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Random delay boosts musical fine motor recovery after stroke

Introduction

Motor impairments are among the most common and most disabling results of stroke worldwide. Previous studies have revealed that learning to play the piano helps to improve motor functioning in standardised motor tasks (Schneider et al, 2007; Amengual et al, 2013). These improvements are accompanied by changes in connectivity (Altenmüller et al, 2009) and auditory-motor coupling (Rojo et al, 2011; Rodriguez-Fornells et al, 2012). However, it remains unclear whether auditory-motor connectivity causes motor rehabilitation or occurs as a side-effect. Alternatively, it could be argued that rehabilitation benefit is exclusively due to the beneficial nature of the finger movements involved in piano playing.

Patients

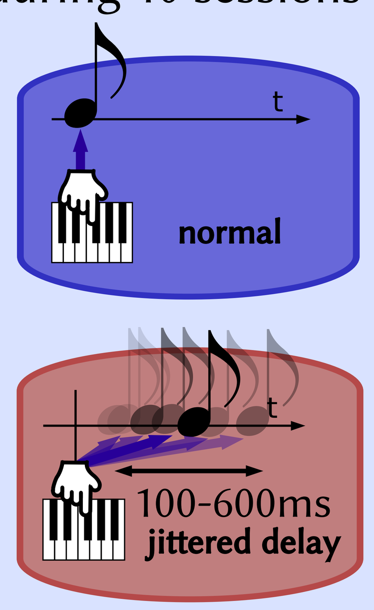
37 patients in early stroke rehabilitation:
- No previous musical training,
- Light to moderate motor impairment,
- Capable of moving the index finger independently,
- No other neurological or psychiatric condition.

	normal	delay
Gender (F/M)	8/10	9/10
Age (years)	62.6 (SD 12.7)	66.7 (SD 10.0)
Education (years)	10.2 (SD 1.3)	9.8 (SD 1.2)
Barthel Index (0..100)	70.0 (SD 28.6)	52.9 (SD 20.6)
Time since stroke (median days)	33.5	31.0
Stroke type (haemorrhage/ischemia)	6/12	0/19
Affected hemisphere (L/R)	8/10	9/10

Methods

Therapy: learning to play simple finger exercises and familiar children's songs on the piano during 10 sessions of 30 minutes.

- **normal** group (n=18), the keyboard emitted a tone immediately at keystroke.
- **delay** group (n=19), the tone was emitted after a time interval between 100 and 600ms, chosen randomly at each keystroke.



Aim

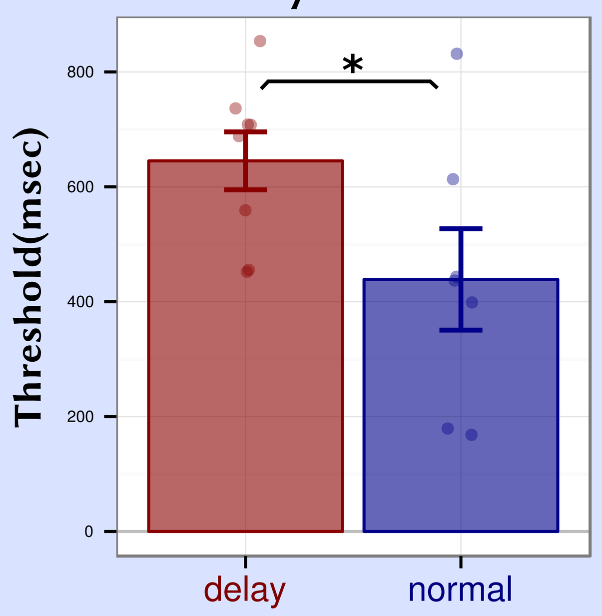
Does the stroke patient's brain use the temporal information contained in the auditory feedback in the process of music-supported motor rehabilitation?

