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Regularity and asynchrony when tapping to tactile, auditory and combined pulses

Joren Six, Laura Aarens, Hade Demoor, Thomas Kint, Marc Leman
IPEM, University Ghent

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Overview I

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Context

Figure: Tango lesson.

How to dance the tango without being able to follow the beat.

For:

- Early-deafened late-implanted adult cochlear implant users [2]
- People with beat deafness[3]

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Context

How to dance the tango without being able to follow the beat.

Emphasize beats using a non-sound modality.

- × Which feedback modality?
- × How to provide feedback events in sync with music?
- × When to provide this feedback?

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Feedback modality

Which feedback modality?

- $\times$ Visual feedback is distracting and obtrusive.
- $\times$ Perception of smell is slow.
- $\times$ Taste is unpractical.
- $\rightarrow$ **Tactile feedback** can be fast, wearable and inconspicuous.

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Feedback modality

- ✓ Which feedback modality?
- × How to provide feedback events in sync with music?
- × When to provide this feedback?

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Feedback synchronization

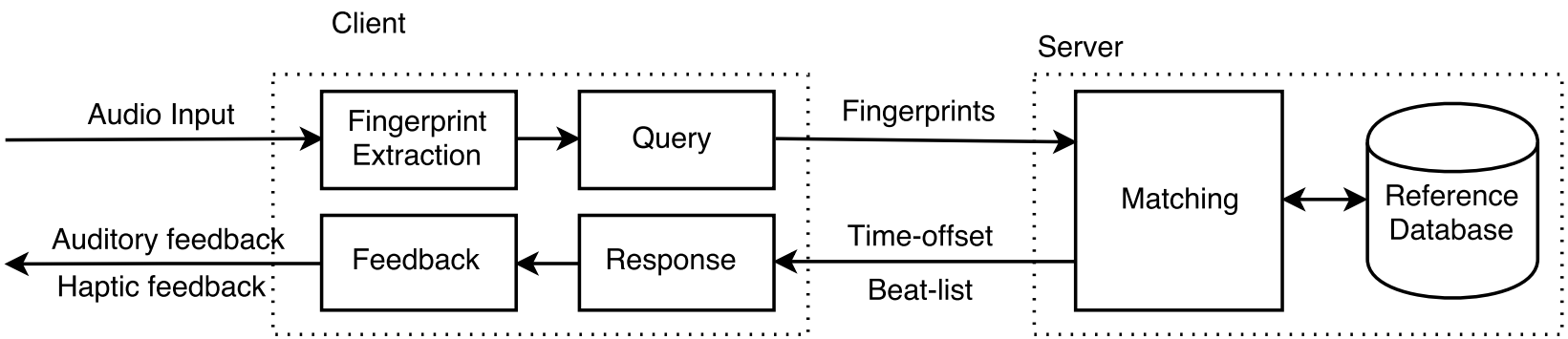

Figure: Schema of beat feedback technology.

Demo-movie, More details in [5]

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Feedback synchronization

- ✓ Which feedback modality?
- ✓ How to provide feedback events in sync with music?
- × **When to provide this feedback?**

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Problem - Multimodal processing

We want to provide:

- tactile feedback
- in *musical* tempi (90-150BPM)
- perceived at the same time as audible beats

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Problem - Multimodal processing

Only limited literature on multisensory integration available [4, 1]

When exactly to provide tactile feedback?

Specific experiment seemed required.

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Method - Tapping experiment

Subjects: 27 subjects, 3 CI users

Set-Up: A table with a drum in quiet room

Procedure: Tap along with stimulus at 90, 120 or 150BPM.

