A STATIS approach to linking brain and behaviour during naturalistic music listening (1322)

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Highlights

- STATIS can be used to quantify individual differences in multidimensional data
- EEG data were more similar than mouse tracker ratings
- Projecting multidimensional data onto a common plane allows us to identify patterns within and between modalities

Summary

Music is a complex, engaging stimulus that stimulates networks involved with auditory processing and subjective response. Acoustic features extracted from the music can provide detail on auditory response, but how can we examine the subjective aspect of music listening in the brain?

STATIS analysis (Structuration des Tableaux à Trois Indices de la Statistique/Structuring Three-way Statistical Tables) provides the means of quantifying individual differences in subjective ratings tasks.

In this study, we applied STATIS to continuous EEG and mouse tracker data during a music listening task. We found a higher degree of similarity in participants' EEG data compared to their mouse tracker data.

Background: Music is an engaging stimulus that can generate a wide array of subjective experiences. It combines bottom-up sensory processing with top-down cognitive conceptualization, but linking how highly individualistic brain and behavioural states are created from a common stimulus, and how those states are linked, is less than straightforward. In the present study, participants listened to a heterogeneous selection of excerpts from Western art music and provided continuous ratings on induced emotional states while EEG activity was recorded. We used STATIS ('Structuration des Tableaux a Trois Indices de la Statistique', see Abdi et al., 2007) to describe patterns of within- and between-participant similarity for both EEG and emotional ratings data.

Methods: We collected EEG data from 14 healthy adults listening to musical excerpts (n = 40). Excerpts were between 40 and 120 seconds in length, and consisted of Western art music from the Renaissance to contemporary periods with varying orchestration, including vocal works. We pre-processed the EEG data in Brainstorm (Tadel et al., 2011) and completed the STATIS analysis in Matlab (Mathworks, 2016b).

Results: Participants showed a high degree of similarity in the EEG time series, but were more variable in their mouse tracker ratings. A compromise matrix was calculated weighting the EEG and rating data from each musical piece by their similarity, returning centroids corresponding to the weighted grand mean of each song for both EEG and ratings data. We then calculated a projection matrix and applied it to each participant's time-series data to calculate their distance from the music centroid on the same plane using Euclidean distance. Higher similarity was again seen in the EEG data.

Conclusions: STATIS is a novel analysis that enables comparison between multidimensional datasets. Perceptual and behavioural responses to music are subjective, and the ability to project these multidimensional data onto a common plane allows for the identification of patterns within and between these modalities. STATIS provides a sound methodological link between brain and behaviour that is essential to studying naturalistic activity.

References:

Abdi, H., Valentin, D., Chollet, S., & Chrea, C. (2007). Analyzing assessors and products in sorting tasks: DISTATIS, theory and applications. *Food quality and preference*, *18*(4), 627-640.

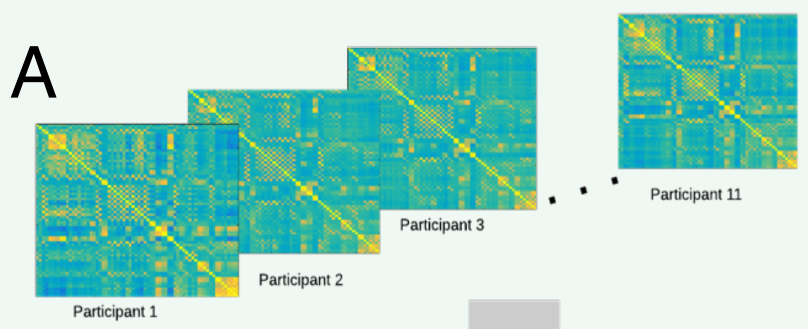
Tadel, F., Baillet, S., Mosher, J.C., Pantazis, D., Leahy. R.M. (2011). Brainstorm: A User-Friendly Application for MEG/EEG Analysis. *Computational Intelligence and Neuroscience.*

What is STATIS?

