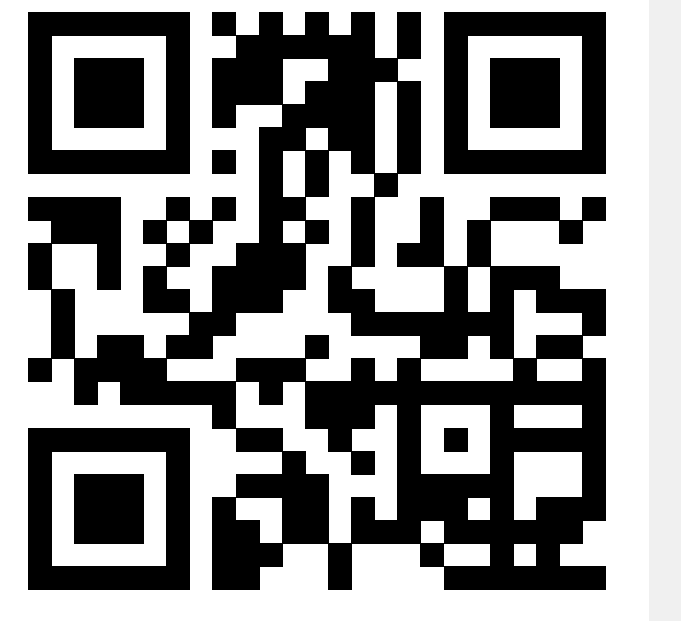




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# A continuous model of pulse clarity