- **Auditory** stimulus
  - Continuous vs discrete
- **Tactile** stimulus
  - Rigid vs Micro-timing
- **Combined** auditory and tactile stimulus

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Method - Tapping experiment

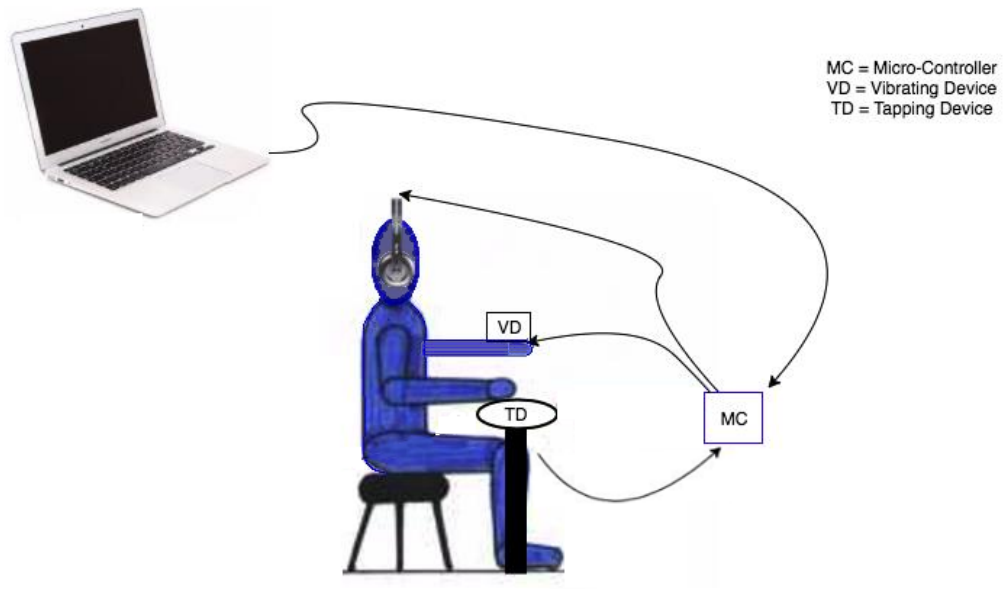

Figure: Measurement schema set-up.

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Method - Tapping experiment

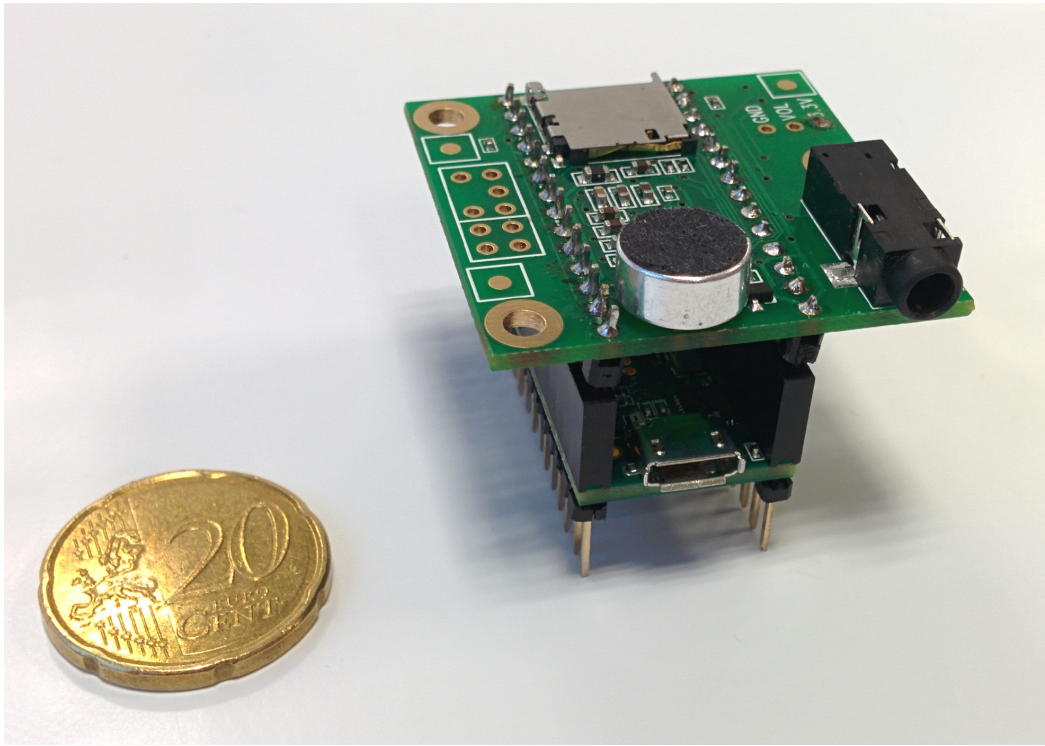

Figure: Micro-controller for precise measurement.

