

Approaching an Audience Model of Listening Experience

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**C I R
M M T** Centre for Interdisciplinary Research
in Music Media and Technology

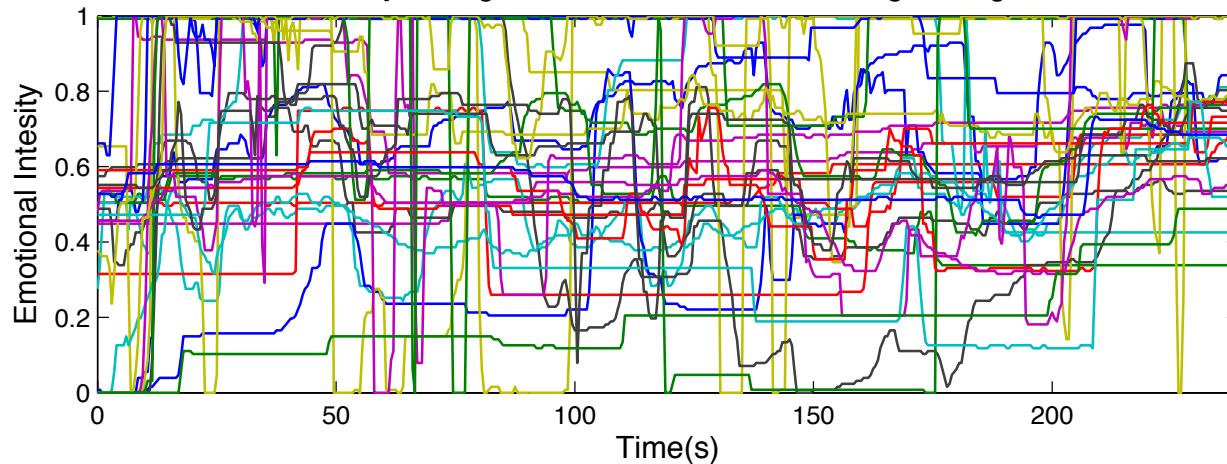
Outline

- The Question: Is there stimulus related information in continuous response data?
- An answer: Measuring simultaneity of active responses across the audience:
 - Testing coordination of audience activity: Goodness-of-Fit Test
 - Testing coordination of alternating activities
 - Testing coordination between two audiences' activity
- Conclusions

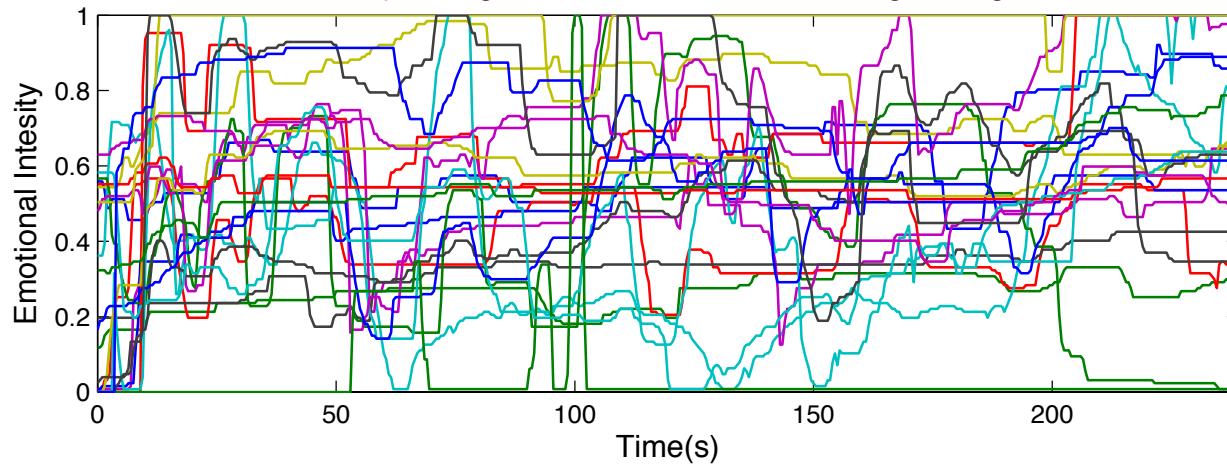
Introducing the Data

- Ratings of Experienced Emotional Intensity
- Two audiences: 1st at live performance, 2nd watching audiovisual recording.
- Stimuli: Boston Symphony Orchestra performing orchestral works by Mozart.
 - Overture to the Marriage of Figaro, K492
 - Rondo from First Symphony, K16
 - Adagio from Clarinet Concerto, K622
 - Finale from Jupiter Symphony, K551

Raw Emotional Intensity Ratings of Audience 1 to the Marriage of Figaro Overture, K492

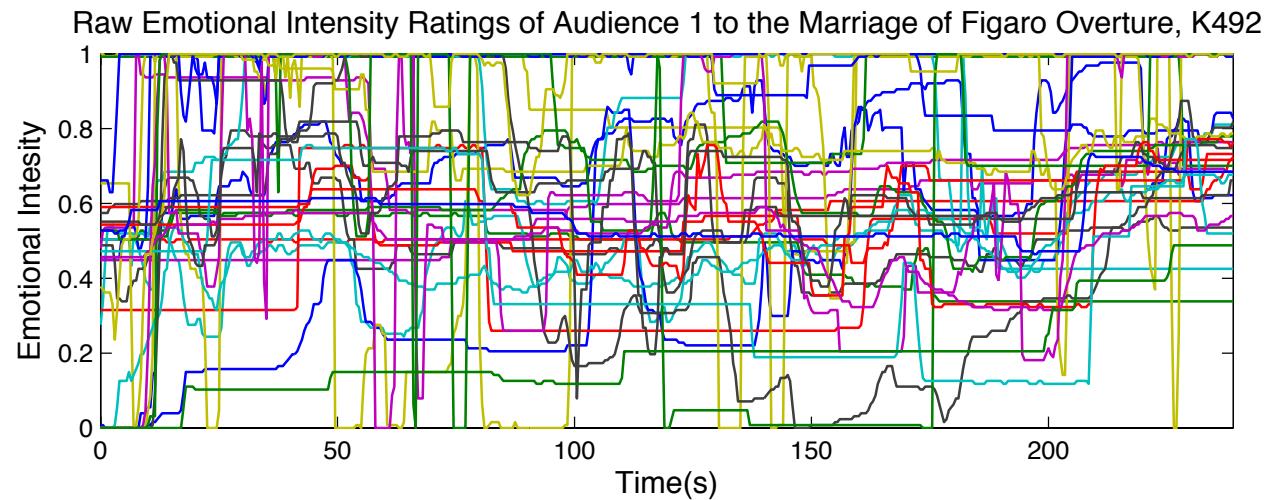


Raw Emotional Intensity Ratings of Audience 2 to the Marriage of Figaro Overture, K492

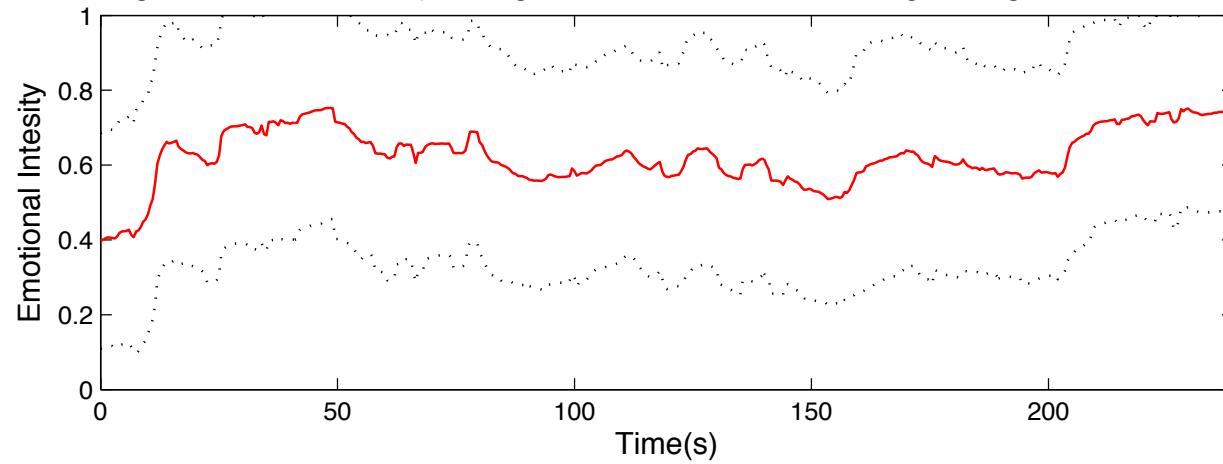


Is there information to be found in this data?