## Towards inspecting affect through expectations in time



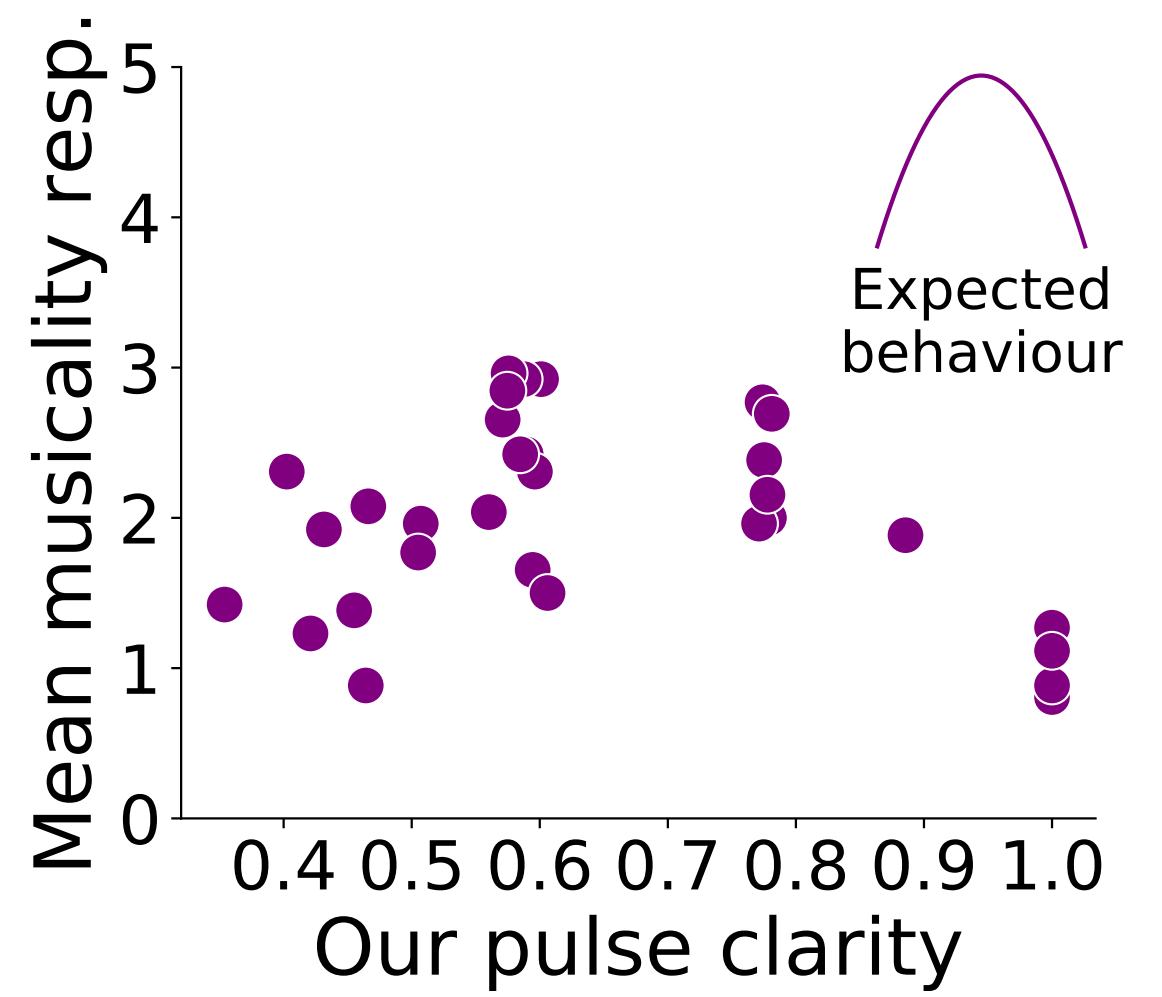
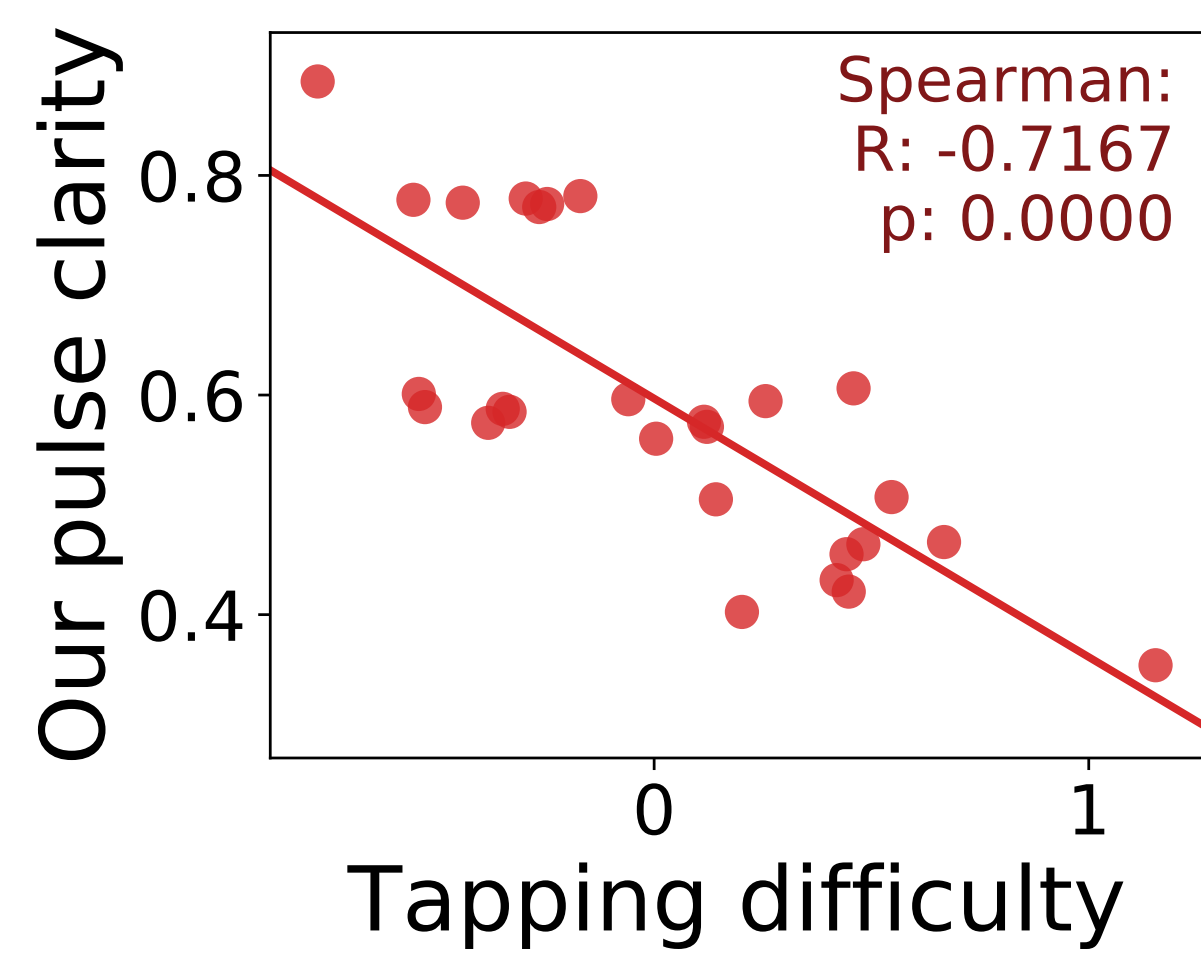
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TL; DR

A model of **pulse clarity** that develops in time globally correlates with **tapping difficulty** and presents an **inverted U-shaped** relationship with **musicality**



Grand goal: reach a computational model to analyze affect in music.