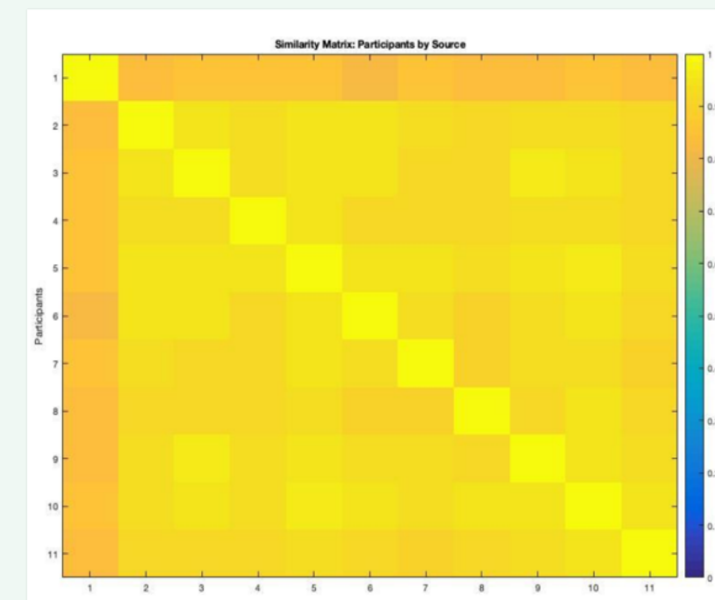
STATIS is a method that quantifies individual differences between adjacency matrices. Each adjacency matrix **A** (defined by the between-timeseries cosine similarity) is decomposed, returning a between-participant similarity matrix (**B**) that describes how similar a participant's input matrix is to each other participant. A consensus matrix of centroids (**C**) is then constructed and describes the *weighted grand mean* of each input variable. Each participant's distance from this grand mean point can be calculated, enabling the description of each participant's deviation from the group consensus using Euclidean distance (**D**).

EEG Data:

