Observation of an expert model induces a coarticulated drawing movement pattern in a single session

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***Abstract*— We tested how observation of a skilled pattern of planar movements can assist in the learning of a new motor skill, which otherwise requires rigorous long-term practice to achieve fast and smooth performance. Sixty participants performed a sequence of planar hand movements on pre-test, acquisition, post-test and 24h post-training blocks, under 1 of 4 conditions: an observation group (OG), a slowed observation group (SOG), a random motion control group (RMCG) and a double physical training control group (DPTCG). The OG and SOG observed a co-aligned expert model's right hand performing the study task intermittently throughout acquisition, RMCG observed random dots movement instead of a model. Participants in the DPTCG received extra physical practice trials instead of the visually observed trials. Kinematic analysis revealed that only in conditions with observation of an expert model there was an instant robust improvement in motor planning of the task. This step-wise improvement was not only persistent in post-training retests but was also apparently implicit and subject to further incremental improvements in movement strategy over the period of 24 hours. We suggest that observation of hand movements of an expert model coaligned with self-produced movements during training can significantly condense the time-course of ecologically relevant drawing / writing skill mastery. Current findings may contribute to optimization of motor training and rehabilitation in virtual or simulated environments.**

***Keywords*— Kinematics; model observation; coarticulation; drawing; motor skill learning, planar movements**

I. Introduction

Humans learn many skills (procedural, “how-to” knowledge) through observation. Observing others performing a motor skill has been shown to benefit acquisition and learning, and importantly can even lead to skill consolidation of the observer [1]. A combination of observational and physical training has been shown to be very effective and even superior to physical practice alone [2]. In learning a sequence of planar hand movements passing through several targets, e.g., in handwriting, extensive training is needed to achieve fast and smooth performance through formation of new movement elements (primitives) and concatenation of movement components [3]. The current study explored whether observation of a skilled movement pattern intermittent with physical practice may result in a condensed time-course of motor learning.

II. Methods

First, we trained a naïve subject through a well-established multi-session training protocol to the level of expert [3]. The video of “expert” hand movements holding a stylus from the last (10-th) practice session was used as a model in observation trials of the novice trainees, either at the original speed of performance or in a slowed version, at a 1/3 of the original expert speed, allowing better observation of the movement. No visualization of the path (ink trace) was afforded. The hand movements were recorded at 160 Hz using a stylus on a tablet computer placed flat on a table at a comfortable distance.

Sixty healthy young participants were randomly assigned to one of four groups, with each group receiving a different type of training. The layout of the stimuli was as in a previous study [3]. The participants were instructed to place the stylus on the dot next to the letter “A”, and then, as quickly and accurately as possible, pass through the other dots in alphabetical order and return to “A” (i.e. A->B->C->D->A), and wait there until the dots disappeared (which occurred when stopped on A for 500 ms). Performance feedback (path or accuracy of passing through the dots) was not provided. All groups had six blocks of training with 60 trials in each block, All participants performed a pre-test, training, post-test and 24h post-training blocks, under 1 of 4 conditions: an observation group (OG), a slowed observation group (SOG), a random motion control group (RMCG) and a double physical training control group (DPTCG). The OG and SOG observed an expert model's right hand performing the study task intermittently throughout acquisition, RMCG observed random dots movement instead of a model. On the next day, three performance tests were afforded: (i) Trained consolidation test - trained spatial layout and order of targets, (ii) Mirror transfer test – mirror reversed (left-right) spatial layout requiring a mirror-reversed movement order, (iii) Scaled transfer test - spatial layout that was scaled down by 30% from the original, but the original target sizes and order were maintained. For analysis, movement onset was defined as the last time that the tangential velocity was less than 5% of the peak tangential velocity. The end of the movement was defined as the last time the tangential velocity was greater than 5% of the peak tangential velocity. Movement duration was defined as the time between movement onset and the end of the movement. Coarticulation score was defined as an overlap of two movement primitives - the ratio of the heights of the troughs to the heights of the peak in the tangential velocity profile. The improvement in coarticulation reflected greater overlap between the movements.