### Previously...

- Theories on how music generates **affect** propose they emerge from **unrealized expectations** [Meyer, 1956, Huron, 2006, Vuust and Witek, 2014].
- In rhythms, the beat (or tactus) is the first expectation [Povel and Essens, 1985].
- Pulse clarity** and **rhythmic complexity** are measures previously related to musical affect [Witek et al., 2014, Trost et al., 2015].
- Musical expectations develop in time. Most rhythmic complexity models provide only an overall metric.

### What's New

#### Current goal:

Develop a model of **pulse clarity** that evolves in time.

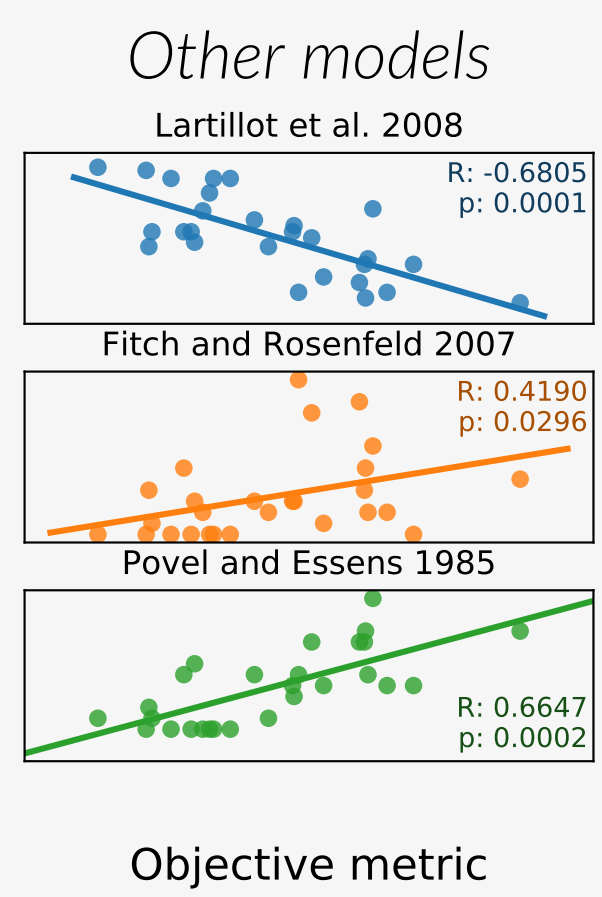
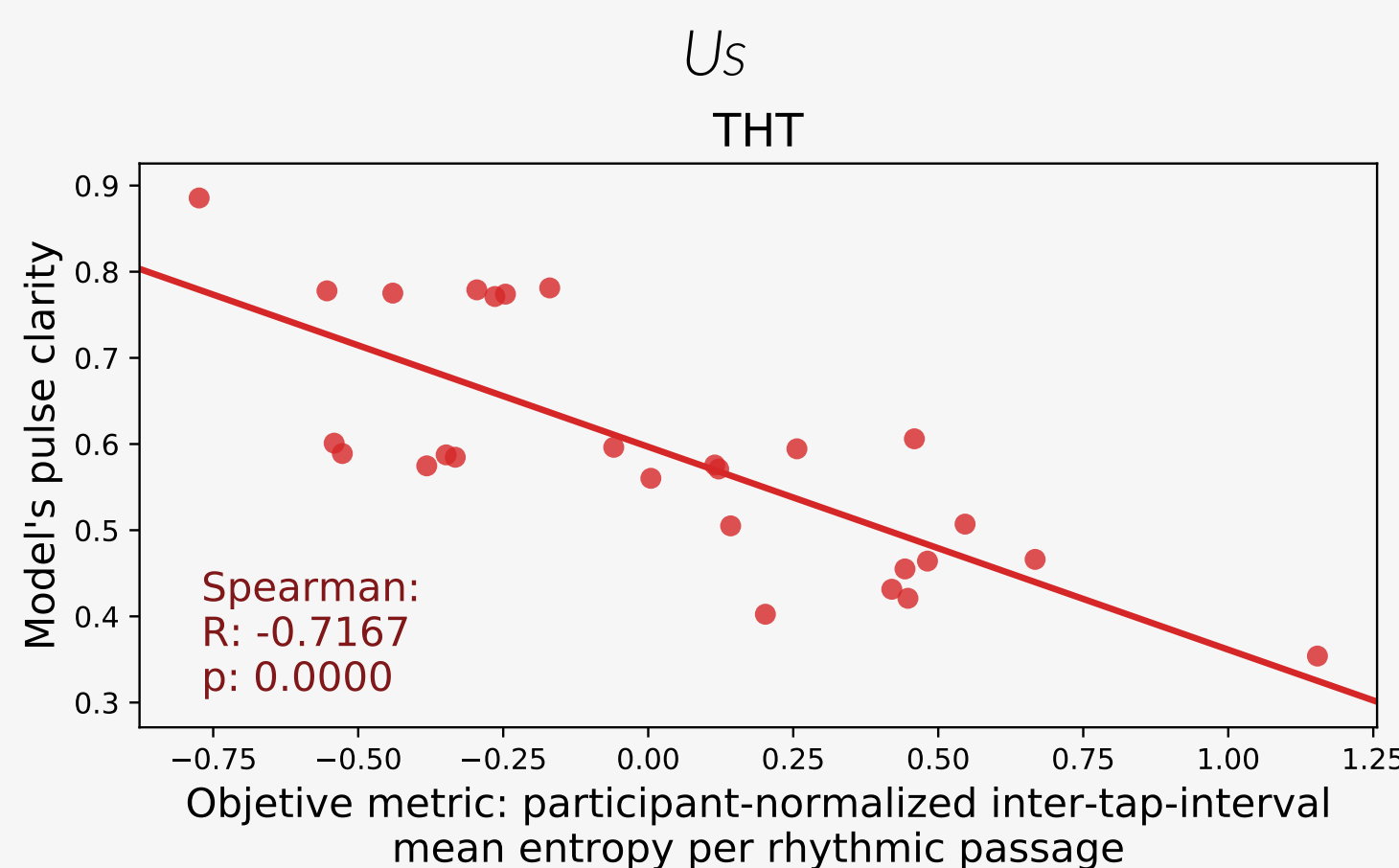
- We introduce an agent-based **beat tracking** model for rhythms named **THT**.
- THT works **casually** and provides a continuous metric of **certainty** of the inferred beat.
- The metric should be a proxy for **pulse clarity**.

