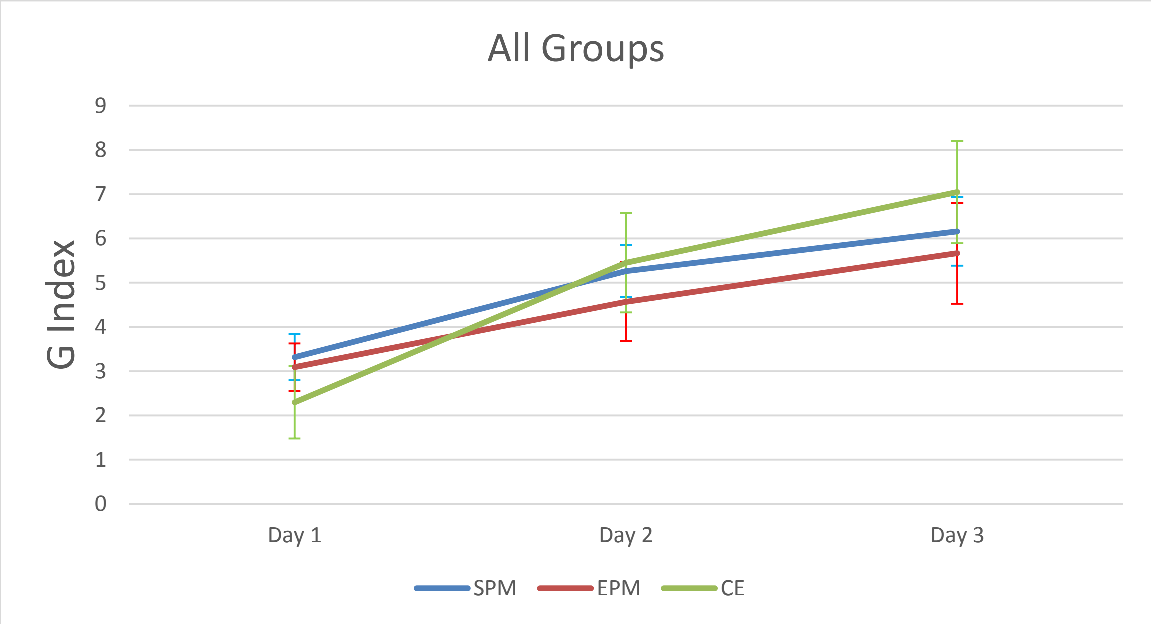


Figure 3. G-index of all groups across days.

When examining the number of sequences performed during training, we found that the number of sequences increased over days; a significant *main effect of day* (first day: *M= 8.1, SD= 2.81;* second day *M= 9.64, SD= 2.1;* third day: *M= 10.73, SD= 3.34; F (2,112) = 46.35, p<0.05*). Throughout the training phase, SPM and CE groups were instructed to perform the sequence at self-pace. The average pace of the initial 6 participants of the SPM and CE groups was 7.7 sequences/block. Based on this rate, the experimenters performed the sequence of finger movements in the EPM group which eventually was at an average rate of 8.09 sequences/block across EPM group participants. However, after completion of the study, the average rate of finger sequences performed during training by the SPM and CE groups increased to 10.1 and 10.33 sequences/block for the SPM and CE groups respectively. After study completion we found a significant main effect for group. Participants performed a different number of sequences during training (SPM*: M= 10.19, SD= 3.28;* EPM *M= 8.09, SD= 2.18;* CE: *M= 10.33, SD= 3.09; F* (2,

56) =4.65, *p*=0.01). Supported by post-hoc comparison, the main difference was in the number of sequences performed during training between the EPM and the other groups ($F\ (1, 55)= 9.67$, $p<0.05$). Moreover, we found that the increase in number of sequences across days was different across groups. When examining the interaction effect, we found a significant effect between day and group (F (4, 112)= 3.13, p<0.05).