Continuous Ratings of Emotional Intensity from Two Audiences



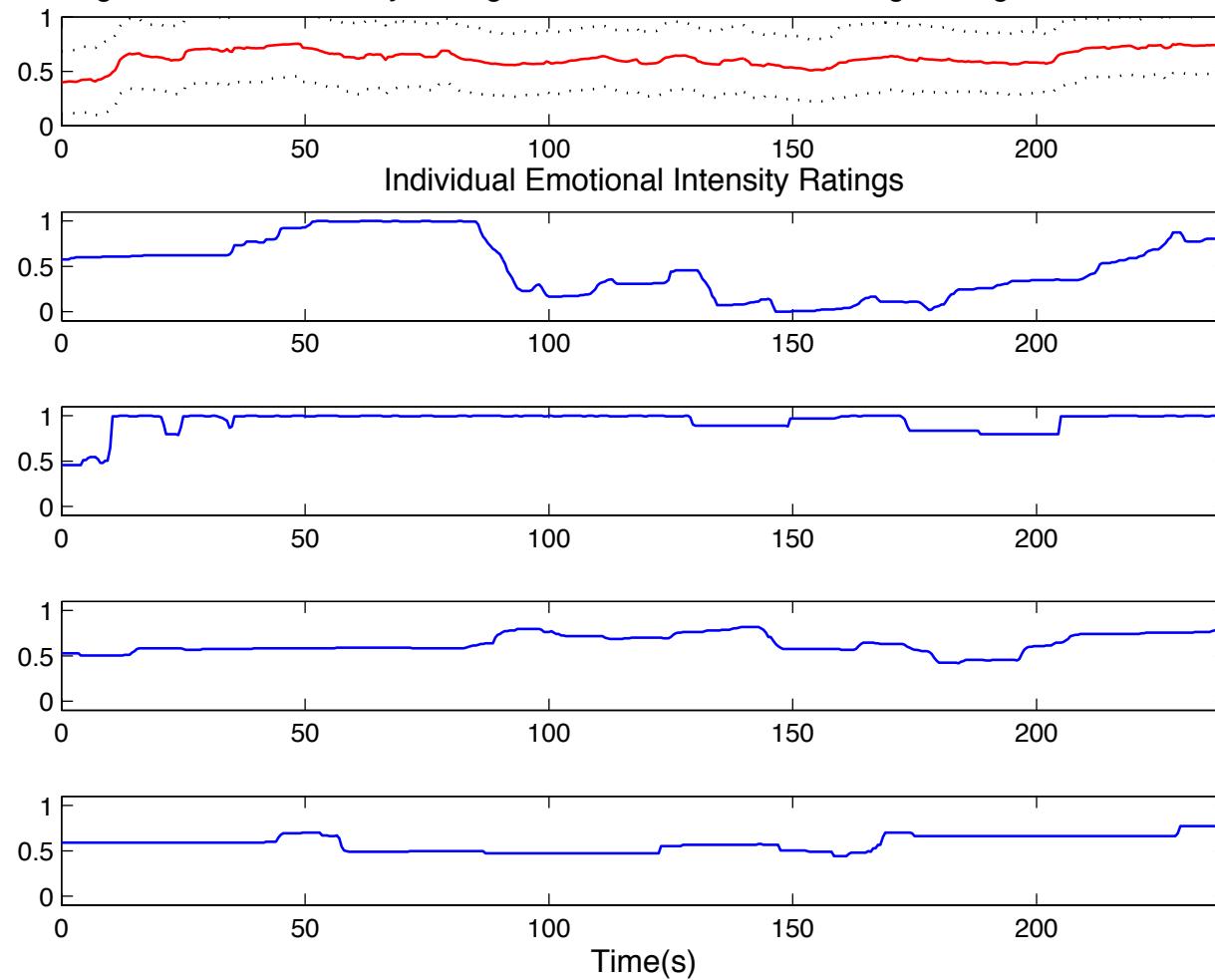
Average Emotional Intensity Rating of Audience 1 to the Marriage of Figaro Overture, K492



Common summary of audience response

Q: How representative is this time series of individuals' responses?

Average Emotional Intensity Rating of Audience 1 to the Marriage of Figaro Overture, K492



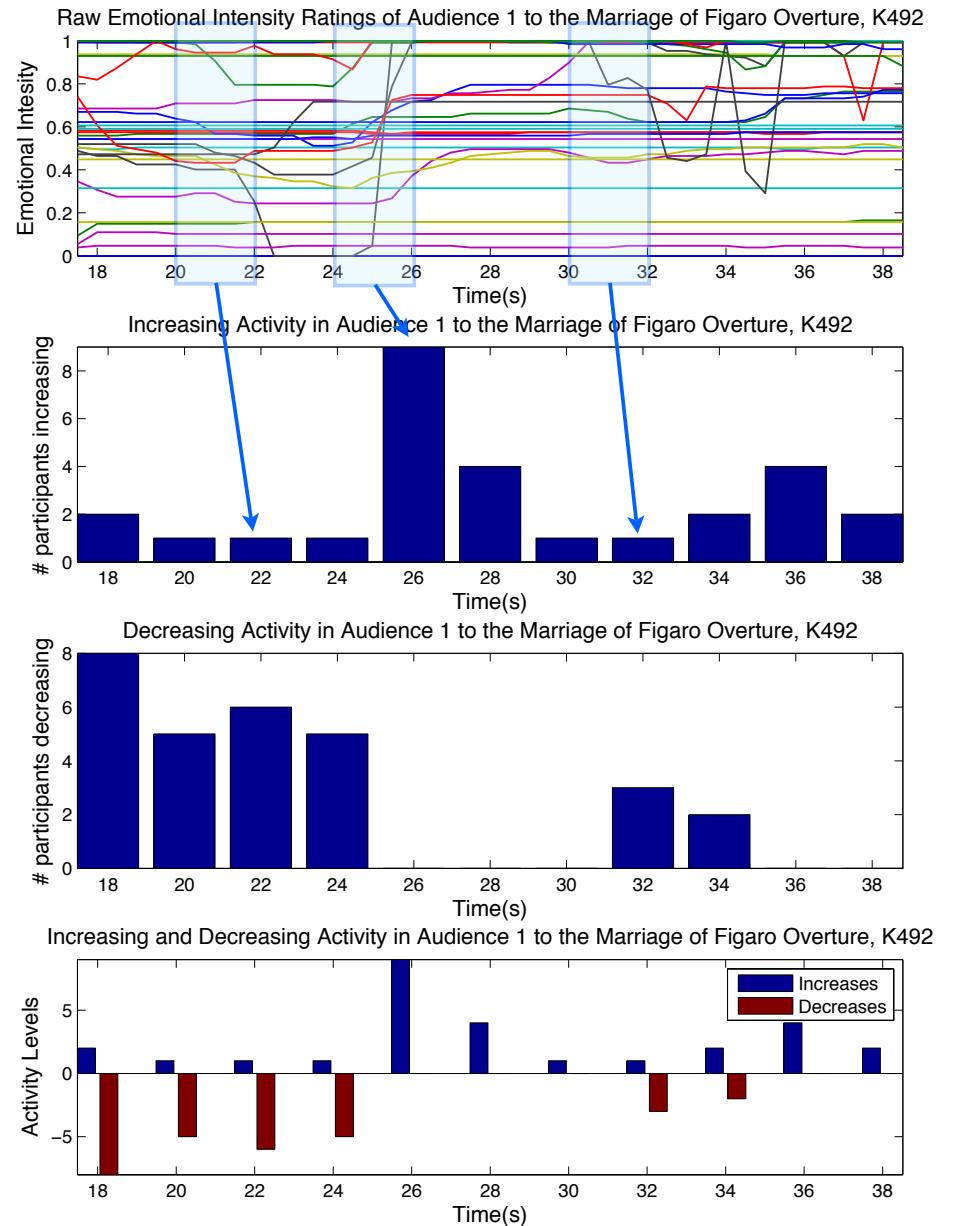
Distinct Contours for the
Same Stimulus

The average is not the whole
story. Is there coordination?

Activity Analysis

Measuring coordination of events across synchronized time series.