### Did it work?

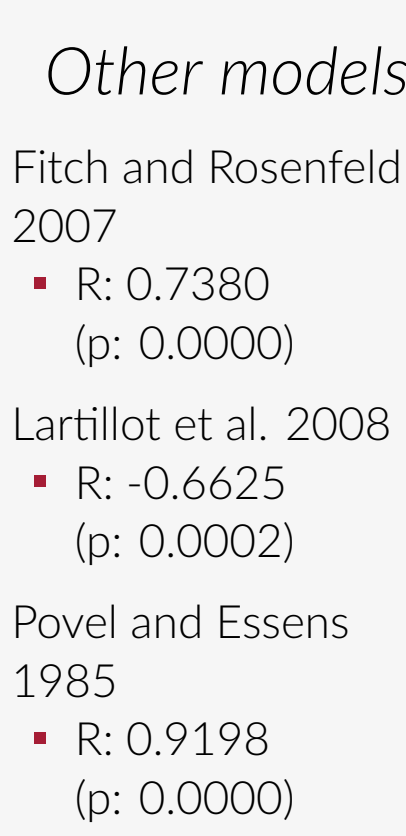
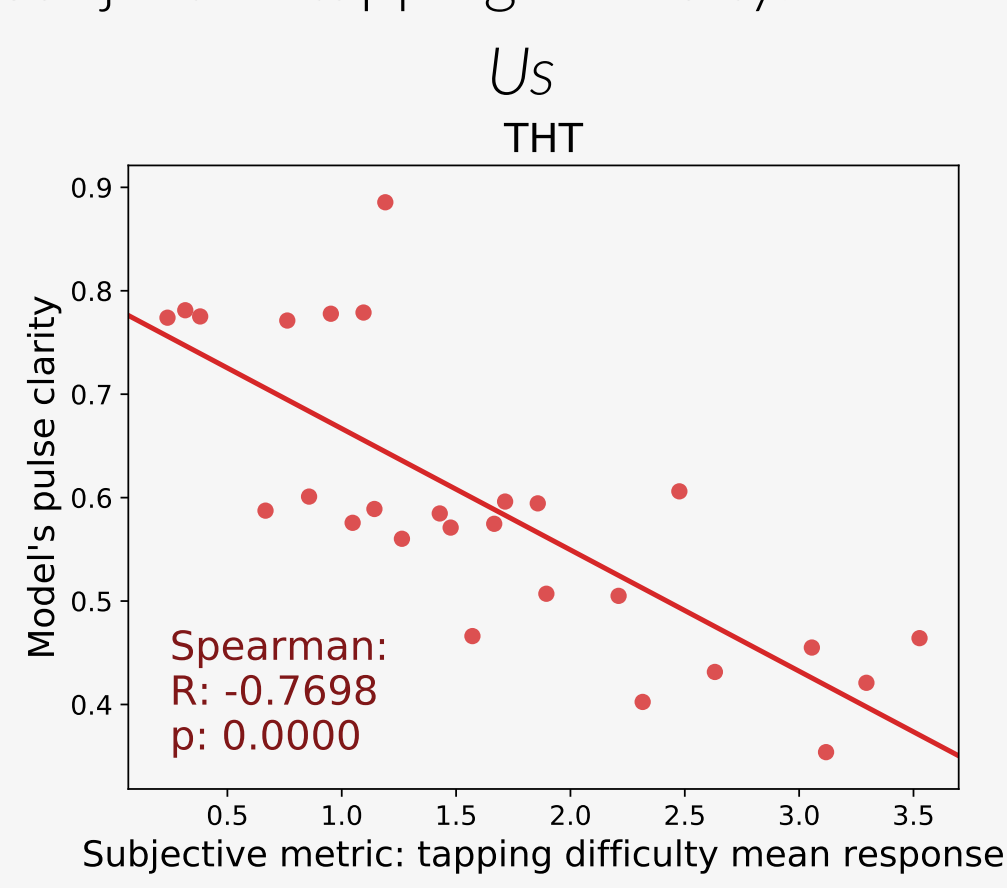
- We tested overall **beat clarity** to compare with previous work.
- We performed an **experiment** where participants tapped to their subjective beat while listening to rhythmic passages.
- We measured **tapping difficulty** with a question (**subjective** metric) and by analyzing tapping synchrony (**objective** metric).
- Our **pulse clarity** metric correlated significantly with experimental results. It also presented an **inverted U-shaped** relationship with **musicality** and **need-to-move** questions asked to participants.