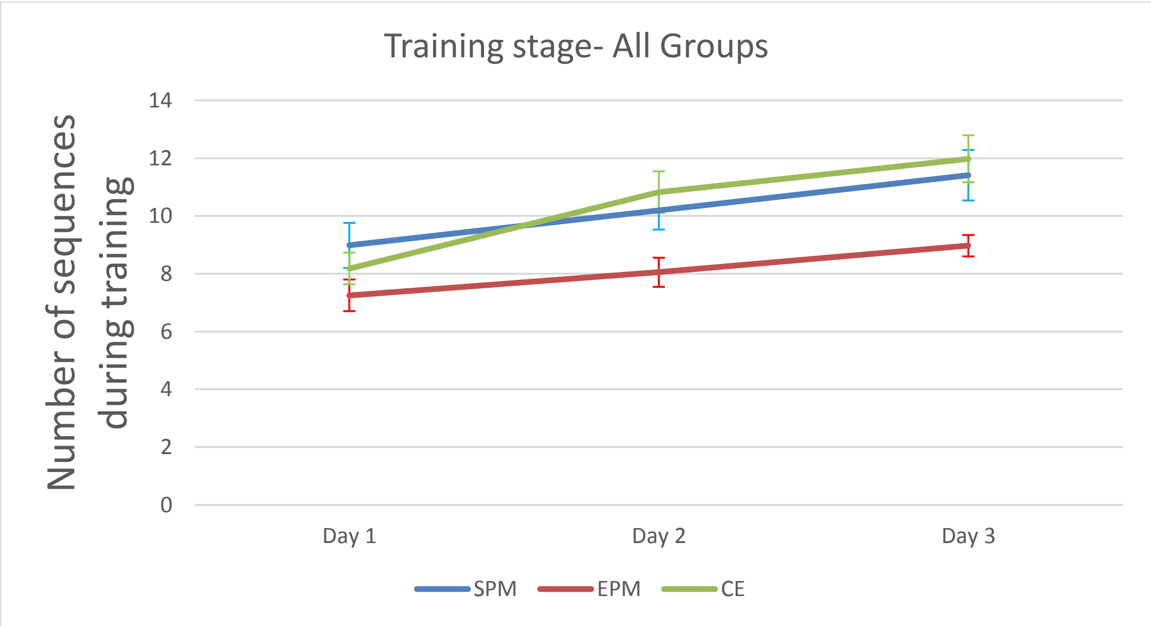


Figure 4. The average number of sequences performed by each group during the training stage across days. Error bars represent SEM across subjects within each group.

Discussion

Passive movement has long been recognized as constituting a powerful learning strategy for motor skills acquisition. Passive limb movement by an external source (i.e. experimenter / physiotherapist, or robotic device) can enhance subsequent performance of the trained movement (Wong et al., 2012), and to advance the learning process of motor skills on multiple tasks (Wong et al., 2012; Bernardi et al., 2015; Kummel et al., 2014). In addition, it has been shown to have beneficial effects not only in unimanual but also in bimanual tasks (Beets et al., 2012). Nonetheless, motor acquisition can be achieved when the subject itself controls the passive movement of one side of the body by moving the other side of the body (Ossmy & Mukamel, 2016b). Hence, in the current study we were the first to investigate the differences between the traditional learning by passive movement generated by an external source (EPM), and self-generated passive movement (SPM). In this study, we used three experimental training groups for comparison: EPM, SPM, and CE.

We hypothesize that voluntary control during passive movement plays a significant role in motor skill learning; therefore, the aim of the current study is to manipulate voluntary control during passive movement and compare performance gains between self-generated passive movement (SPM) and traditional passive movement (EPM). Our hypothesis is non-directional. If SPM is better than EPM, it will inform us about the significant role of voluntary control during learning. If EPM is better, it would point to interhemispheric interference during self-generated passive training.

In a previous study in our lab, we have demonstrated significant learning when the passive movement in one limb is generated by active movement of the subject's opposite limb (Ossmy & Mukamel, 2017). In other words, the learning hand was passively moved while subject's voluntary control was maintained (Ossmy & Mukamel, 2016b). In recent studies we found that the combination of passive movement with manipulated visual input is better than either one alone for short term learning. Therefore, the current study is a follow-up study of previous research conducted in our laboratory (Ossmy & Mukamel 2016b), which provides information on passive motor movement acquisition skills during a long-term practice period (of 3 days).