III. Results

Only in conditions with observation of an expert model there was an instant robust improvement in motor planning of the task, reflected in reduction in mean movement duration and improvement in the coarticulation score **(Figure 1).**

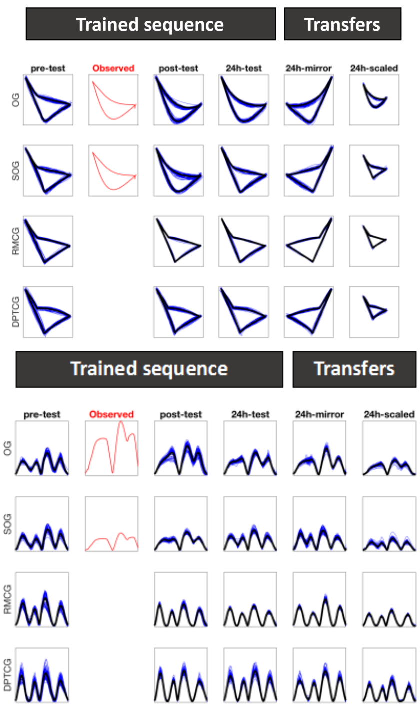

Figure 1. (**upper**) All trajectories (blue lines) and mean trajectory (black line) from representative subjects from the four groups, for the five tests. All graphs have the same scale. The x and y axes correspond to left-right and forward-back movements respectively. The red trajectories (2nd column) correspond to the expert's video recordings shown to the OG and SOG groups. (**lower**) Time-normalized tangential velocity profiles and mean tangential velocity from representative subjects from the four groups, for the five tests. The x axis is normalized time, while the y axis is the tangential velocity. The red velocity profiles correspond to those from the videos shown to the OG and SOG groups. Velocity profiles with 4 peaks indicate that the movement can be segmented into four movements between the points, whereas those with three peaks indicate that movements from A→B and B→C show a large degree of overlap or coarticulation.

The two control groups showed no improvement in either measure. This step-wise improvement was not only persistent in post-training retest but was also apparently implicit and subject to further incremental improvements in movement strategy over the period of 24 hours. The participants in the observation group (OG) performed the movements faster than the slowed observation group (SOG), whereas both observation groups showed similar values for a coarticulation score (see **Figure 2 upper panel**). The improved coarticulation ability of the observation groups generalized to scaled and reversed transfer tests (see **Figure 2 lower panel**).

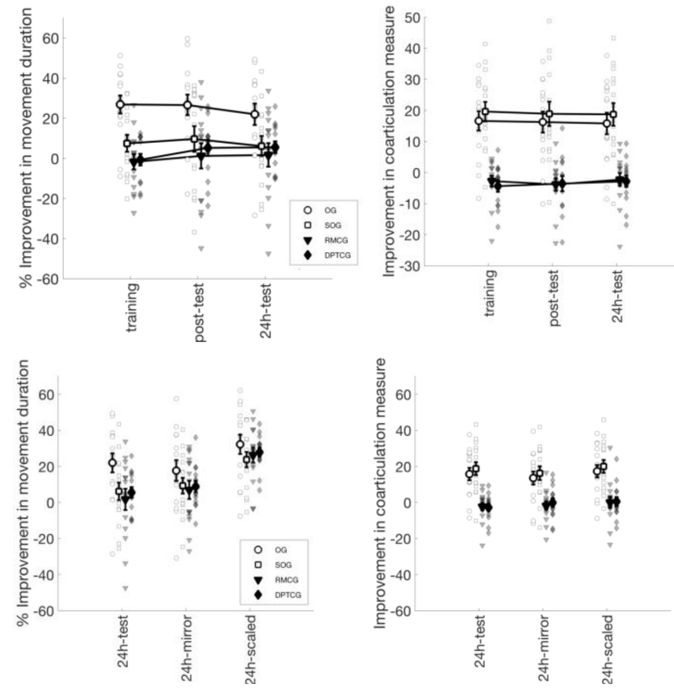

Figure 2. (**upper panel**) Time-course of changes in normalized improvement movement duration, relative to the pre-test. Left - mean (across subjects) of and the distribution of individual scores at three time points, training, post-training and 24h post-training. Right - Improvement in coarticulation measure (higher values correspond to greater coarticulation), relative to the pre-test. (**lower panel**) Left - relative improvement at two transfer conditions in comparison to trained condition performance at the 24h re-test. Right - relative improvement of the coarticulation measure in the transfer conditions.

IV. Discussion

Observation training is increasingly suggested as a therapeutic approach in motor rehabilitation [4]. Our results suggest that: 1) practice by observation of an expert's movements is a very effective learning experience - it saves extensive training to reach the concept of co-articulation of movement components; 2) nevertheless, the resultant procedural knowledge is qualitatively and quantitatively different from the knowledge (skill) created by a multi-session physical practice. The coarticulation score may prove useful in VR and simulators training as a way of tracking how trainees overlap their execution of movements, without requiring the problematic explicit decomposition of the movement into sub-movements.

V. References

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