3' Speech

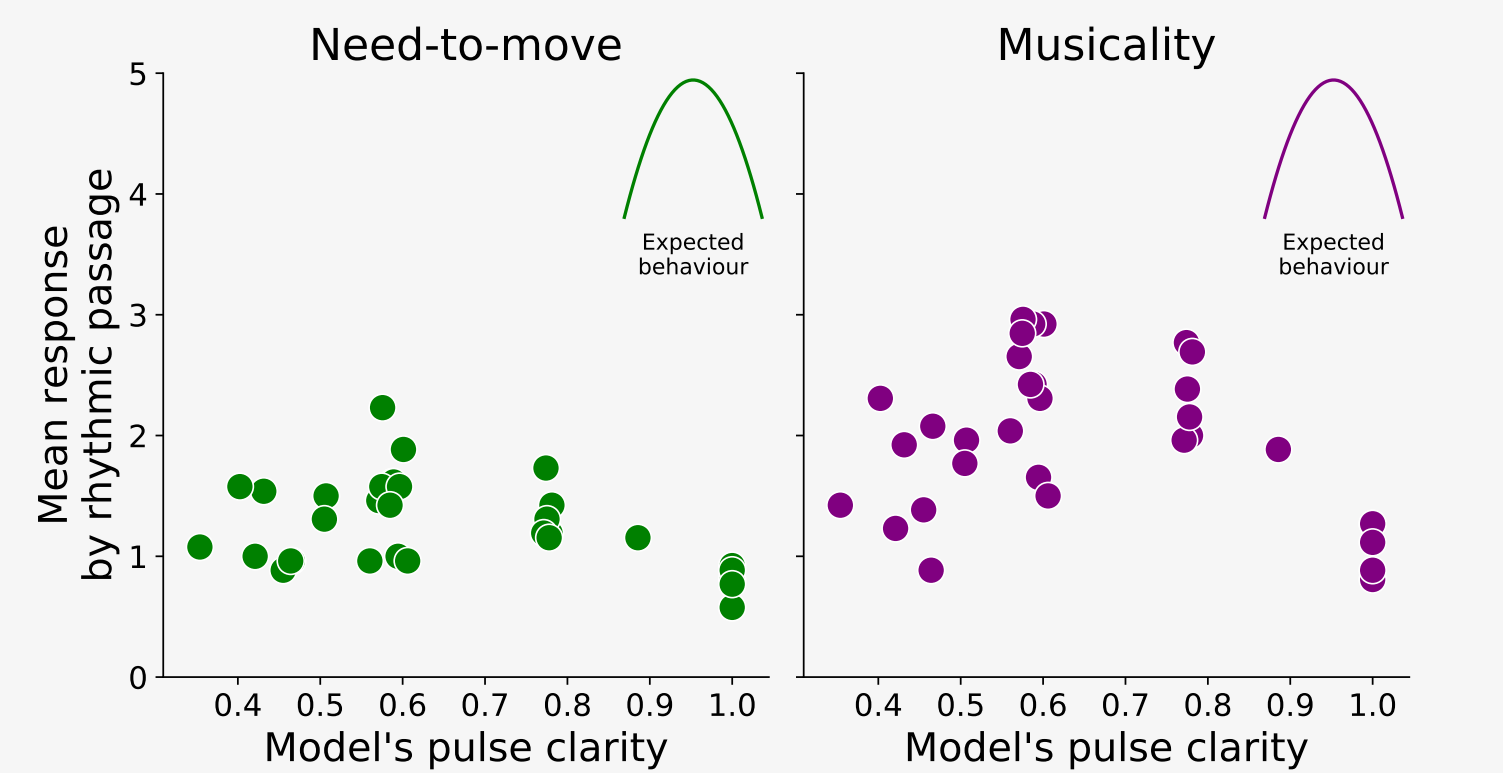
THT's pulse clarity correlates significantly with objective tapping difficulty.