In the current study, we found a significant main effect of day; we can see a significant improvement in every day in each of the experimental groups of study. Despite the simplicity of the task, the groups didn't stop increasing their learning at the first day, and continued improving across days.

In our previous study in the lab, we found that the addition of passive movement to the incongruent visual feedback (similar to our SPM group) led to the highest left hand performance gains, which was significantly greater, compared to the experimental condition similar to our CE group (Ossmy & Mukamel, 2016b). Although at the descriptive level, the results of the current study are in agreement with these results, the difference between the SPM and CE groups did not reach statistical significance. A few differences between the two studies may provide an explanation: first, the design of the previous study was within subjects, while the current study design was between subjects, which can explain the reduction in statistical power. Second, differences in the amount of training. In the previous study, the training stages contained ten blocks, each block lasted 50 s followed by 10 s of rest. While in the current study the training stages contained a total of 21 blocks, each block lasted 30 s followed by 9 s of rest. Third, the previous study used augmented reality (AR), in which the participants saw their virtual hands embedded in the natural live view of the room, by using the camera on the goggles. In the current study we used virtual reality (VR) in which the participants' virtual hands were embedded in a virtual room and the entire scene was virtual. Such a difference can influence the degree of subject immersion in the experimental environment and may affect learning.

Although it has been discovered that traditional passive movement generated by an external source (Wong et al., 2012; Bernardi et al., 2015; Kummel et al., 2014)), and also passive movement generated by self (Ossmy & Mukamel, 2016b) promote motor movement acquisition, there are no studies that compared the difference between these two methods of training.

Although there were no significant differences between the groups over the experiment, we can descriptively see that the SPM groups' motor learning (G-index) is better than the motor learning of the CE group in the first day. This is in agreement with finding from our previous study in which we found a greater advantage for the group who practiced the task with passive movement generated by self, than the group who practiced with the opposite hand only (equivalent to our SPM and CE groups respectively) (Ossmy & Mukamel, 2016b). Moreover, we found a marginally significant interaction between group and day. Interestingly, those results remain in the short term, and the benefit of the SPM performance becomes balanced with the CE performance in the long term. We can conclude from this that in the long-term, there is no much difference or benefit for one of the methods over the other one (SPM, EPM). Furthermore, it might benefit to practice motor movement with one side of the body for improving the homologue part of the body (CE), than passively move the learning organ at the same time (SPM) which requires a specialized device.

During motor skill learning, observation and physical practice presumably engage similar neural mechanisms to create internal motor representations, which then provide the ability to accurately reproduce those voluntary actions (Dushanova and Donoghue, 2010). In the end of the 20^{th} century, a fascinating manifestation has been reported in monkey's brains - neurons that respond not only during execution of an action, but also during mere observation of someone else performing an execution of a motor action (Di Pallegrino et al., 1992; Rizzolatti et al., 1996). In other words, these neurons are active both when an action is performed and when viewing that same action performed by another. These neurons termed "mirror neurons" are located in motor areas in the brain, such as primary motor cortex and the supplementary motor area (Dushanova and Donoghue, 2010). Following studies suggest that this system exists in the humans' brain in a similar way (Mukamel et al., 2010; Rizzolatti and Craighero, 2004). Hence, with the fact that all groups in the current study were supplied with visual feedback of the left hand movement, it may be that the visual feedback was powerful enough to overshadow possible differences between the different training groups.

Current results have implications for rehabilitation and suggest that patients suffering from hemiparesis may undergo physical practice only with their healthy part of the body and together with visual manipulations improve the performance of the affected part of the body. The patient can practice independently with their healthy limb without the need of expensive robots that passively moves their affected limb.