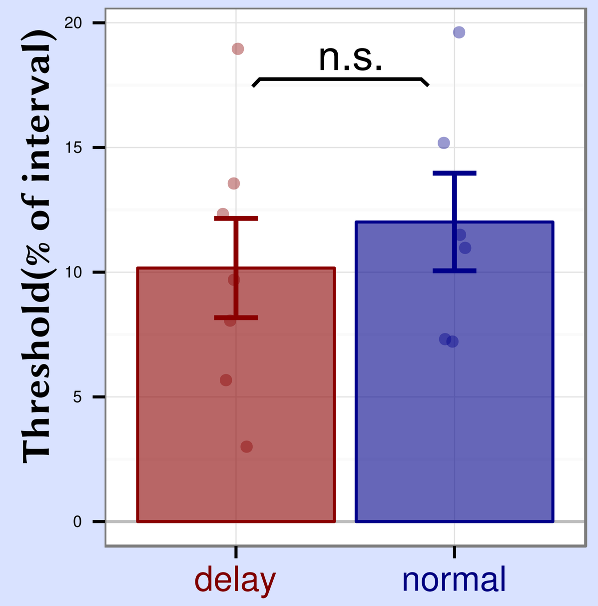
Hypothesis A The timing of the sound has no influence, the therapy is basically just finger exercises. **Prediction:** no difference between the groups.

Hypothesis B The brain uses the sound as an error-correction feedback. **Prediction:** jittered delay impairs rehabilitation.

Hypothesis C The brain uses the sound-action link with a widened temporal integration window or to update the internal model. **Prediction:** jittered delay would benefit rehabilitation.