THT's pulse clarity correlates significantly with subjective tapping difficulty.



THT's pulse clarity presents an inverted U-shaped relationship with musicality and need-to-move responses.

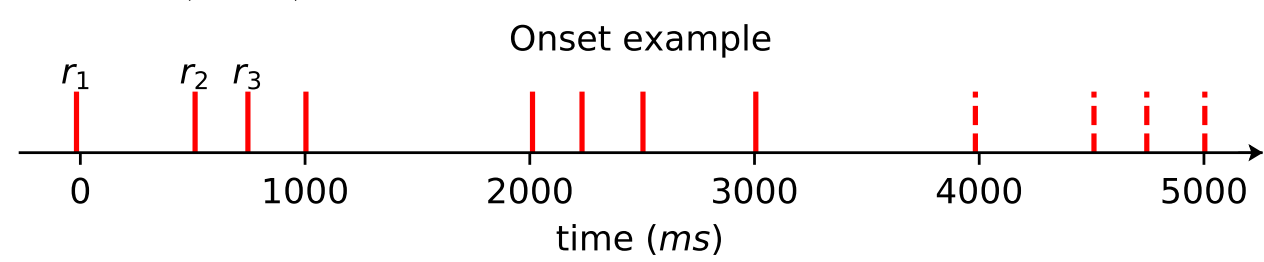


Results

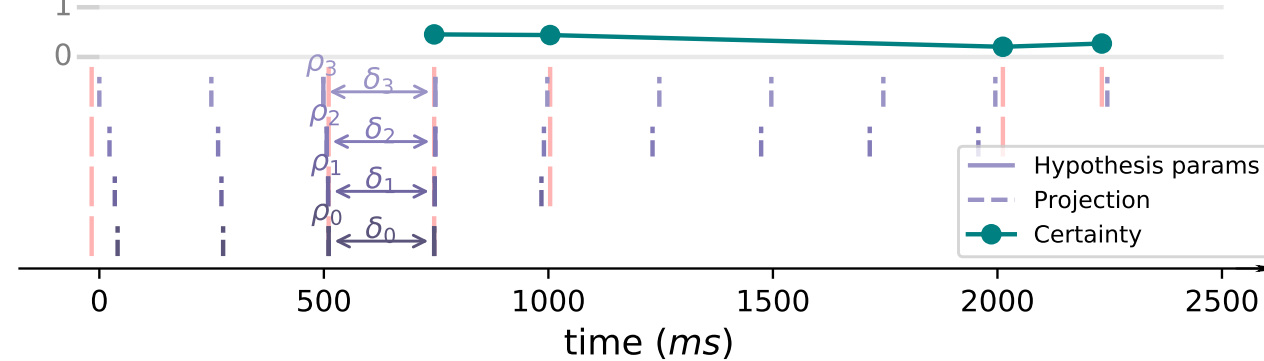
### The Model

THT is an agent-based model. Each agent keeps tabs on a tactus hypothesis and hence are named **hypothesis trackers**. A possible tactus is represented by a phase ( $\phi$ ) and a period ( $\delta$ ). Trackers are created and updated while listening to the rhythm. Hypotheses have a **certainty score** in  $[0, 1]$ . Hypotheses parameters and score evolve overtime.