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Method - Tapping experiment

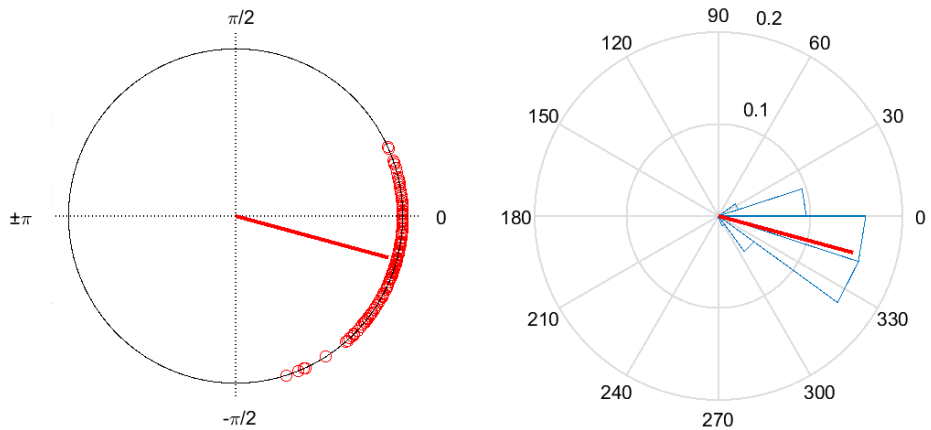

Figure: Experimental data includes regularity (vector size) and asynchrony (angle).

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Regularity

Definition

Regularity quantifies the differences in repeated inter event intervals.

Main effects were found for Tempo, Sound and Stimulus No significant effect between auditory vs auditory + tactile, suggestive

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Asynchrony

Definition

Asynchrony quantifies the time differences between actual and expected events.

Main effects were found for Tempo and Stimulus

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Asynchrony

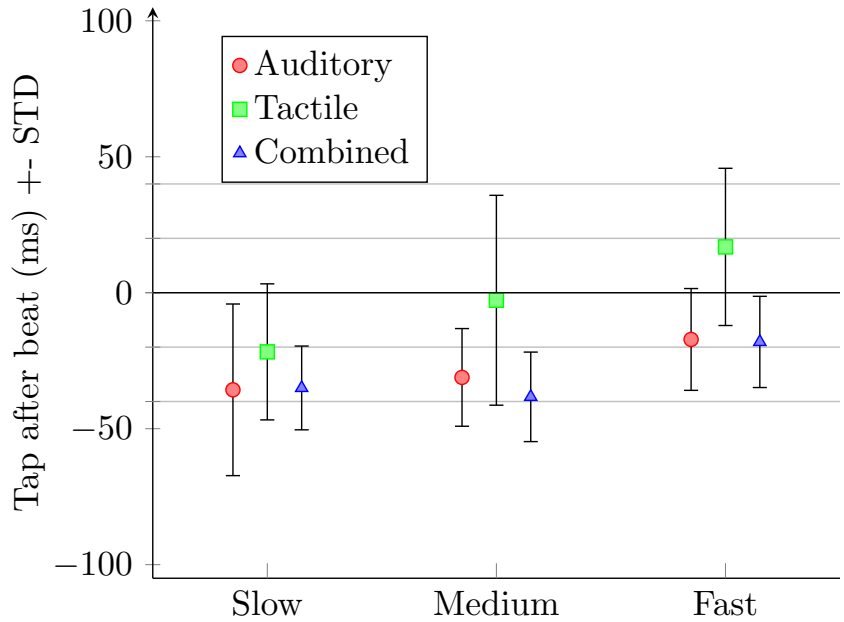

Figure: Asynchrony for tactile pulses seems tempo dependent - from anticipatory to reactionary behavior.