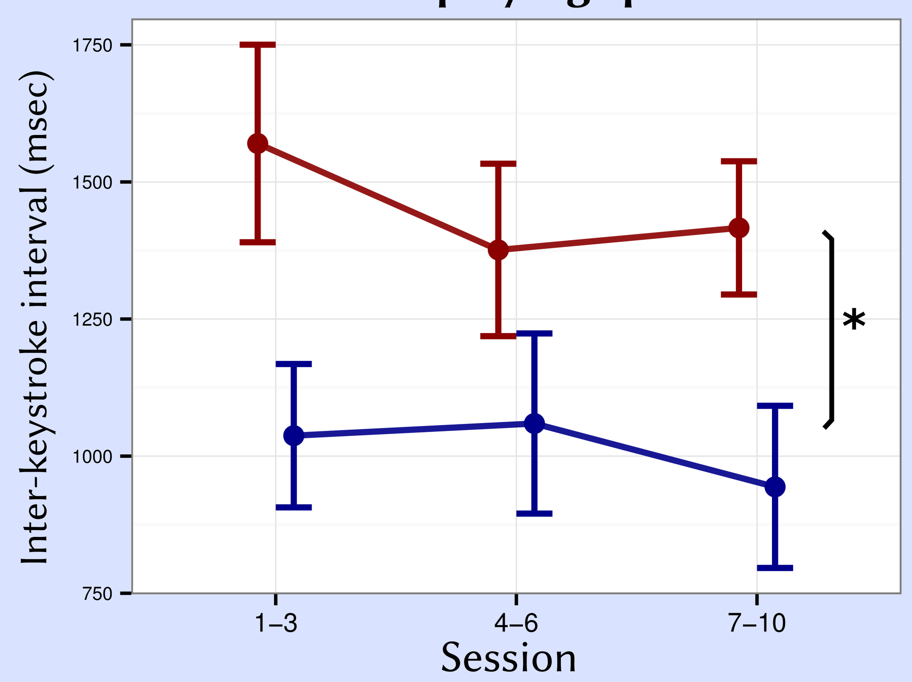
Auditory-Motor Tests





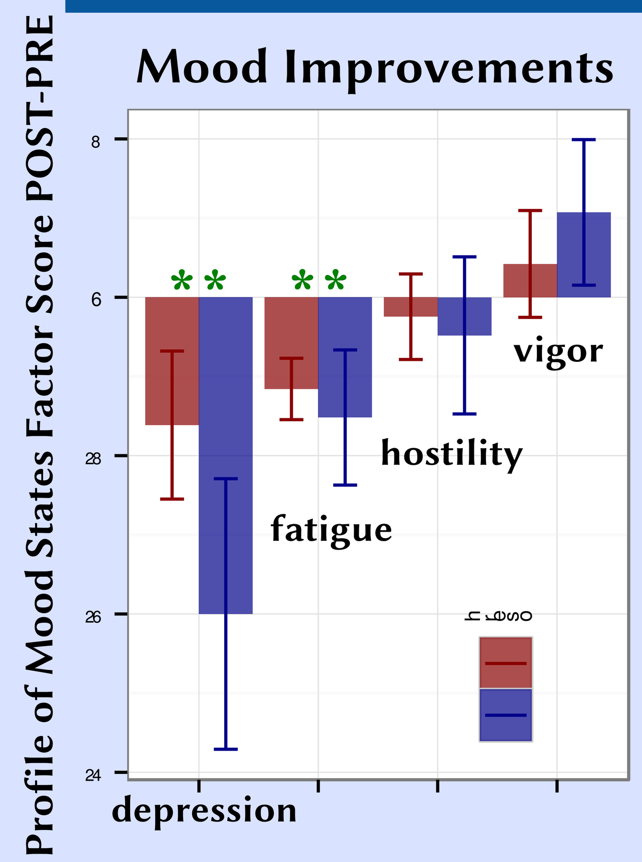
Auditory-motor coupling but not general auditory processing is disrupted in the **delay** group.

Within-therapy performance



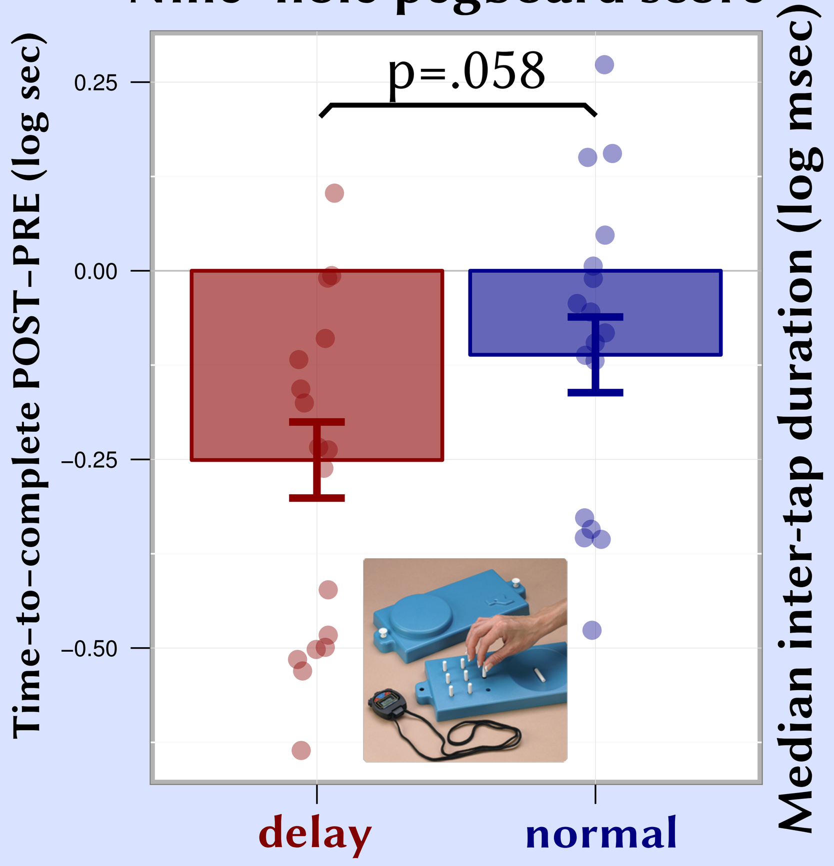
Patients in the **delay** group play slower than those in the **normal** group.

