When We Are Moved

Events in Music: Audience Activity Analysis through Continuous Ratings of Experience

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The Challenges of Continuous Response Data

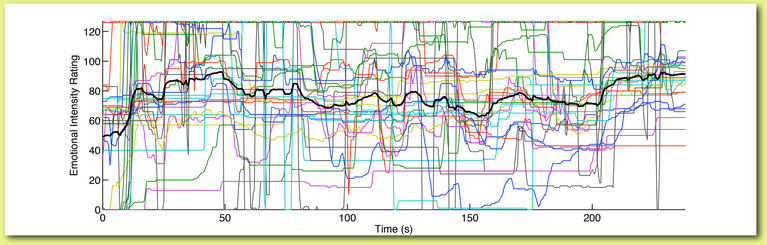


Fig 1: Thirty audience members' ratings, in colour, of Experienced Emotional Intensity during a live performance of Mozart's Overture to Le nozze di Figaro *and the average rating for this population in black.*

Listener ratings collected continuously in response to music are notoriously diverse (Figure 1). The standard approach for summarizing this data is taking the average rating as a function of time (Luck, 2007) (Levitin, 2007) (McAdams, 2004) (Schubert, 2004, 2001) (Krumhansl, 1996, 1998) (Madsen, 1993) (Nielsen, 1983).

- Reported average intersubject correlations range 0.16 (Krumhansl, 1996) to 0.59 (Luck et al. 2007): not significant because of serial correlation in time series data (Schubert, 2002)
- Standard deviation between ratings in time often cover 25% of total rating range. (Figure 8) (Madsen, 1993)

If the intersubject variance makes changes in the average insignificant is there any more information to be found in the data?

Individual vs Group behaviour

Different listening experiences are possible: why throw that information away?
Rather than statistically model the unrealistic "average" listener, describe the populations behaviour over time, the Audience's behaviour.

Audience Activity Analysis

- Rating scales are subjective: consider only **when** subjects change ratings and **in what direction** (increasing or decreasing).
- There is a variable reaction lag between events and subject responses: consider behaviour over time windows of 3 seconds (Schubert, 2004).

If we count how many subjects increase or decrease ratings in all 3 second windows (sliding), there is quantifiable change from one moment to the next.

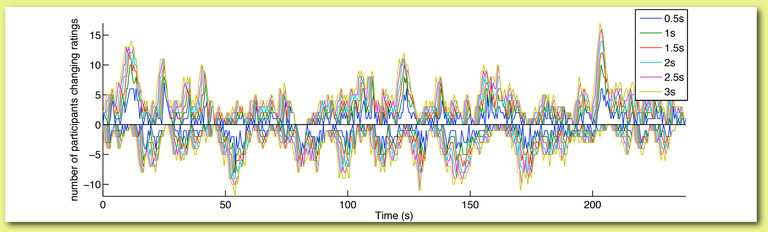


Fig 2: Number of participants increasing (positive) and decreasing (negative) ratings in sliding time windows of sizes 0.5s to 3s over the course of Mozart's Overture to Le nozze di Figaro, *out of a population of thirty.*

While there are no moments with more than half the population changing ratings simultaneously in our example data set (Figure 2), there is interesting alternation between increasing and decreasing peaks.

To compare the experiences of different subject populations, we divid these counting time series by their means to generate the Relative Activity Levels of Figure 6. Variation in activity levels suggest that musical moments have concentrated effect on the audience.

Significant Musical Events

For most 3 second time intervals, the activity is middling: nearly always a few individuals changing rating in either direction.

Let's consider also the distribution of rating changes (first order difference) over 3 second intervals. Which time intervals have behaviour that would reject the null hypothesis in a T-test with α = 0.05? In Figure 3, we have 60 points of "T-test significance", well over the randomly expected 24 of our 477 "trials" or windows.

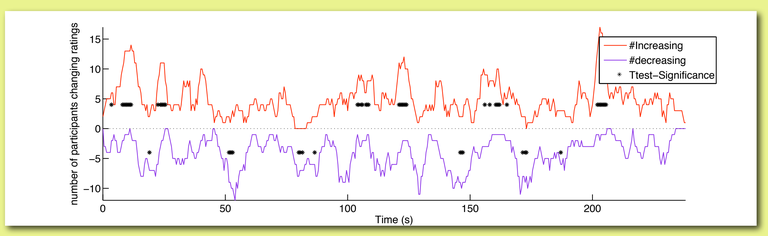
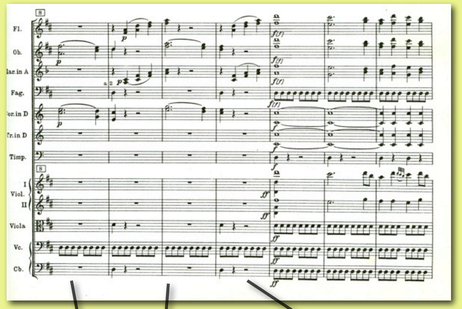


Fig 3: Number of participants increasing (positive) and decreasing (negative) ratings in sliding time windows of sizes 0.5s to 3s over the course of Mozart's Overture to Le nozze di Figaro, out of a population of thirty, and time intervals of size 3s identified as showing T-test significant changes in ratings for α = 0.05.