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Discussion

Suggests an assistive technology should modify tactile feedback dependent on tempo.

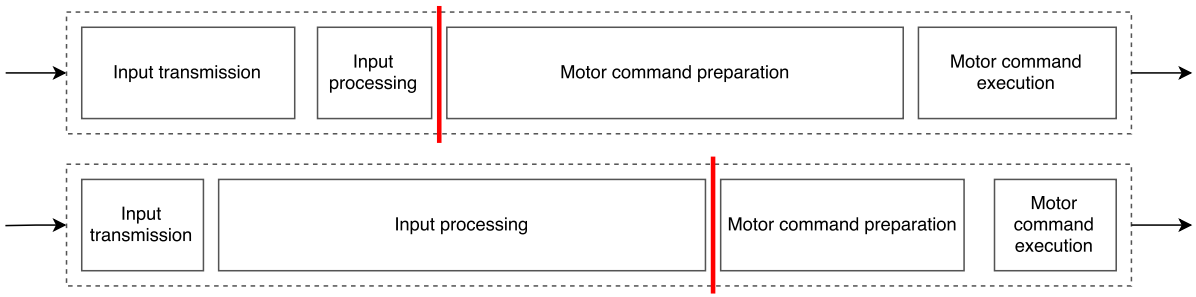

Figure: Simplified model of total system delay, the contribution of each sub-system is unknown. The red line shows the ideal sync point.

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Discussion

Are late implanted CI-users able to dance?

- Motion capture study?
- Insights into multisensory integration processes.

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Inconclusive tapping performance

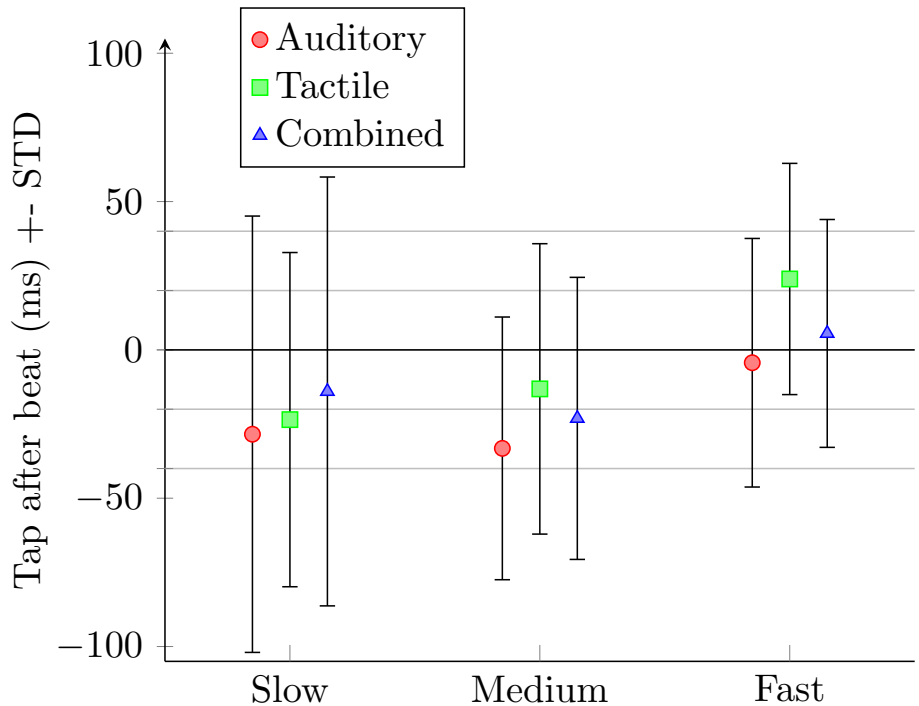

Figure: Inconclusive tapping performance by three CI users.