Modeling Perception of Rhythmic Complexity: Computational and Neural Measures

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Background

- Better understanding of how humans process and track beat and rhythm has the potential to inform evaluation of rhythmic complexity and guide extraction of relevant audio features.
- Recent EEG analysis approaches such as *Inter-Subject Correlation* (ISC) have made ecologically valid listening settings more feasible.
- ISC is thought to index a state of engagement. [2]
- We study the relationships between computational representations of real-world audio and neural correlates of cognition.

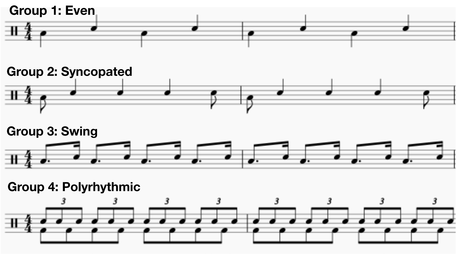
Experimental Overview

Stimuli
- 12 'Bollywood' song excerpts, 4 synthesized 'Plain' Rhythms, 4 categories: Even, Syncopated, Polyrhythmic, Swing.
- Sung in Hindi and Hindi dialects.
- All stimuli around 30 sec in length.

Participants
- *N = 5,* various musical backgrounds; no Hindi-language experience.

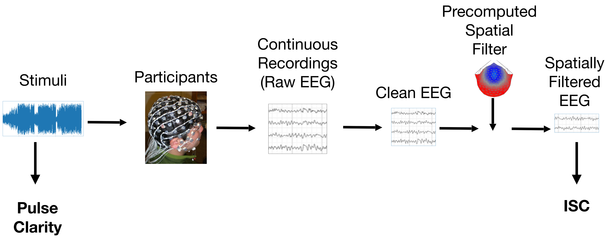
NMED-RP Dataset available from the Stanford Digital Repository [5]

Data collection
- Participants listened attentively to repeated presentations of stimuli.
- 27-28 trials were for each stimulus across participants.
- 128-channel EEG recorded using EGI platform.
- Data acquired at sampling rate of 1 kHz with vertex reference.



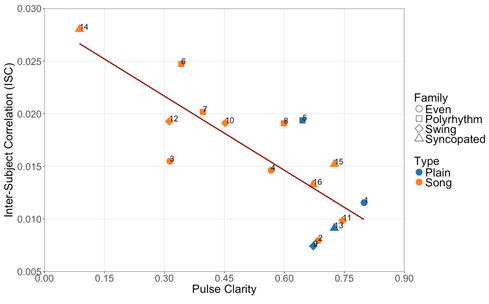
Baseline Rhythm Profile for Each Rhythm Family

Audio and EEG Analysis



1. For each stimulus, the Pulse Clarity was computed using the MIR toolbox for MATLAB.
2. Continuous recordings (Raw EEG) were epoch into trials and cleaned
3. Data were then aggregated across all trials (Clean EEG). A precomputed spatial filter was applied to the Clean EEG [5], reducing each data trial to a component-by-time matrix (spatially filtered EEG).
4. ISC was computed on a one-against-all basis using activations from the maximally reliable component.

Results



Scatterplot of Pulse Clarity versus Inter-Subject Correlation (ISC)

- In addition to being statistically significant ($r = -0.8$, $p < 0.001$), the correlation between Pulse Clarity and ISC is also negative.
- This means that stimuli with lower pulse clarity evoked higher ISC in the EEG responses.
- Three of the four 'plain' stimuli, denoting rhythm exemplars not embedded in natural music, are among the stimuli with the highest pulse clarity and lowest ISC.

Discussion

- In interpreting this inverse relationship between pulse clarity and ISC, we surmise that higher ISC might be driven by heightened attention when listening to stimuli with more complex beat structures.
- Previously reported behavioral results from this dataset indicated that enjoyment and perceived complexity were low—while ease of finding the beat was high—for the 'plain' stimuli relative to the real-world excerpts.
- Thus, a significant relationship may also exist between subjective reports and ISC/pulse clarity measures.
- Future work will also involve additional neural correlation metrics that have proven insightful in recent EEG studies of natural music listening, such as the extent to which EEG tracks time-varying stimulus features. [3, 7]

References

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