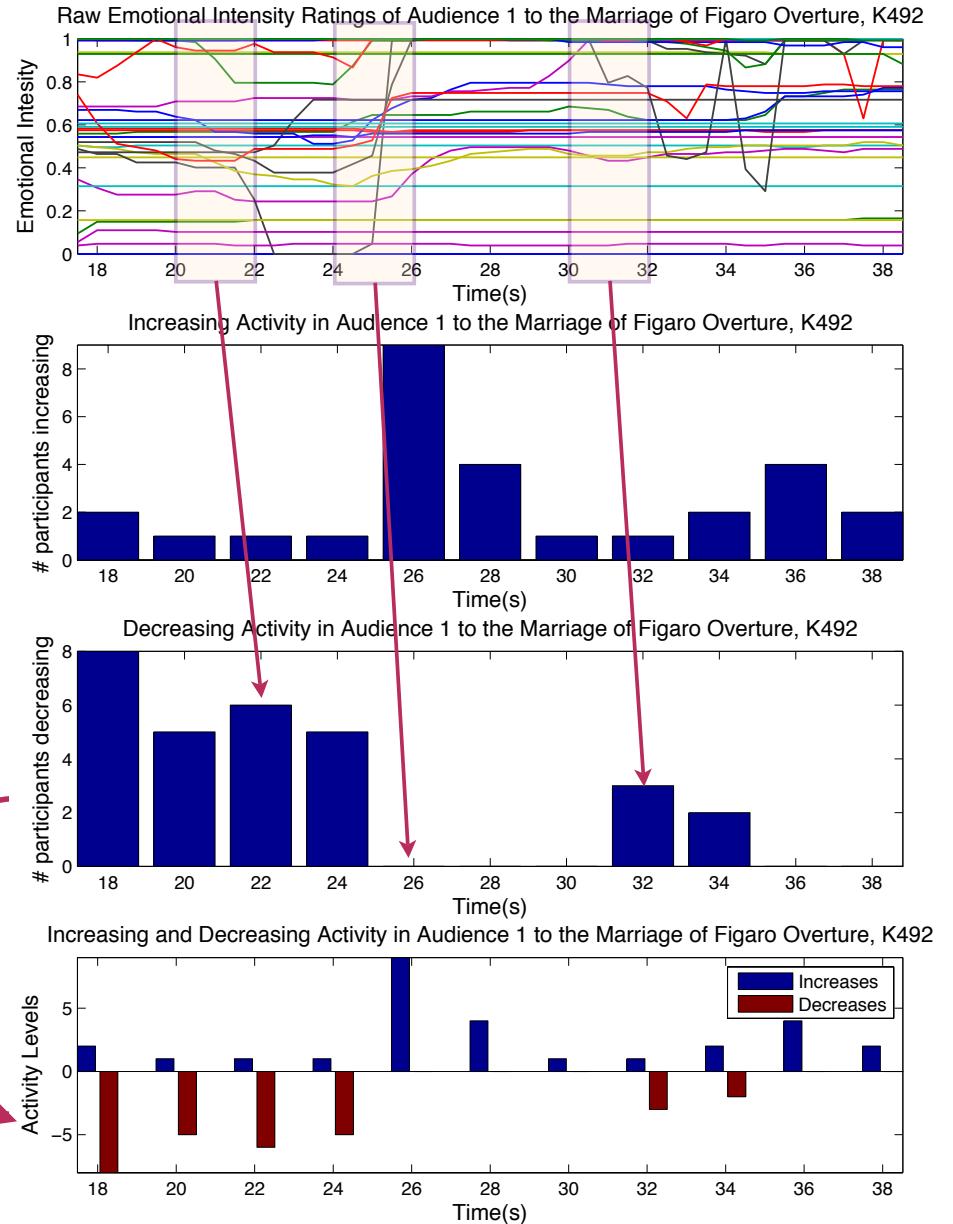
Counting the number of participants showing over 3% change in rating value over the same 2-second time window.

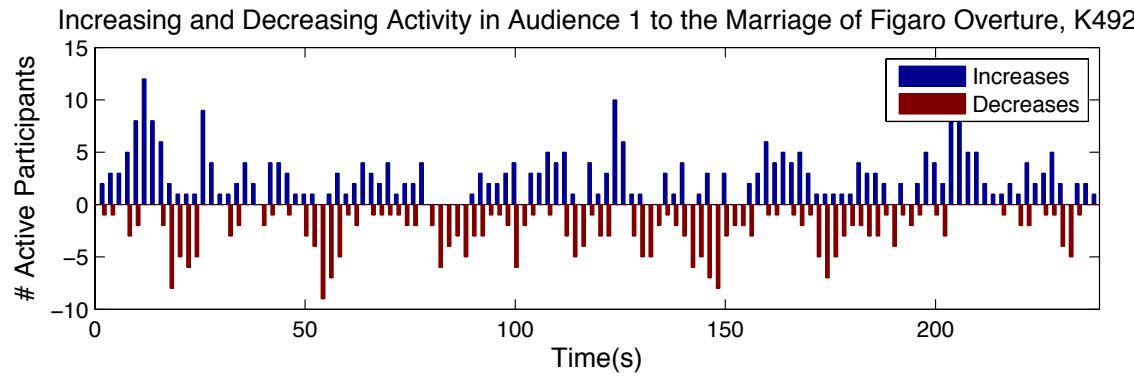
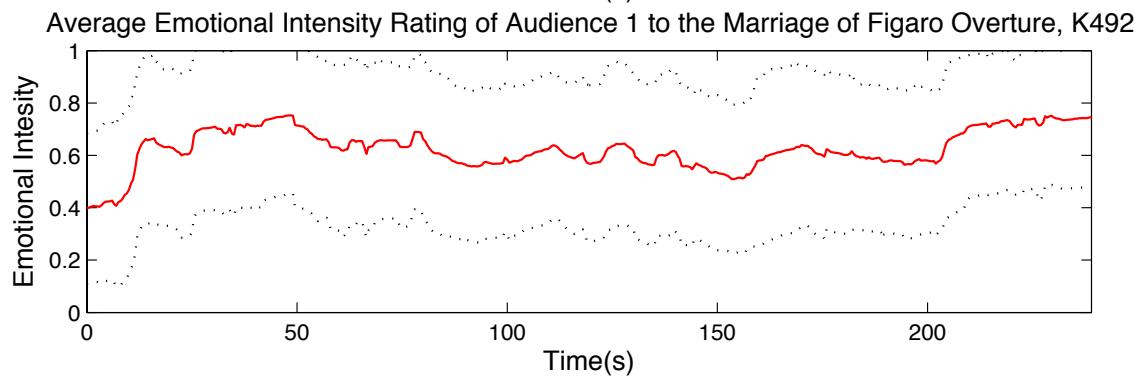
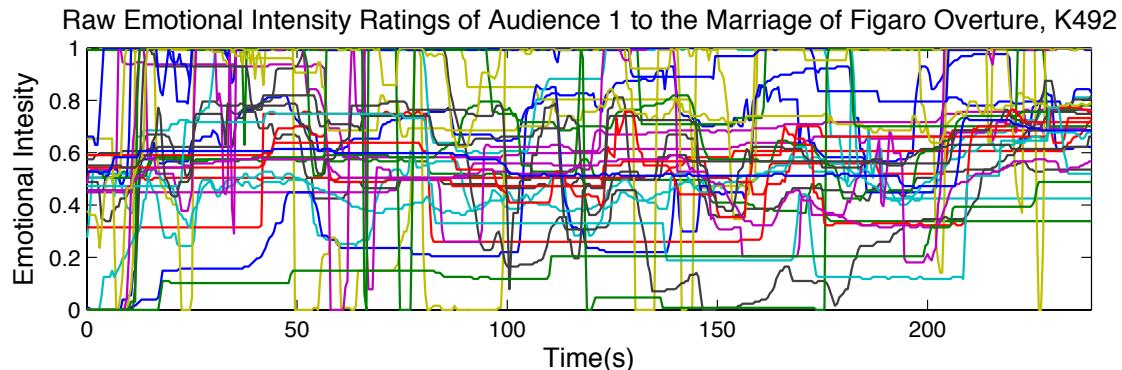


Activity Analysis

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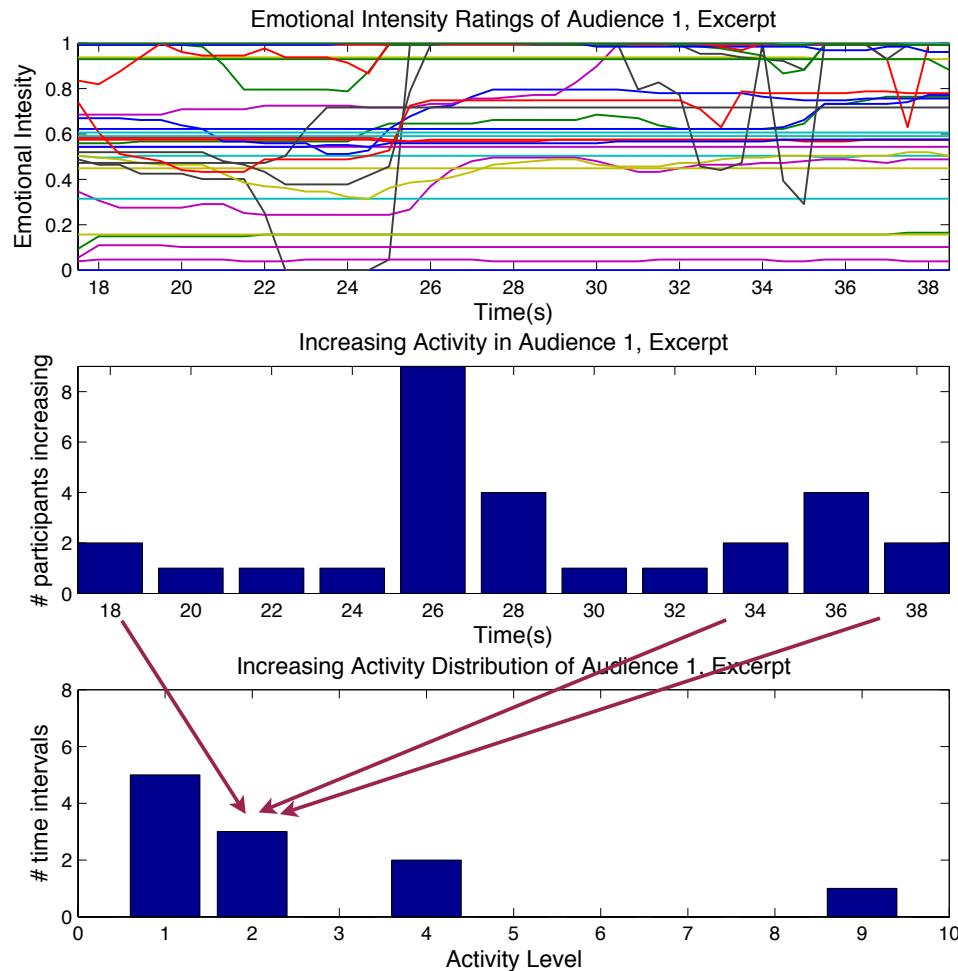




