Crossmodal Encoding of Motor Sequence Memories

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Background

- The field of motor rehabilitation is in need of more efficient and effective rehabilitation strategies.
- Each year, almost 2.5 million Americans suffer from traumatic brain injury (TBI) and roughly 800,000 Americans experience a stroke. [1, 2]
- The total annual direct and indirect costs of stroke and TBI in the United States are $65.5 billion and between $48 and $56 billion, respectively.[3, 4]
- A promising new approach may lie in using sound as a neuromodulatory tool to access motor areas of the brain.
- Pianists, for example, can improve their performance of a previously practiced musical piece just by listening to the piece before the next time they play.[5]

Population Health Implications

- In order to reduce the burden of stroke and TBI, additional funding needs to be committed toward neurology and neurorehabilitation research, as much of the brain is not yet fully understood.
- Interventions to prevent stroke and TBI will reduce the need for motor rehabilitation. Interventions should be targeted to the populations most burdened by stroke and TBI.
- As high-quality neurorehabilitation can be very costly and time-consuming, improving patient access to affordable care could improve patient outcomes and reduce the burden shouldered by caregivers.
- Additionally, auditory neurorehabilitation strategies tend to be less expensive than visual displays and can be used at home.

Aim

- The aim of this study was to determine the effect of exposure to a movement-associated tone sequence on the subsequent learning of a novel, sequential motor task.
  - It was previously unknown if exposure to a sequence of movement-associated tones can actually improve motor performance.
- We hypothesized that motor learning of a sequential key-press task would be facilitated by previous exposure to a tone sequence that is congruent with the movement task, as compared to an incongruent sequence.

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Methods

Participants

Twenty healthy , right-handed adults (10 men, 10 women; average age: 27.0), were randomly assigned to one of two experimental groups.[6]

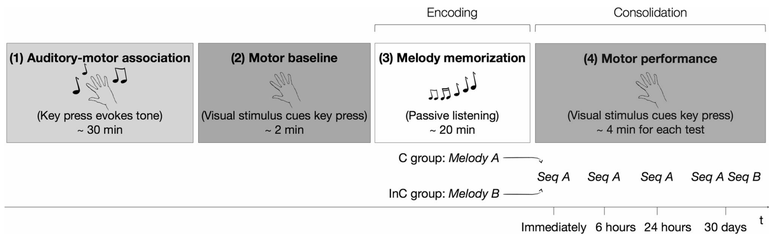
Experimental Groups

- **Congruent Group (C):** participants memorized a 12-unit tone sequence which corresponded to the repeating sequence of 12-key presses required in the motor performance test.
- **Incongruent Group (InC):** participants memorized a 12-unit tone sequence which did not correspond to the repeating sequence of 12-key presses required in the motor performance test.

Performance Parameter

Mean response times of correct trials per subject in the motor performance tests at baseline and immediately, 6 hours, 24 hours, and 30 days after tone sequence memorization.

Experimental Design[6]



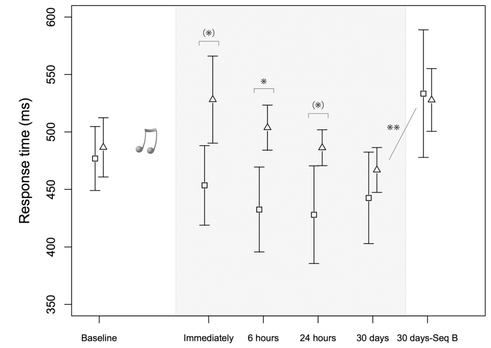
(1) Auditory-motor association: participants learned to associate each of four tones with a particular finger movement by performing random key presses with sound feedback ("piano playing" task). [6]

(2) Motor baseline: participants responded with key presses to circles appearing in a random order on a computer monitor. [6]

(3) Melody memorization: participants were then instructed to memorize either Melody A (congruent (C) group) or Melody B (incongruent (InC) group). [6]

(4) Motor performance: immediately after melody memorization, as well as 6 h, 24 h, and 30 days later, participants performed motor sequence A (Seq A). After the performance of Seq A 30 days after melody memorization, 7 out of 10 participants in each group also performed a motor sequence B (Seq B). [6]

Results



- The figure[6] above shows the mean response times for each motor test. The triangles represent the incongruent group (InC) and the squares represent the congruent group (C). The musical notes represent the melody memorization phase of the experiment. [6]
- After correction for multiple comparisons, there was a **significant difference between groups at 6 h (*, $p < 0.05$)** and a trend toward statistical significance immediately and 24 h after melody memorization ((*), $p = 0.059$). [6]
- There was a significant increase in response time from sequence A to sequence B (Seq B) 30 days after melody memorization to an equal extent in both groups (**, $p < 0.01$). Error bars represent ± standard error of the mean. [6]

Conclusions

- We conclude that exposure to a movement-related tone sequence can crossmodally and specifically affect subsequent performance of a new, never physically-practiced, motor sequence. [7]
- A better understanding of auditory-motor system interactions might contribute to the development of new strategies using sound as a neuromodulatory tool for motor rehabilitation or other dysfunctions involving auditory-motor neuronal networks. [7]

References

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