

# Many Ways of Hearing: Clustering Continuous Responses to Music

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## ABSTRACT

### Background

Is there more than one-way to experience or perceive a piece of music? Anecdotal evidence suggests that many are possible and cognitive theories hypothesise variety [Juslin and Västfjäll, 2008], and yet analyses of music rarely attempt to describe multiple cognitive or affective sequences of experience. Continuous responses collected from different listeners to the same music often show great variability in their temporal sequence, whether ratings of emotional arousal or measures of skin conductance. Either these differences are the result of random noise interfering with the common experience (as assumed implicitly in any analysis of the average response time series), or they reflect distinct interpretations of the stimulating music and corresponding experiences. It is reasonable to expect that the variance in continuous responses is a mixture of incidental noise and legitimate, repeatable differences of response, though separating one from the other is not simple.

Analyses of continuous response to music have often tried to find differences between listener groups, comparing musicians to non-musicians [Lychner, 2008] and those who have studied a piece to others for whom it is unfamiliar [Davis, 2003]. The results of these experiments have often shown the distinction to be a matter of degree rather than type; musicians, for example, have been found to be more conservative in their ratings [Fredrickson, 1995]. There has also been some discussion of differences in continuous ratings as a result of different participants' interpretation of the task and styles of expression [McAdams et al., 2004]. This has been a hurdle for analysis because the extraction of experience from the reporting mechanism requires assumptions to be made about the listeners' "true" subjective experiences. Physiological measures of response are similarly fraught with individual participant differences, though methods for handling these have been explored in related fields.

Fortunately, there are numerical tools for identifying patterns in sets of complicated data such as our collections of continuous responses. By carefully applying cluster analysis to these empirical traces of responses to music in time, it is possible to investigate whether there are indeed distinct and robust responses to the same music hidden in the data.

### Aims

The aim of this study is to evaluate whether continuous responses show evidence of distinct but repeatable temporal patterns of perception or experience to the same musical stimuli. In such cases as different patterns arise, there is the subsequent aim of evaluating the degree of difference and inform future discussion on the quantification of similarity

and difference between individual continuous responses to music.

### Method

Using collections of continuous behavioural responses from multiple experiments (with an average of 30 responses per collection) and several artificially constructed collections of unrelated responses, this study applies hierarchical cluster analysis to separate listeners' responses to the same stimuli. Each clustering is then used to select individual responses to represent subgroups of the collections. The differences between these responses and their relatedness to their respective groups are then assessed using several metrics to evaluate whether and when the real experimental collections show more cohesive and yet distinct subsets than the collections of unrelated responses. This poster will depict the most effective and interesting responses representations, from the initial data under various degrees of smoothing, downsampling and normalisation to representation of contour, large and small scale, in combination with the most appropriate distance metrics for comparing these responses under reduction.

### Results

Preliminary results show that there are two important types of differences between responses: differences of experience, when listeners report actively different experience by diverging at specific moments in time, and differences of degree, when listeners reports differ in scale and sensitivity as some show frequent dramatic changes while others are more conservative in their expression. Filtering and contour sensitive reductions expose more of the former, while measures which preserve rating range information make the latter more visible. Though there is likely some overlap between these two categories when comparing responses, they represent different problems for the investigation of the experience of music.

Some of the experimental response collections did group quite tightly around the average, their cohesiveness made clear in comparison to the unrelated response collections. Other collections, particularly ratings of valence, showed subgroups with distinct interpretations of the music and their experience.

### Conclusions

These results suggest that researchers should look more closely at their data before working on the average. Some of the data analysed has previously been studied in relation to the stimulus [Korhonen et al., 2005] [Coutinho and Cangelosi, 2009] Disagreement between responses for excerpts like that of Rodrigo's *Concierto de Aranjuez* result in the average valence response appearing to be flat, and this has complicated the effort to model continuous responses with features of the stimulus.

This first attempt at identifying robust differences in continuous responses presents evidence that such differences exist, however more work is needed to establish reliable protocols for evaluating new experimental collections. Analyses of more collections containing larger numbers of responses would be very helpful for further study.

### **Keywords**

Continuous response data, Individual responses, Data analysis.

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