Summarizing the Audience Response

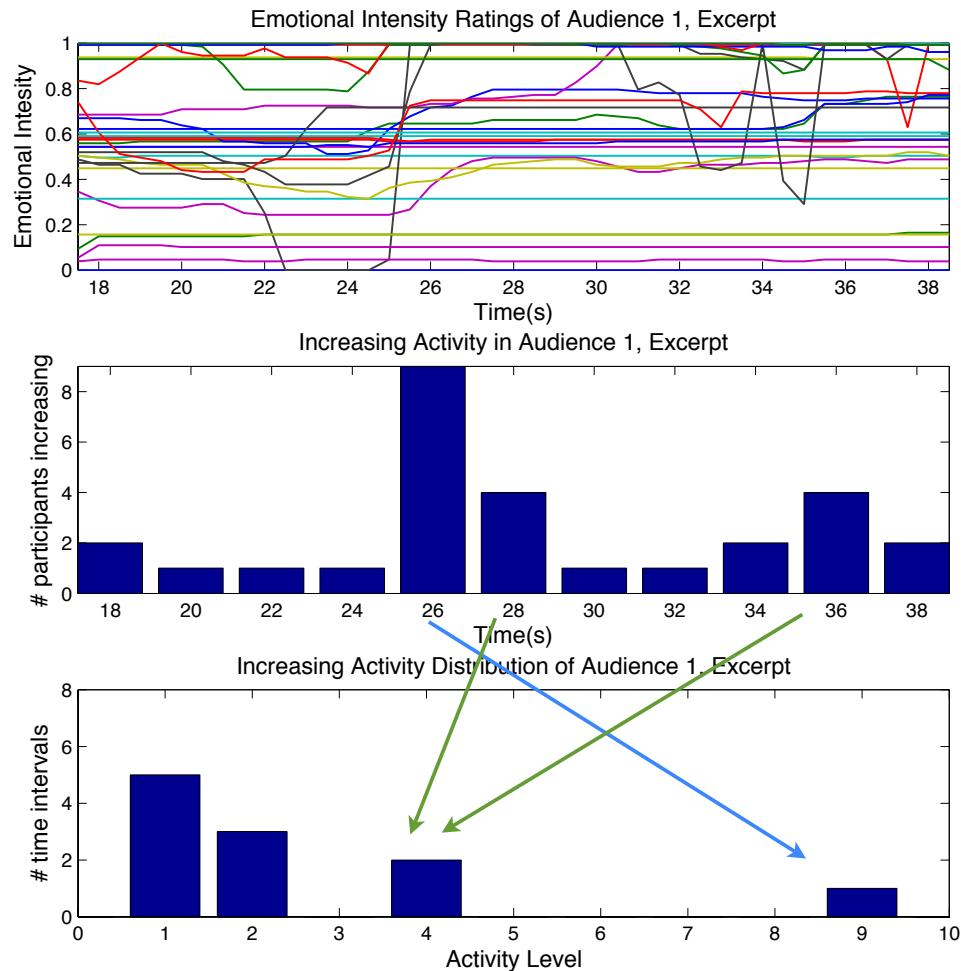
Audience Activity as an Alternative to the Average

Coordination and Activity Levels



- **Levels of Activity:** Ratio of participants changing ratings in the same time interval.
 - Rarely are most people responding at the same time, some people responding nearly all the time.
- **Activity Distribution:** Count the number of time intervals of each level of activity to evaluate the actual activity distribution for this audience and piece.

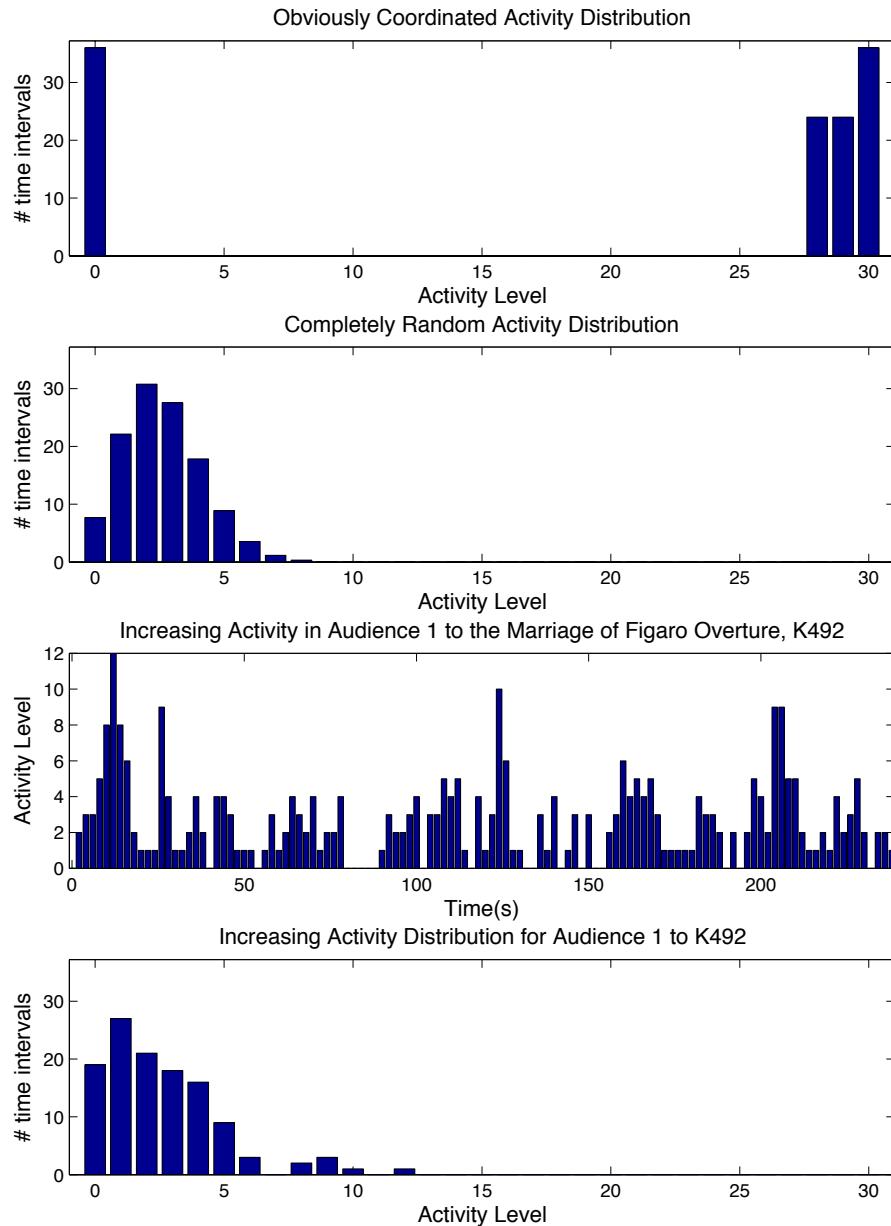
Coordination and Activity Levels



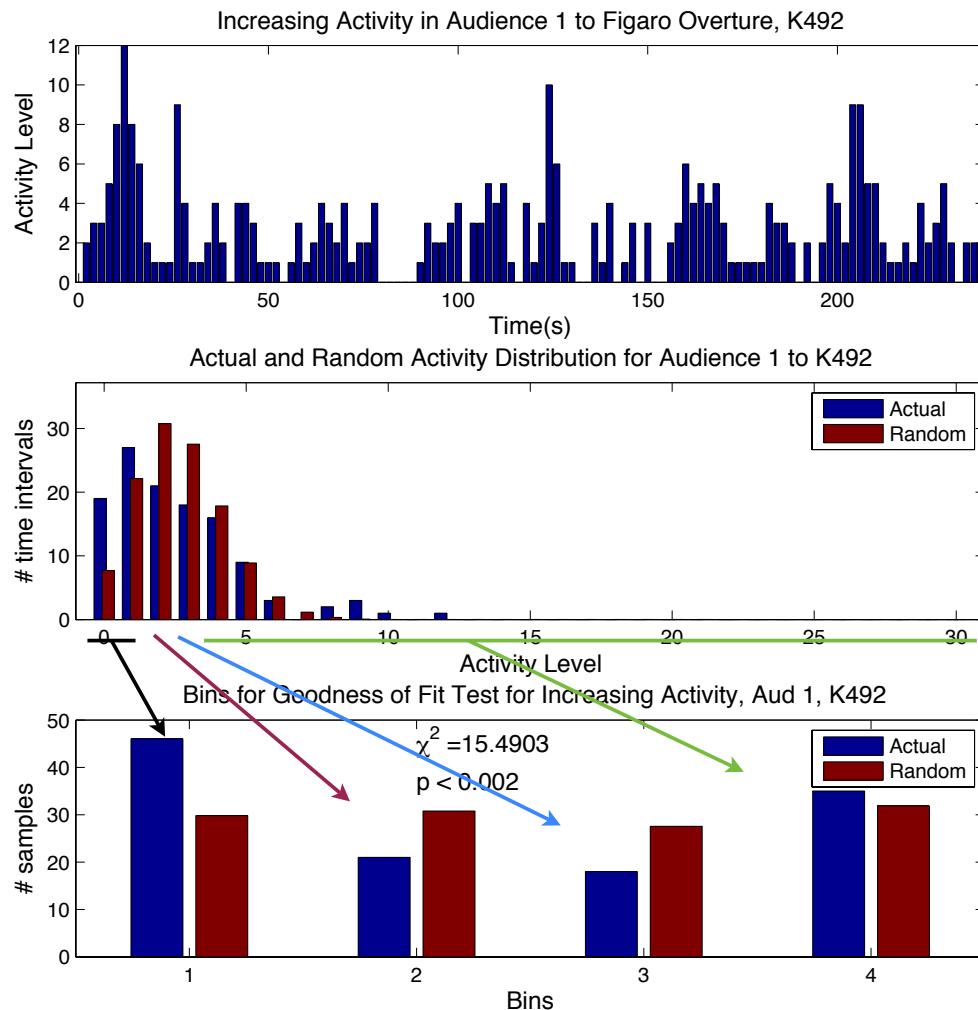
- Levels of Activity: Ratio of participants changing ratings in the same time interval.
- Rarely are most people responding at the same time, some people responding nearly all the time.
- Activity Distribution: Count the number of time intervals of each level of activity to evaluate the actual activity distribution for this audience and piece.