Limitations:

When participant use the VR goggles, the researcher is restricted to control whether the subject has closed his eyes during the task. Therefore visual input cannot be verified. Another limitation we discovered throughout the experiment is that some of the participants didn’t understand the task well enough, and they skipped the last finger of the sequence, finger number one (the pointing finger). This finger was supposed to show up twice in a row, due to the cyclic nature of the sequence (1-4-2-3-1). For some reason, this appeared only in the evaluation stages of subjects in the SPM and CE groups, and not in the EPM group. Currently, we can't explain the reason for this. Finally, we discovered that the pace of finger sequence execution during the training stage was significantly different between the SPM and CE groups to the EPM group. Throughout the training phase, SPM and CE groups performed the sequence at self-pace. For the EPM group, the experimenter performed the finger sequence at a lower a pace (8.03 for EPM vs. 10.1 and 10.33 for SPM and CE respectively. Additionally, the variance in self-pace across subjects in the SPM and CE groups was larger, relative to the EPM group, in which the training pace was controlled by 3 different people (the experimenters). In future studies, we recommend using a metronome or alternatively a robot to control the training rhythm for the EPM group or with the help of sophisticated technology to pair between the personal paces of the experimental group (i.e. SPM) with the subjects of the EPM group. In other words, that the self-pace rhythm of each participant of the experimental group will serve as a template to control the training pace of the EPM participants. That way the training pace will be similar across groups.

Acknowledgments

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תקציר

מחקרים רבים בעבר ובהווה הראו שאימון מוטורי ע״י תנועה פאסיבית משפר למידה מוטורית.
רב המחקרים המסורתיים, ואלו הקיימים בספרות המחקרית חקרו למידה ע״י תנועה פאסיבית באמצעות אימון על-ידי מקור אחר שהוא לא עצמי קרי, רובוט. במחקר הנוכחי אנו קוראים לאימון מסוג זה תנועה פאסיבית ממקור חיצוני (EPM). לכן, במהלך אימון כזה לא קיים קשר בין תנועת הזרוע לבין הרצון של הנבדק. בעקבות מחקר חדש שנעשה במעבדה, השתמשנו במכשיר חדשני שאפשר לנו להחזיר את הקשר הזה במהלך אימון תנועה פאסיבית, ולייצר תנועה פאסיבית מעצמי. באמצעות שימוש במכשיר המיוחד הזה, אנו מחברים בין תנועת אצבע רצונית ופעילה של יד אחת לתנועה פאסיבית עוקבת באצבע היד השנייה. אימון תנועה מסוג זה, שהמקור הוא עצמי, אנו מכנים תנועה פאסיבית ממקור עצמי (SPM).

מעולם לא נבחנו ההבדלים בהצלחת אימון מוטורי בין שתי הגישות, הגישה המסורתית (EPM) לבין הגישה החדשה (SPM). לפיכך, במחקר הנוכחי אנו משווים באופן ישיר למידה מוטורית של ביצוע רצף תנועות אצבע כאשר המקור של התנועה הפאסיבית הוא חיצוני או עצמי.
בניסוי השתתפו 60 נבדקים שחולקו אקראית לשלוש קבוצות אימון, EPM, SPM וקבוצת ביקורת CE והתאמנו במשך שלושה ימים.
כל הקבוצות השתפרו בביצוע המטלה, אך לא נמצאו הבדלים משמעותיים בין שתי קבוצות שיטות האימון. בשל כך אנו מסיקים כי אין בהכרח הבדל משמעותי בין תוצאת טיפול פאסיבי ע״י פיזיוטרפיסט או רובוט לבין תוצאת אימון מתנועה עצמית. לתוצאות הניסוי יש השלכות עבור השאלה האם יש יתרון בטיפול על ידי אימון עם רובוט, או פיזיוטרפיסט על פני תנועה פאסיבית הנובעת מתנועה עצמית.

TEL AVIV UNIVERSITY

אוניברסיטת תל-אביב

הפקולטה למדעי החברה ע"ש גרשון גורדון

ביה"ס למדעי הפסיכולוגיה

למידת כישורים מוטוריים באמצעות אימון תנועה פאסיבי

חיבור זה הוגש כעבודת גמר לקראת התואר "מוסמך אוניברסיטה"- M.A.
באוניברסיטת תל אביב

על ידי

ליהי שדה

העבודה הוכנה בהנחיית:

פרופ' רועי מוכמל

ינואר 2019