Mood

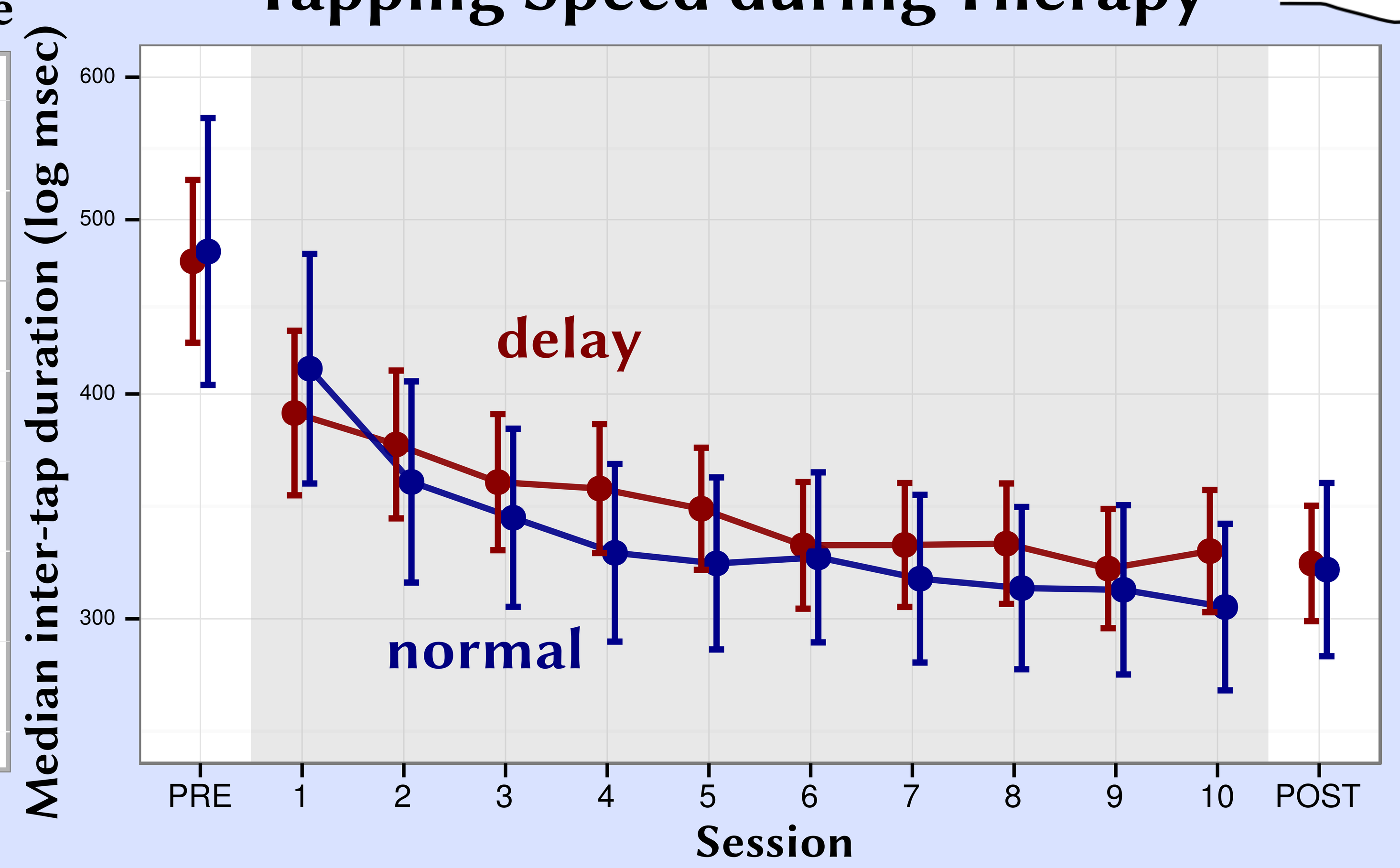


Patients show a reduction in **depression** and **fatigue**, but there were no differences between the groups.