Coordination in Activity Distributions

- Ideally, all participants would respond together, or nearly.
- Random model: all participants respond independently, with equal likelihood of expressing an event at any moment.
(Poisson distribution)
- Practically, we expect a mix of the two, some random noise on top of some degree of coordination.



Testing the Distribution: Goodness of Fit Test



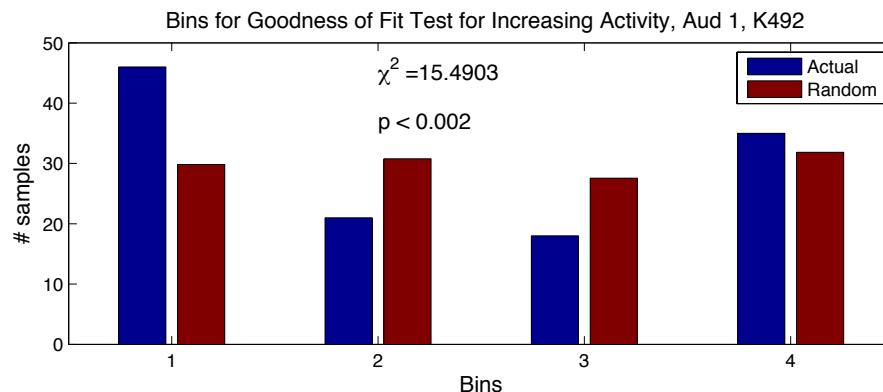
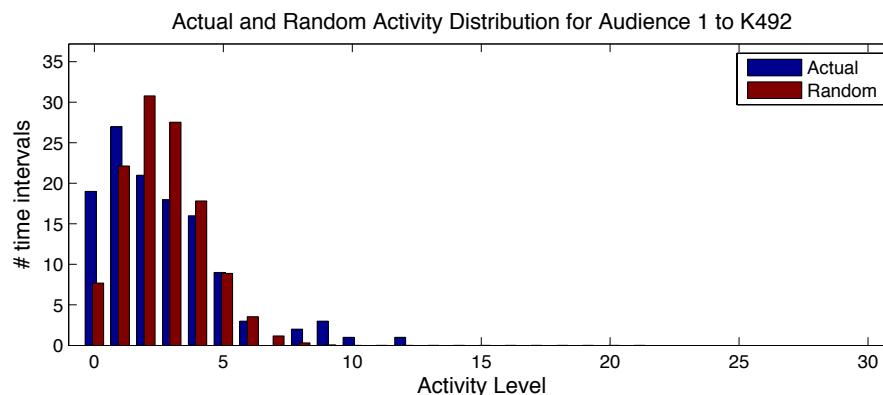
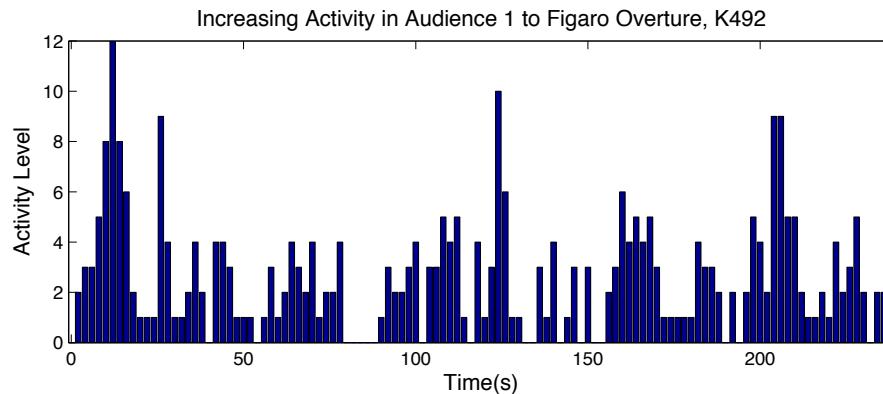
- Evaluate Coordination: Goodness-of-Fit Test of actual distribution against random model of all participants responding independently.

- Collapse distributions into small number of bins (4) for χ^2 calculation.

- Assess significance with $\# \text{bins} - 1$ degrees of freedom.

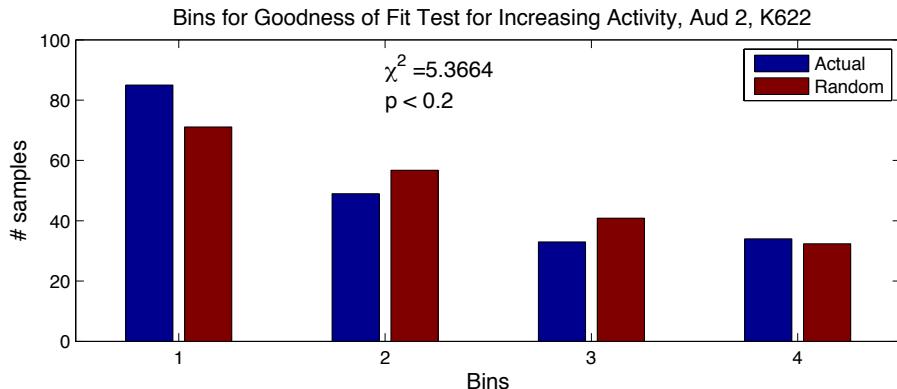
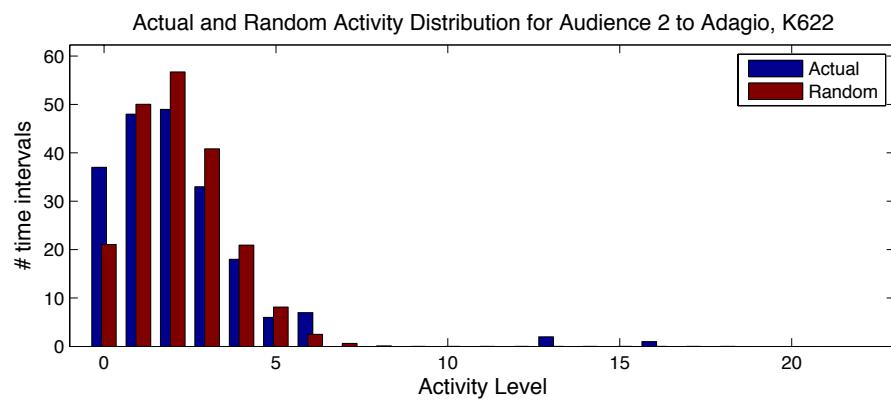
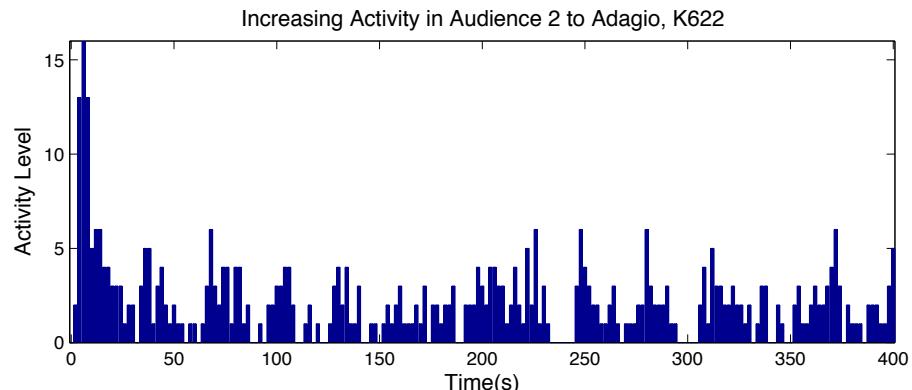
Testing Increasing Activity Distribution 1

- Example: distribution of increasing activity during K492 in Audience 1.
- 3 degrees of freedom
- $\chi^2 = 15.5$, $p < 0.002^{**}$
- Null Hypothesis rejected!
- For this Audience, the pattern of increases in ratings of emotional intensity is coordinated enough to justify looking for causes (in the stimulus).