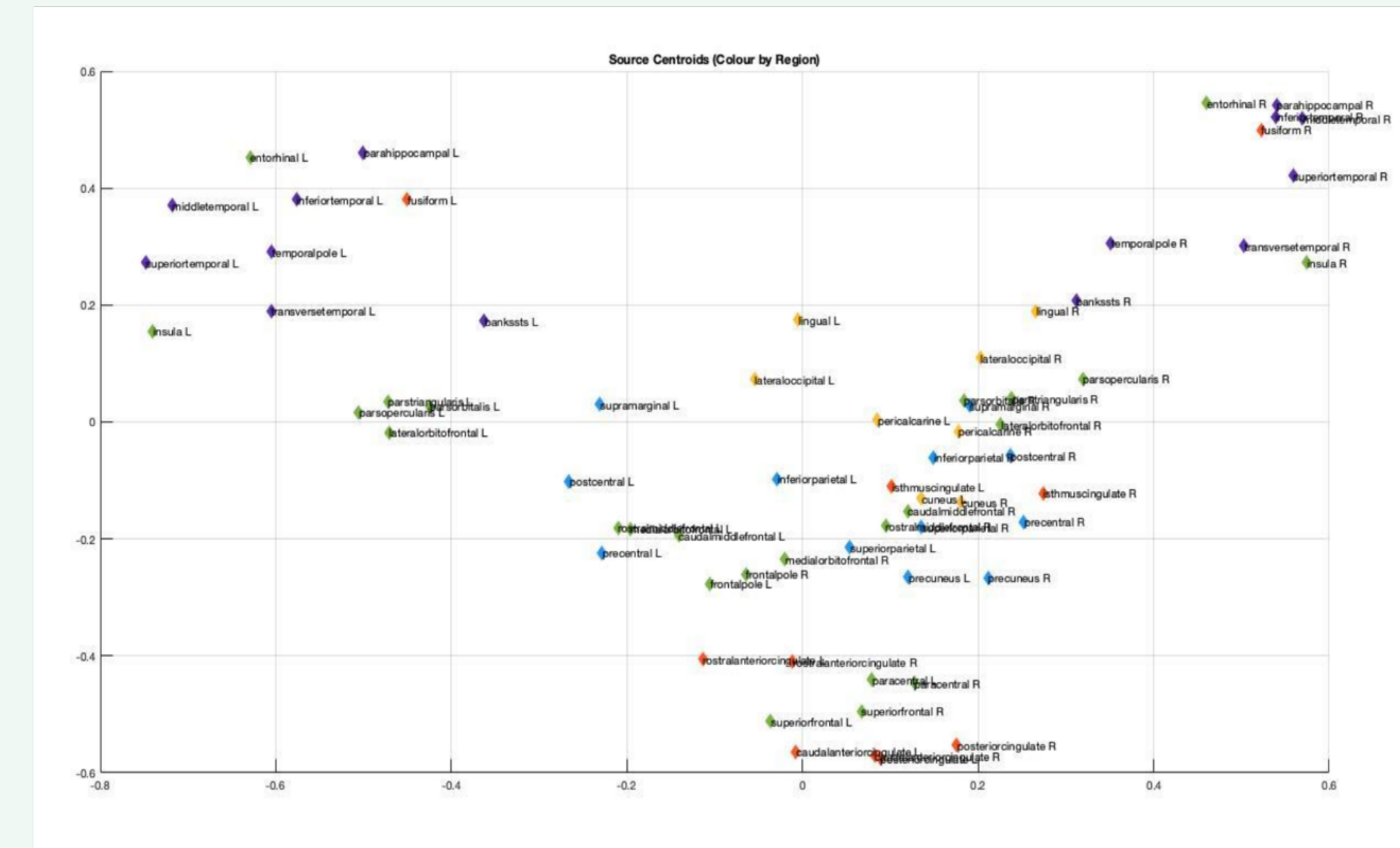
A



B

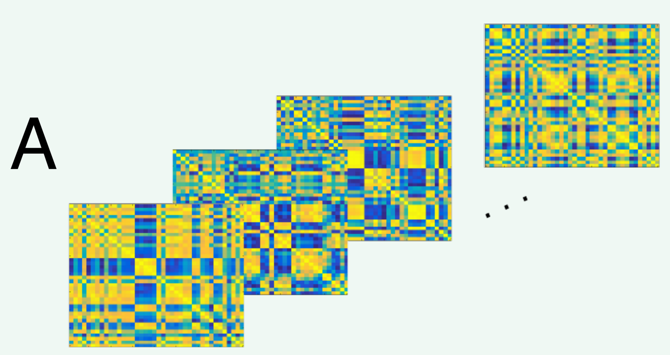


C

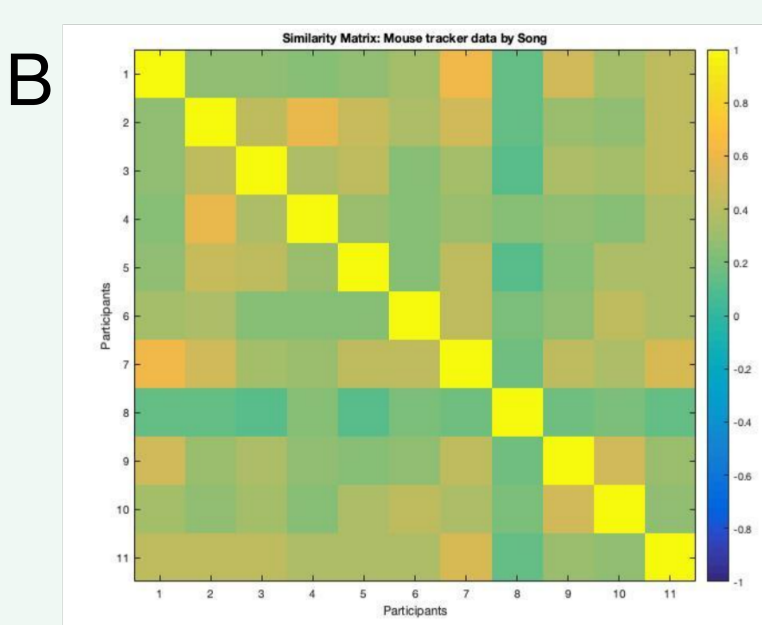


Mouse Tracker Data:

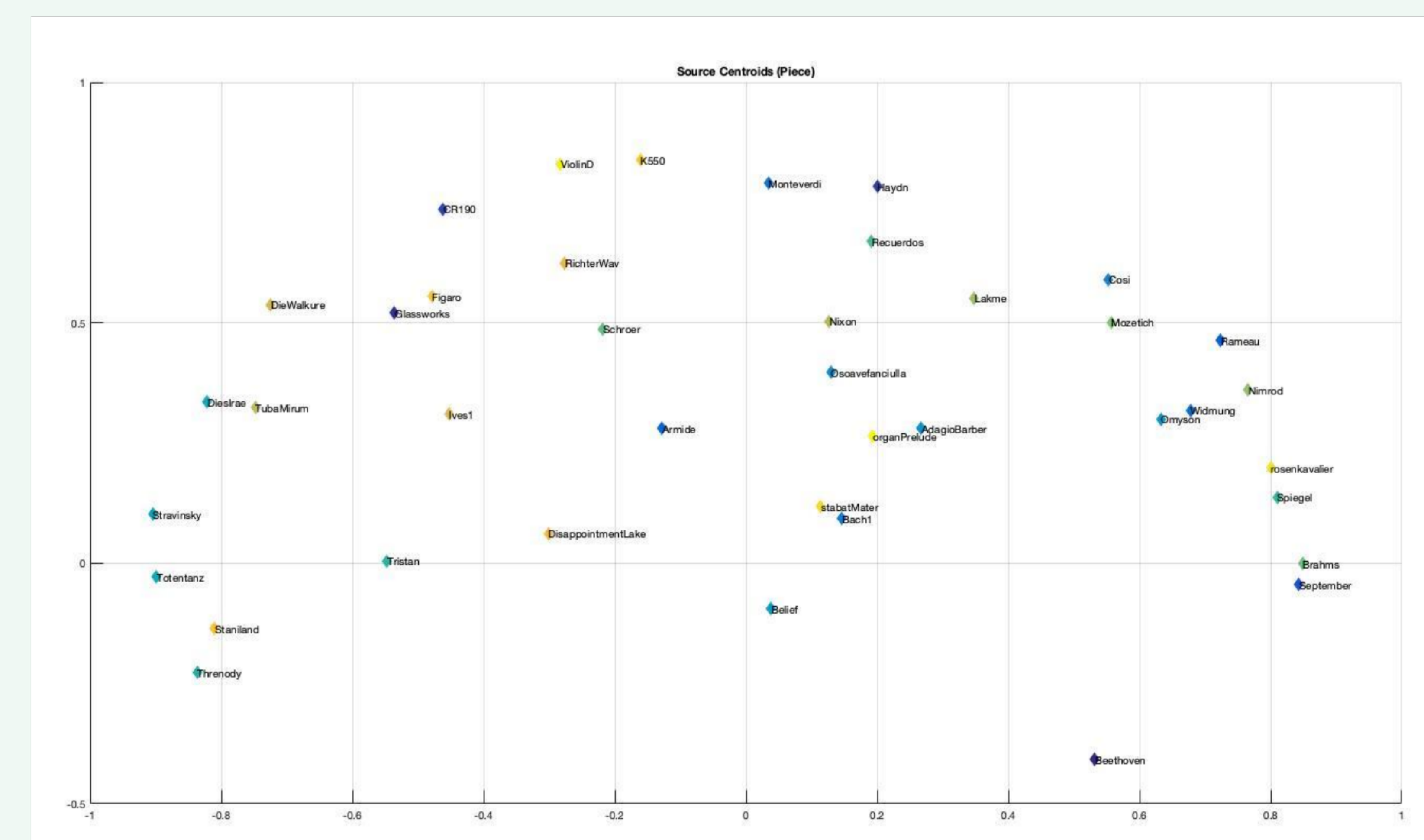
A



B



C



D