Fig 4: mm 8-12 of K492, parallel to mm 23-29 and mm 144-150, examples of significant rating increases.



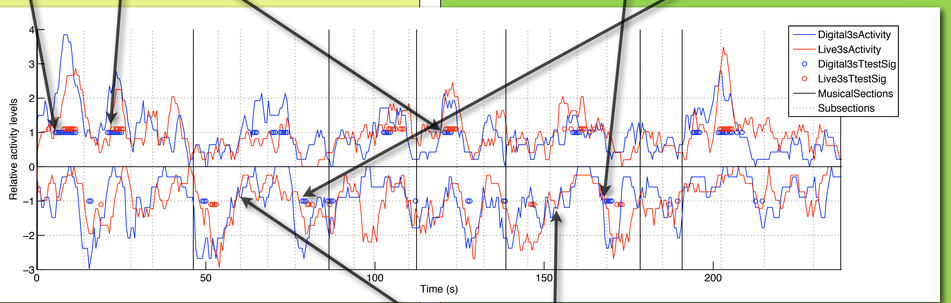
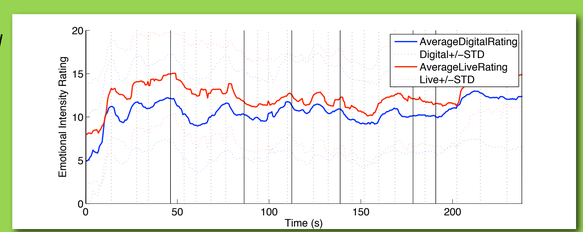


Fig 6: 3 second Relative Activity Levels and t-test significant time windows for the Experienced Emotional Intensity ratings of audience members from two presentations of K492, Mozart's Overture to Le nozze di Figaro, *one a live concert, the other a digital rebroadcast in a concert hall.*

By considering the population's behaviour, we have found **when in time** the music has had significant effect on the experience reported by our participants!

Fig 7: K492 mm 72-78, parallel to mm 185-191, examples of ambiguous and contradictory activity within populations

Fig 8: Average Experienced Emotional Intensity ratings of audience members from two presentations of K492, Mozart's Overture to Le nozze di Figaro, *one a live concert, the other a digital rebroadcast in a concert hall.*



The What of When: Activity Interpretation

Audience activity levels show us when the musical experience is changing by exposing corroborative behaviour in subjects:

- when subjects agree to an increase in rated experienced
- when subjects agree to an decrease in rated experienced
- when subjects agree to no remarkable change in rated experience
- when subjects disagree on the orientation of change

Audience Activity Analysis shows when listeners' ratings coincide and contradict each other in response to catalytic musical moments.

What is in the music

Figures 4, 5 and 7 are excerpts from the orchestral score of *le nozze di Figaro* which correspond to examples of these categories of audience activity from the Experienced Emotional Intensity ratings collected from the two audiences' participants (Figure 6).

The ramping up of the Main Theme, Figure 4, is heard three times. It elicits strong increases in ratings each time, but the repetition also shows desensitization.

Moving from a busy cadential tutti forte to a thinly orchestrated piano, Figure 5, provokes decreases in rated emotional intensity, but the reaction is faster the second time around.

In Figure 7 we have the beginning of a harmonic sequence of hits following the First Subordinate Theme. The second instance of this musical material provokes simultaneous rating changes in opposite directions around the time of the second iteration (measured over time windows of size 1.5 seconds).

Average vs Activity

Comparing Figures 6 and 8, both show tantalizing parallels between these representations of our example populations. However it is nearly impossible to interpret the meaning of the rises and dips in the average ratings because of the wide variance (dotted lines marking the standard deviation above and below the average values). In contrast, the Audience activity graph shows clear alternations in responses over time and the population approach allows for significance testing of rating changes from moment to moment.

Conclusions

We can numerically analyze listener reactions without throwing away their variability.

Audience activity shows the changing musical experience more clearly than averaged subject ratings.

Once we know when and how people are reacting, we can look at what they are reacting to in the music.

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