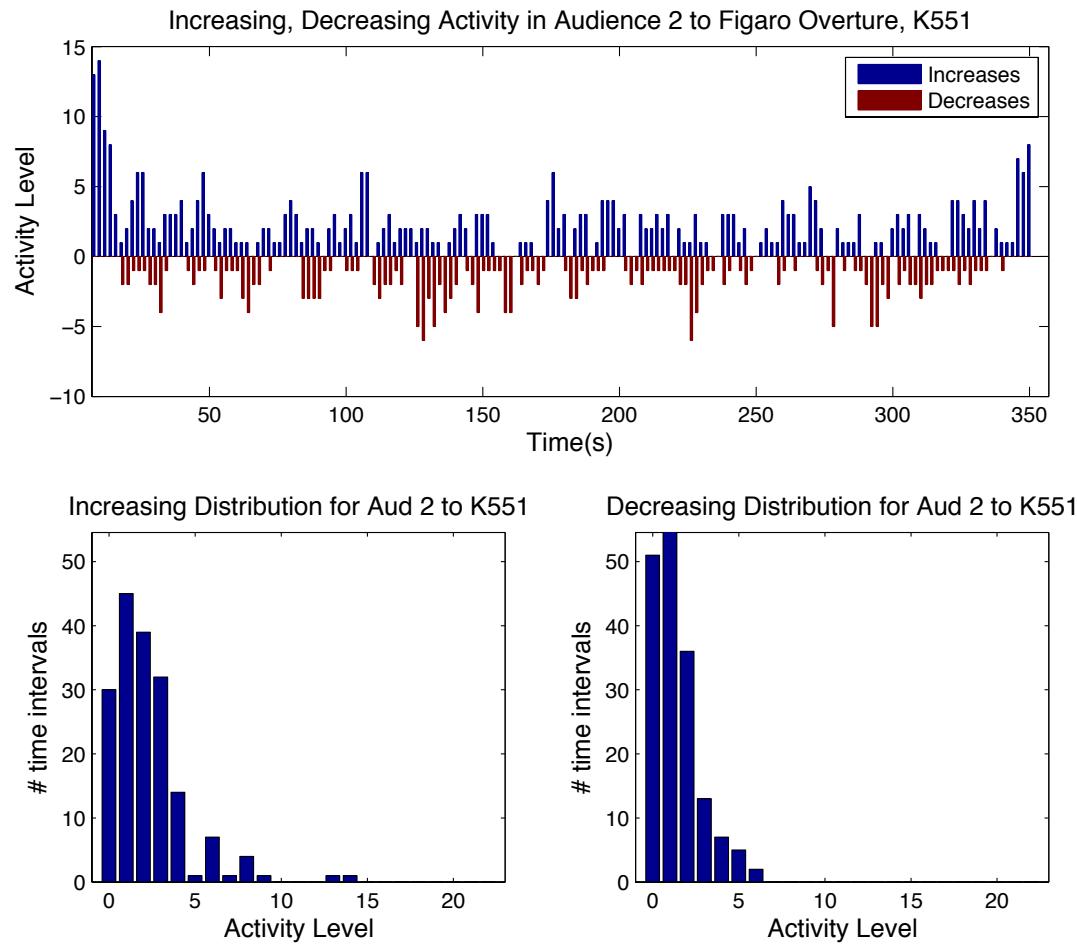


Testing Increasing Activity Distribution 2

- Example: distribution of increasing activity during K622 in Audience 2.
- 3 degrees of freedom
- $\chi^2 = 5.4$, $p < 0.5$
- Null Hypothesis NOT rejected!
- For this piece, this audience did not show more coordination than would be expected from a random process. There is not sufficient reason to try to relate the response pattern to the music.

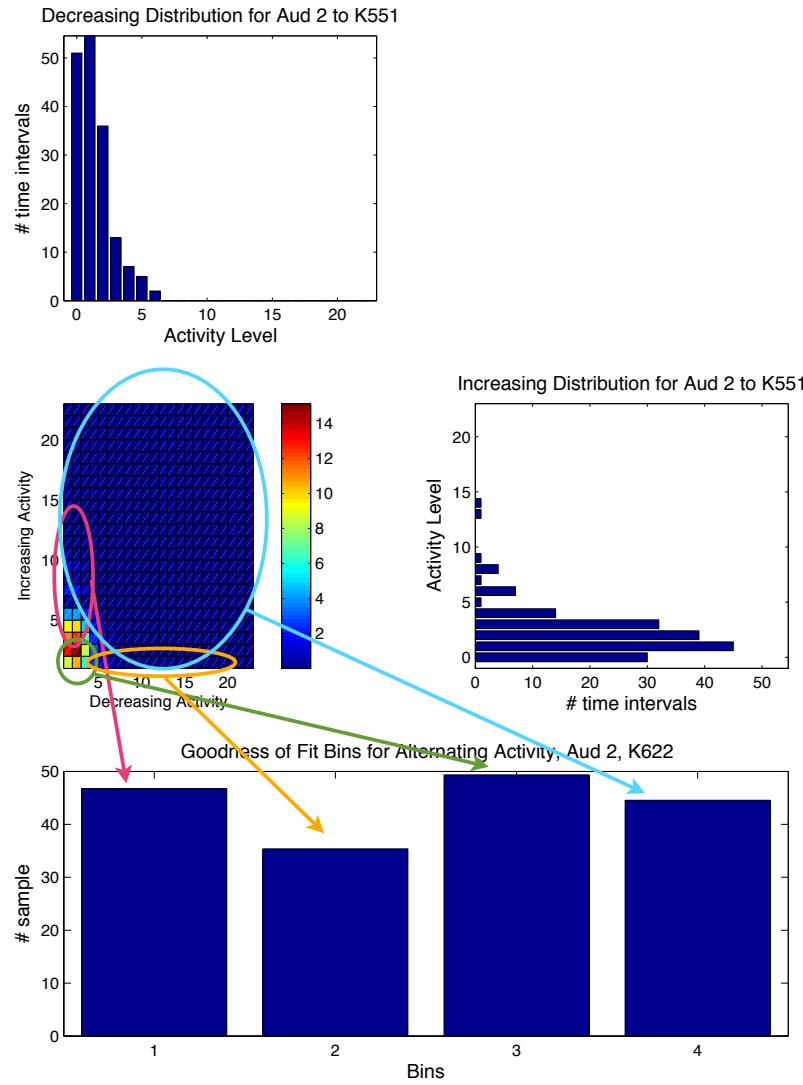


Alternating activity Coordination Test



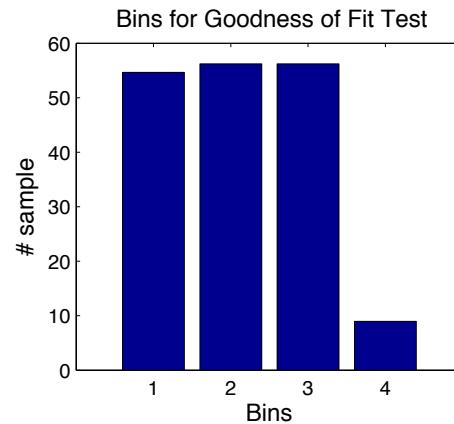
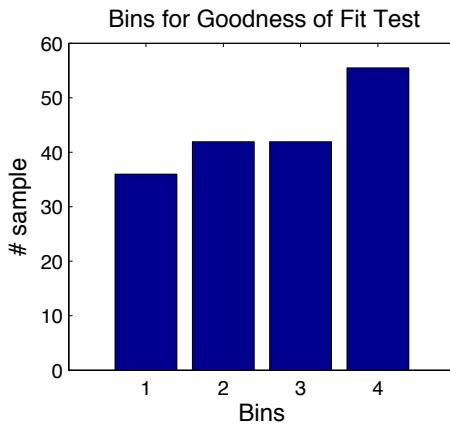
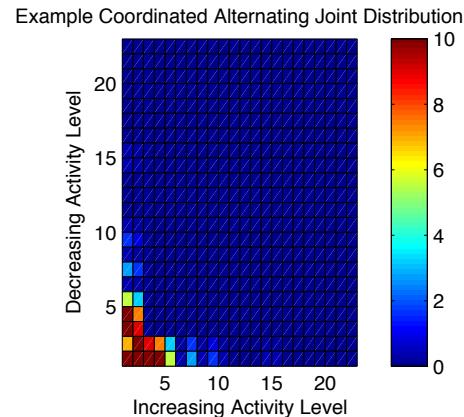
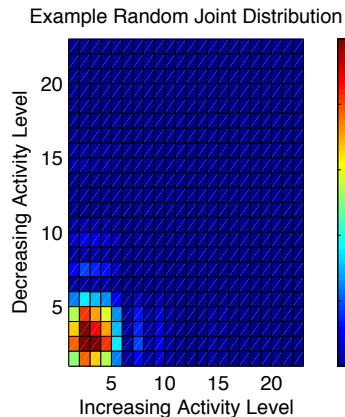
- Two actions possible: Increasing and Decreasing of emotional intensity:
- Test to see if the audience is alternating between the two using a joint distribution.
- Null Hypothesis: Increasing activity and decreasing activity are independent of each other.