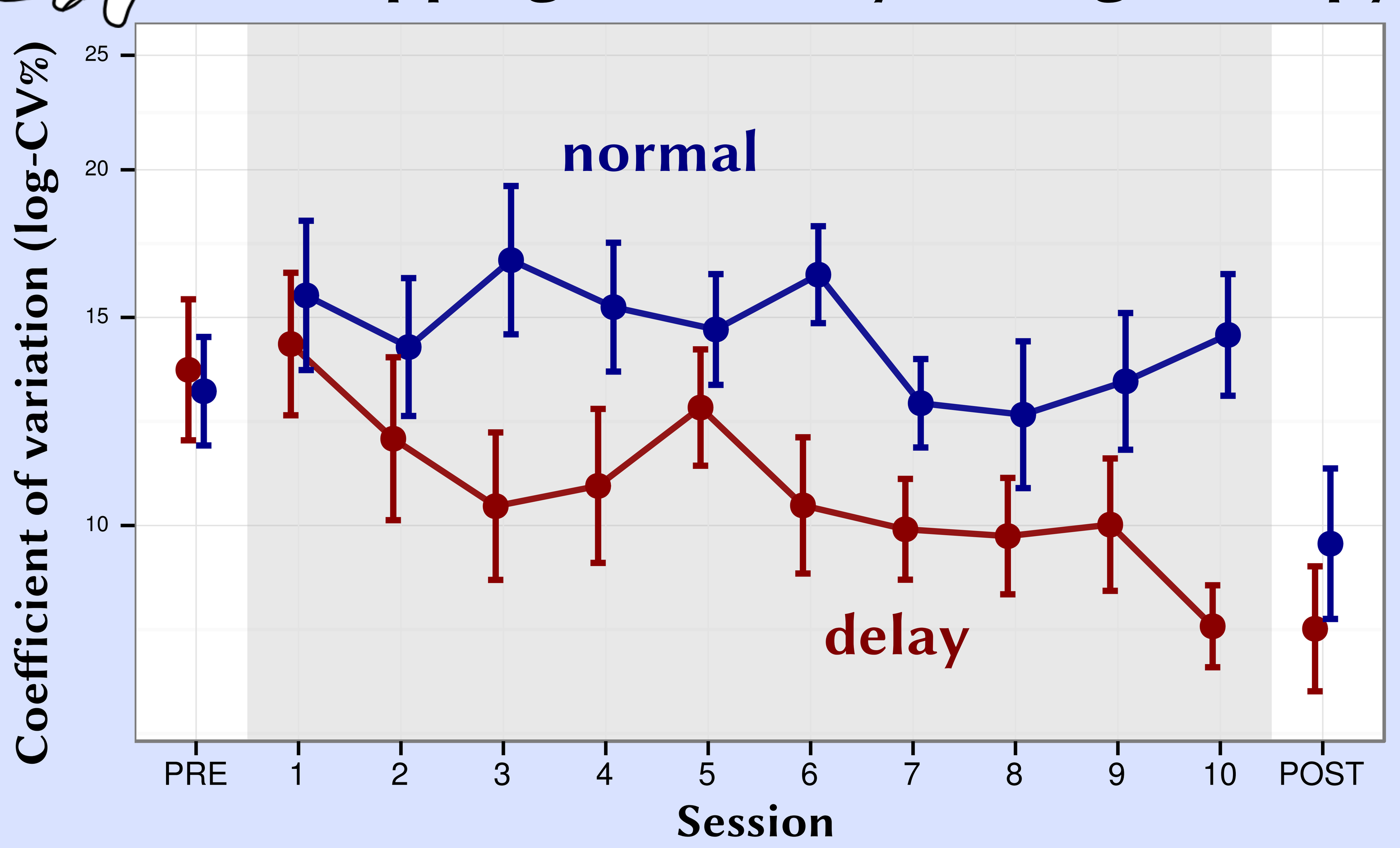
Clinical Tests



The **delay** group improves more in the NHPT (proxy for daily activities).



Both groups improve in finger tapping speed, and in particular in the first few sessions.



The **delay** group taps more regularly in the course of therapy. After therapy, both groups are equally regular.

Conclusion

We investigated fine motor rehabilitation after stroke using musical training. Both groups improved their fine motor control over the course of therapy. A delayed sound further improved motor rehabilitation in several clinical dimensions. We conclude that auditory feedback does play a role in in music-supported stroke therapy. Possibly, the irregularities in the delayed sound pushed patients to improve their movement more. Alternatively, the patient's sensorimotor system might have been incited to continually update its internal model due to a mismatch between predicted and perceived sound timing.

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