Multiple Components of Motor Sequence Learning

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Introduction

- Motor skill acquisition can be thought to involve distinct behavioural components such as **accuracy** and **synchronization**. In addition, encoding processes such as motor consolidation may facilitate performance gains overtime.
- Accuracy refers to the ability to make a "correct" response, whereas synchronization refers to being able to time a response.
  - Improved accuracy has been associated with increased activity in the **hippocampus, putamen,** and **frontal regions**, whereas improved synchronization has been associated with activity in the **primary motor cortex** and **cerebellum** (Steele & Penhune, 2010).
- Consolidation refers to processes that "fix" a motor skill in memory following a period of practice (Krakauer & Shadmehr, 2006). Consolidation is usually defined as improvement in performance between the last block of training on Day 1, and the first block of training on Day 2.
  - Sleep between Day 1 and Day 2 may affect consolidation (Brawn, Nusbaum, & Margoliash, 2010; Hall, 2010; Morgan, Kehne, Sprenger, & Malison, 2010).
  - The type of task may affect consolidation (Robertson, Pascual-Leone, & Miall, 2004).

Objectives

- The current study aims to:
  - Examine **differences** in improvement between accuracy and synchronization.
  - Test for consolidation between Day 1 and Day 2 on both **accuracy** and **synchronization** using the MFST (or Multiple Finger Sequence Task).

Hypotheses

- For measures of accuracy and synchronization, participants were expected to show:
  - Improved performance for a **repeating sequence**, but not for **non-repeated sequences**.
  - Consolidation for a **repeating sequence**, but not for **non-repeated sequences**.

Method

Participants

- **13** neurologically healthy individuals; **8** female, **5** male
- Aged between 18 – 35 years (M = 22.53, SD = 3.41)
- Right-handed
- Non-musicians

Procedure

- Each block of the **MFST** consists of **14** trials:
  - **Learning** trials: fixed, repeating sequence of 13 elements (10 presentations)
  - **Random** trials: variable, random sequence of 13 elements (4 presentations), but matched for transitions between fingers.
- The presentation of these trials is randomized within each block.

Measures

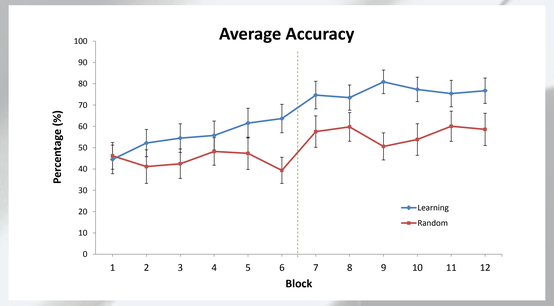
- Key-presses were coded for accuracy and synchronization:
  - **Accuracy**: % correct key-presses for each trial
  - **Synchronization**: temporal offset (ms) between stimulus and key-press (for correct responses)

Day 1		Day 2	
Blocks 1 to 6		Blocks 7 to 12	
Learning	Random	Learning	Random

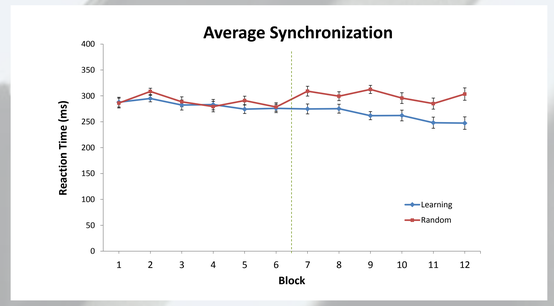
Results

Improvement in Accuracy and Synchronization across Day 1 and Day 2 on Multiple Finger Sequence Task

Dotted line between Block 6 and Block 7 indicates separation between days.



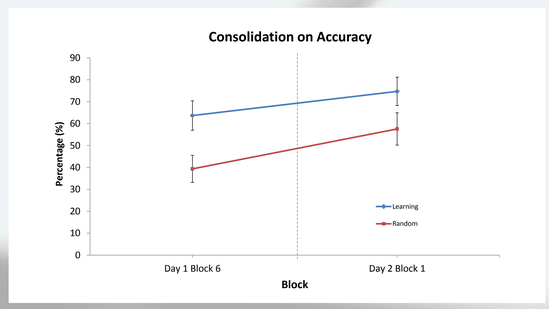
- Main effect of Sequence Type. $F(1, 12) = 54.46$, $p < .01$**, $\eta_p 2 = .819$
- Main effect of Block. $F(11, 132) = 18.36$, $p < .01$**, $\eta_p 2 = .605$
- Statistically significant interaction between Sequence Type and Block. $F(11, 132) = 7.747$, $p < .01$**, $\eta_p 2 = .392$



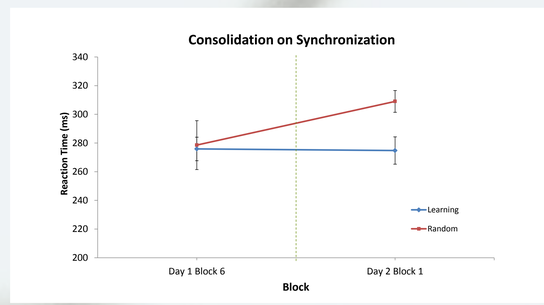
- Main effect of Sequence Type. $F(1, 12) = 12.52$, $p < .01$**, $\eta_p 2 = .511$
- Statistically significant interaction between Sequence Type and Block. $F(11, 132) = 3.761$, $p < .05$*, $\eta_p 2 = .239$

Consolidation on Accuracy and Synchronization between end of Day 1 and start of Day 2

Dotted line between Block 6 and Block 7 indicates separation between days.



- Main effect of Sequence Type. $F(1, 12) = 44.55$, $p < .01$**, $\eta_p 2 = .788$
- Main effect of Block. $F(1, 12) = 25.69$, $p < .01$**, $\eta_p 2 = .682$



- No statistically significant main or interaction effects.

Conclusions

- Overall, improvement in accuracy for the single, **repeating** sequence was greater than for the **non-repeating, random** sequences.
  - Improvements in accuracy on random sequences may be related to general task features, such as spatial relationships and overall timing.
- Synchronization on random sequences appeared to **worsen** on Day 2. This worsening may be related to a learned expectation of the repeating sequence interfering with performance.
- There was no evidence for **sequence-specific** consolidation on accuracy or synchronization measures.
  - Lack of consolidation may be related to high task difficulty and order of practice patterns (repeating vs. non-repeating sequences).
- Divergent patterns of improvement between accuracy and synchronization support the idea that separate components of motor learning may be regulated by different neural and cognitive processes.
- Future studies examining other behavioural components (such as velocity and duration) may provide further insights into the nature of motor sequence learning.

References

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