Alternating activity Coordination Test



- Null Hypothesis: Increasing activity and decreasing activity are independent of each other.
- Model distribution: if the activity were independent
- Evaluate differences between model and actual joint distributions of activity through four bins:
 - When mostly increasing
 - When mostly decreasing
 - When hardly active
 - Everything else

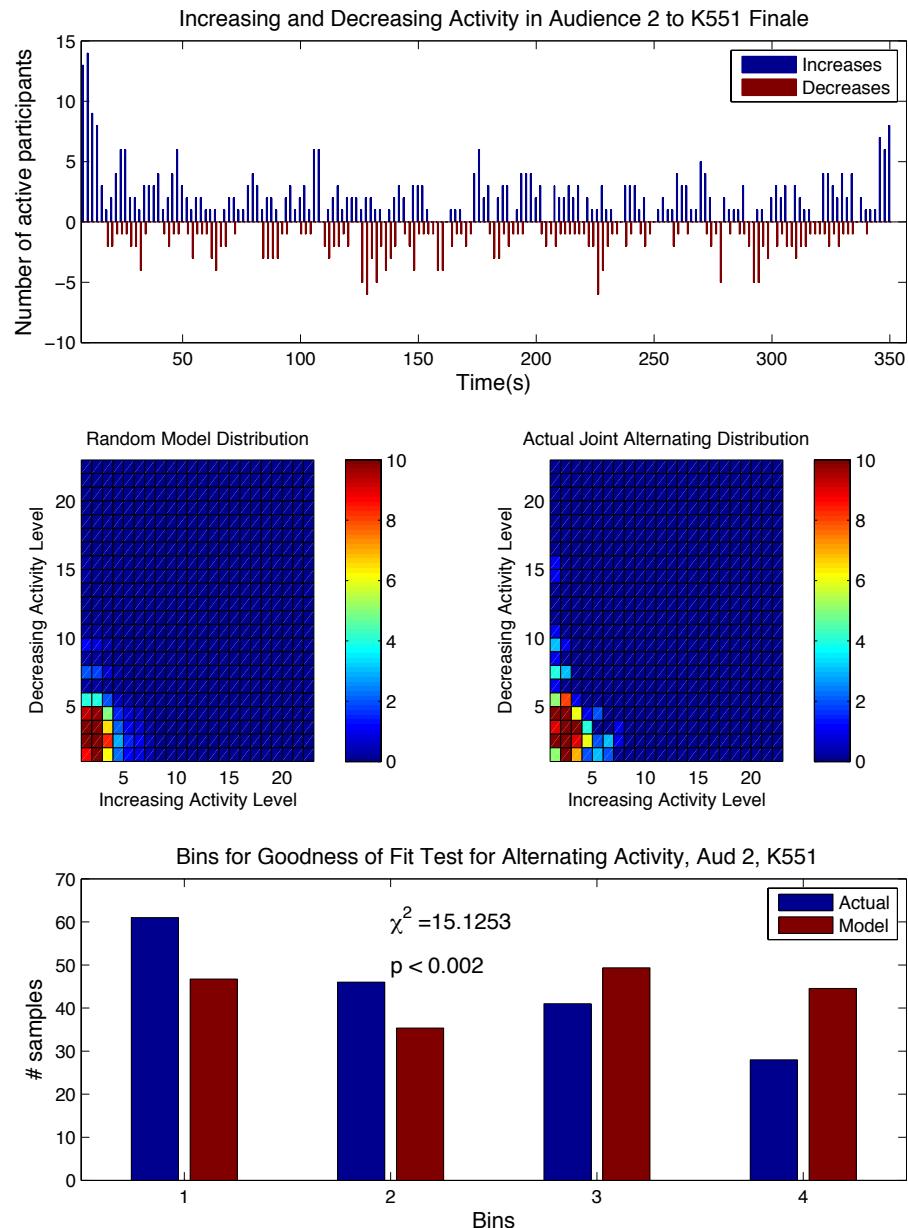
Alternating activity Coordination Test



- Random model distribution: Increasing activity and decreasing activity are independent of each other.
- Ideal distribution: Participants rarely actively disagree on emotional force rating changes in any 2 second window.
- Four bins group joint activity levels to emphasize the difference between these two possibilities.

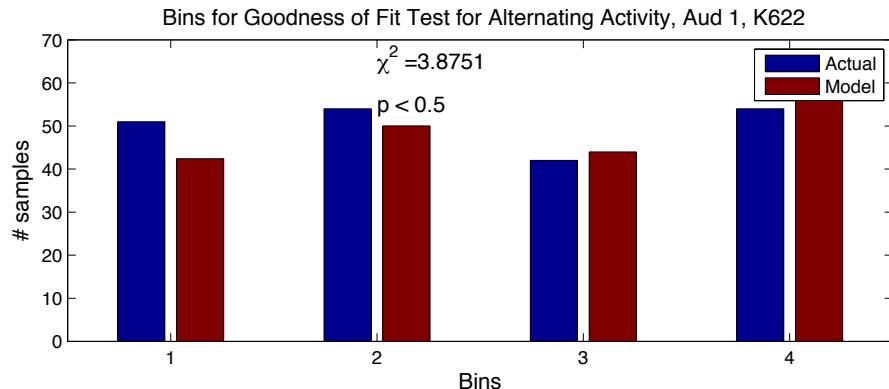
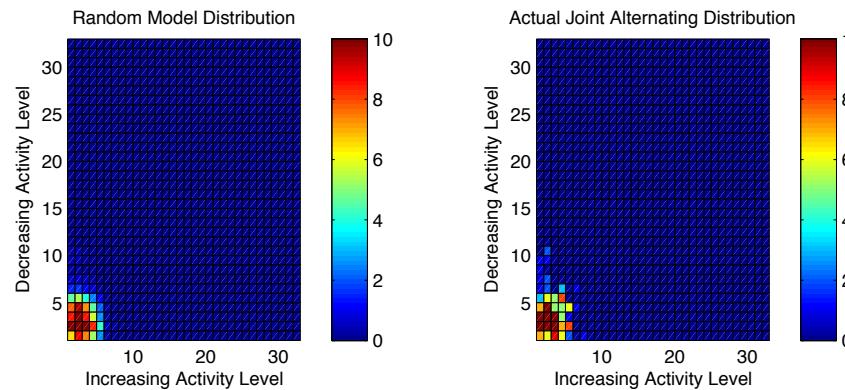
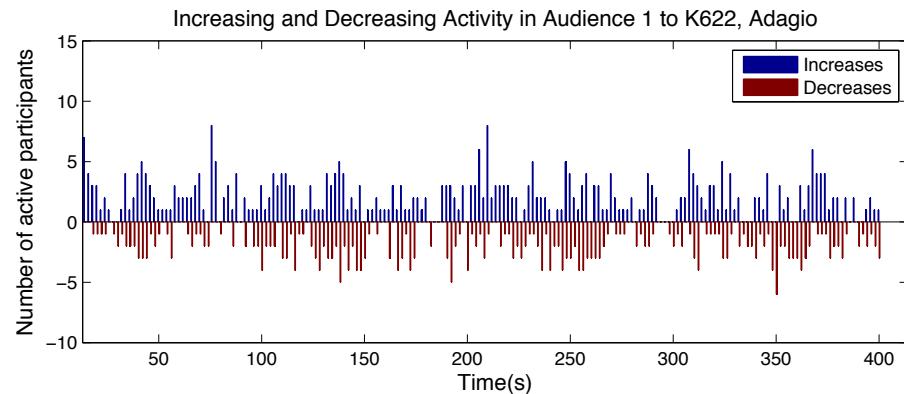
Testing Alternating Activity Distribution 1

- Example: distribution of alternating activity during K551 in Audience 2.
- 3 degrees of freedom
- $\chi^2 = 15.1$, $p < 0.002$
- Null Hypothesis rejected!
- For this piece and audience, the patterns of increases and decreases in ratings appear to be related (i.e., alternating), supporting the assumption that the stimulus is driving both.