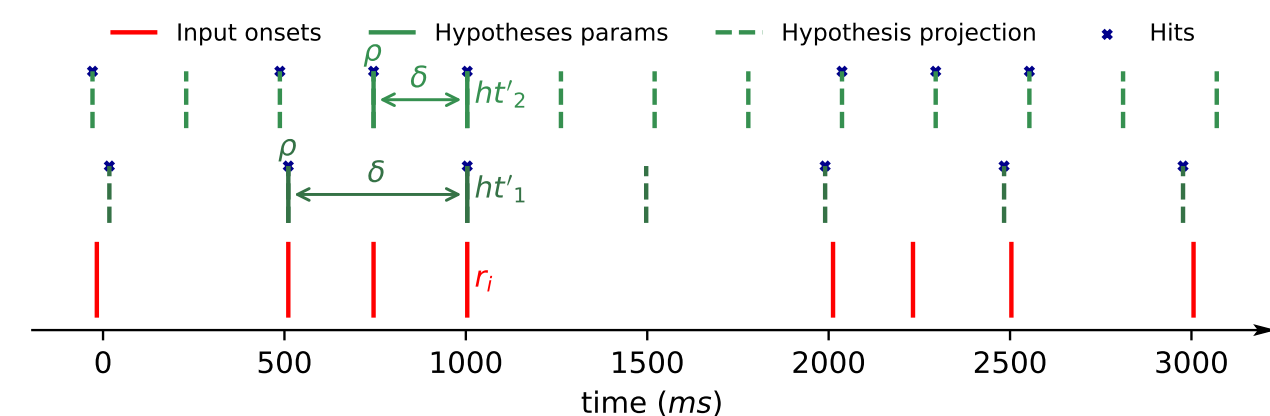
Input: ( $r_{1..N}$ ) a sequence of onset times in ms



Output: a set of **hypothesis trackers** with their history



Hypotheses:



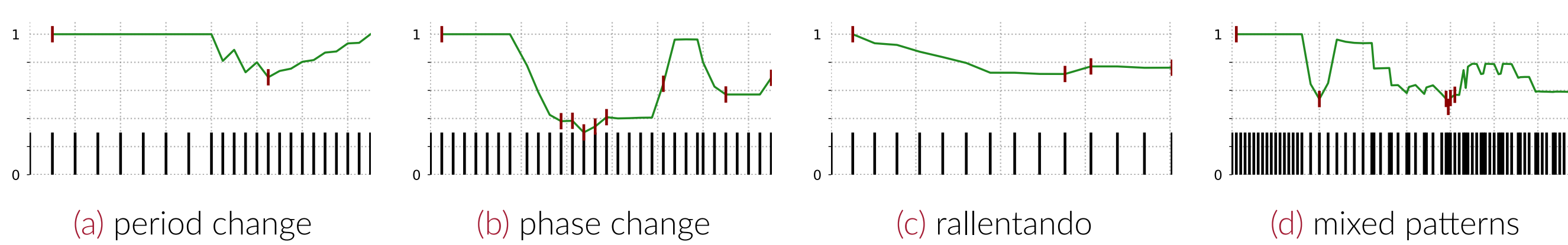
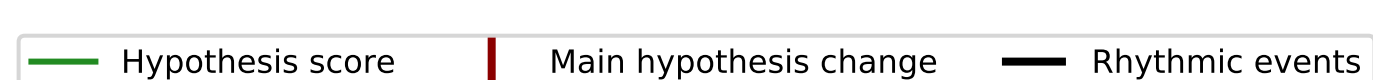
Certainty score:

$$\text{Certainty score} = \frac{\text{hits by hypothesis}}{\text{hypothesis events}} \times \frac{\text{hits by hypothesis}}{\text{rhythm events}}$$

Hits between a hypothesis projection and a rhythmic event score 1 and decay exponentially with the distance.

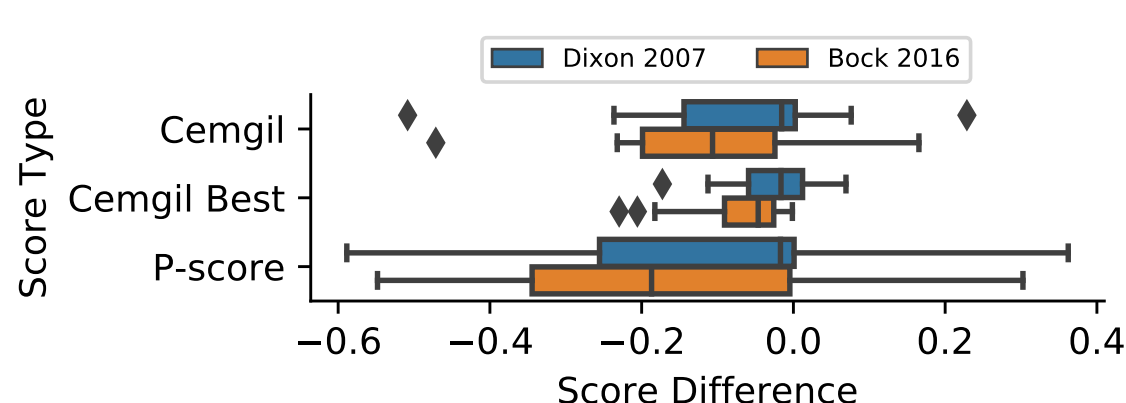
#### Model's behaviour

Main hypothesis score decays when the rhythmic scene changes and then the main hypothesis is adapted.



Global **pulse clarity** was calculated as the mean score of the main hypothesis over time.

THT beat tracking capabilities were compared with two recognized models on the MIREX training dataset.

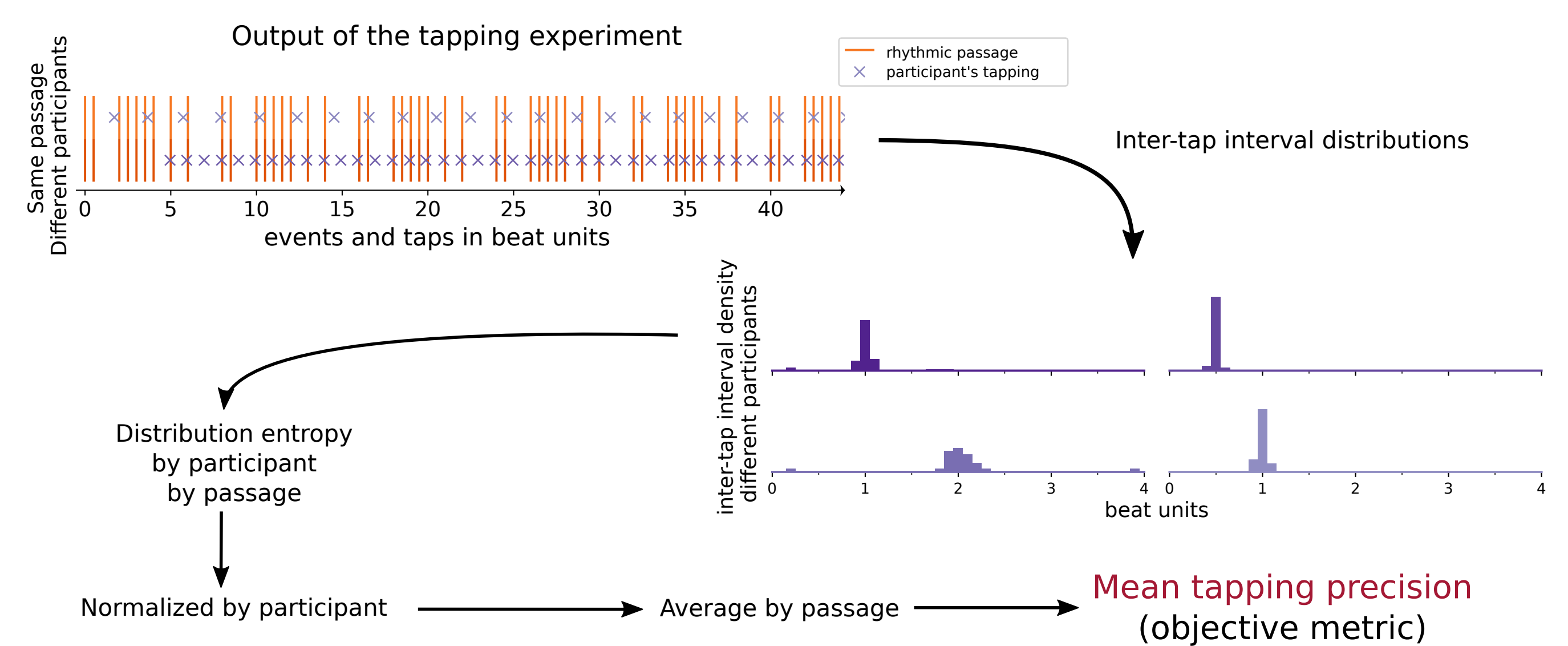


- Score medians are close by behind.
- The compared models are not causal (look into the future).
- One of the main differences is the beat level chosen by THT.

### The Experiment

Task: tap the beat freely while listening to rhythmic examples of varied difficulty.

- 28 participants (8 women)
- Mean years of musical training: 4.43 (3.81 sd)
- Mean age: 28.5 (8.15 sd)
- 33 rhythmic passages



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The Details