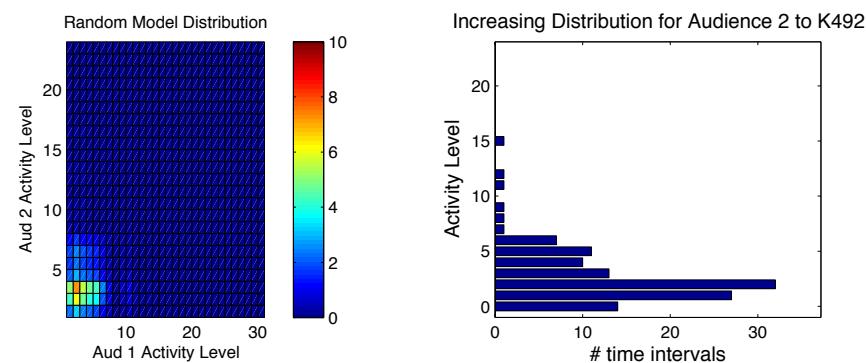
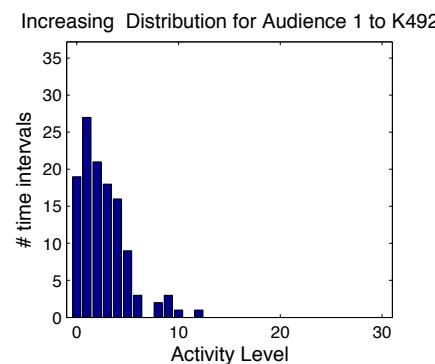
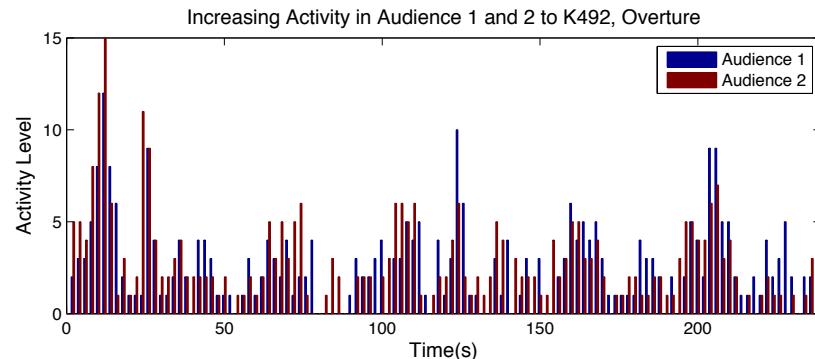


Testing Alternating Activity Distribution 2

- Example: distribution of increasing activity during K622 in Audience 1.
- 3 degrees of freedom
- $\chi^2 = 3.9$, $p < 0.5$
- Null Hypothesis NOT rejected!
- For this piece and audience, the patterns of increases and decreases in ratings appear to be independent of each other, suggesting that the stimulus did not succeed in driving a single simple emotional path.

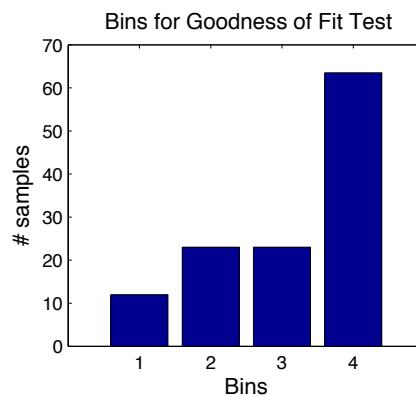
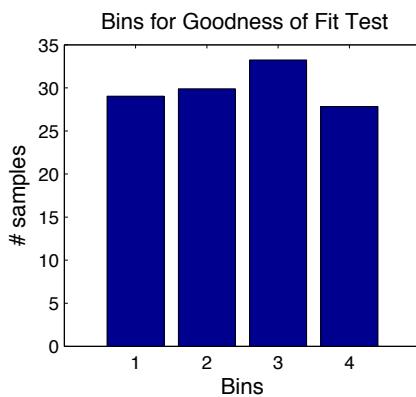
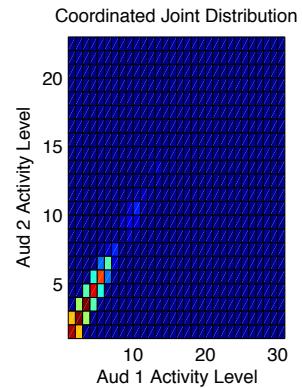
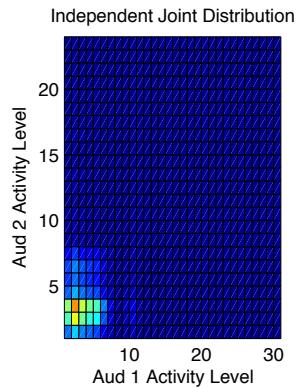


Two Audience Activity Coordination Test



- Two audiences responding to the same stimulus: Do they show the same pattern of activity over time?
- Like the Alternating Coordination Test, we can evaluate the joint distribution of the two activities.

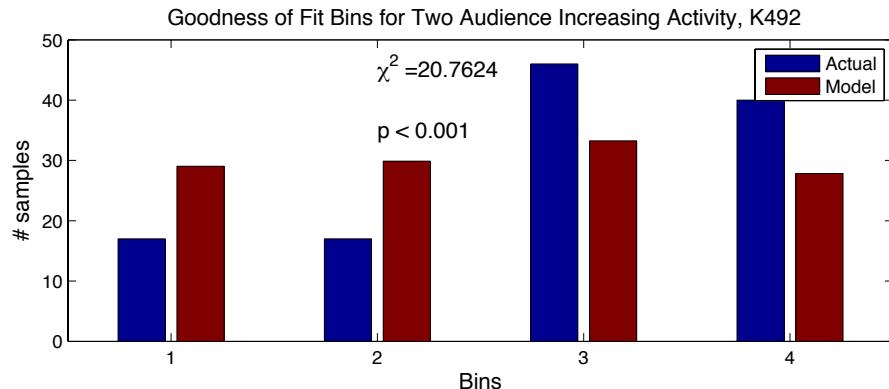
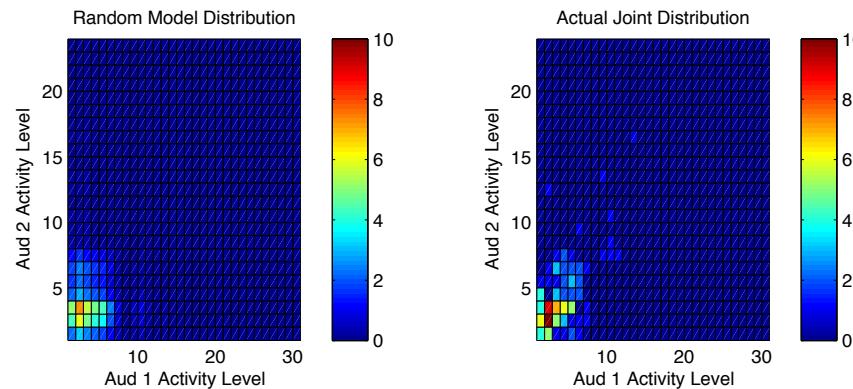
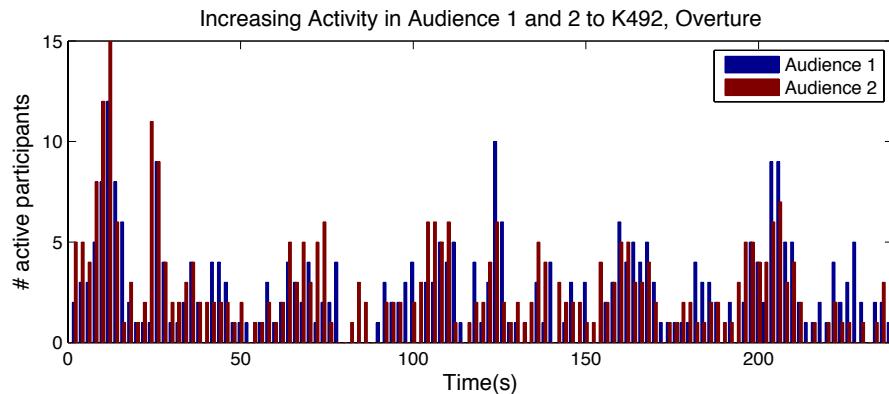
Alternating activity Coordination Test



- Random model: Increasing ratings in one group have no relationship to the increasing ratings in the other.
- Ideal distribution: The level of activity of one audience matches the level of activity of the other for all 2 second windows.
- Four bins group joint activity levels to emphasize the difference between these two possibilities.

Two Audience Activity Distribution 1

- Example: joint distribution of audiences' increasing activity during K492.
- 3 degrees of freedom
- $\chi^2 = 20.8$, $p < 0.001$
- Null Hypothesis rejected!
- For this piece, the two audiences shared many moments of similar increasing activity, strengthening the claim that the ratings were driven by the stimulus.



Results for this data set: Simple Activity

Table of results for increasing activity and decreasing activity. Against the random model of all participants having equal likelihood of changing ratings at any moment.

- Implications:
 - Increases in ratings are more often significantly coordinated than decreases in ratings.
 - Larger audience shows more coordination.

Activity		Audience 1		Audience 2	
		Inc	Dec	Inc	Dec
Piece					
K492	p<	0.002**	0.002**	0.001**	0.1
K16	p<	0.025**	0.5	0.5	0.97
K622	p<	0.05*	0.5	0.2	0.9
K551	p<	0.025*	0.001**	0.05*	0.5

* satisfies $\alpha < 0.05$

**satisfies $\alpha < 0.005$

Results for this data set: Alternating Activity

Table of results for alternating increasing and decreasing activity against the random model of increasing activity being independent of decreasing activity and vice versa.

- Implications:
 - Some stimuli do not induce alternating increases and decreases in ratings.

Alternating		Audience 1	Audience 2
Piece		Alt Inc/Dec	Alt Inc/Dec
K492	p<	0.001**	0.001**
K16	p<	0.5	0.3
K622	p<	0.5	0.15
K551	p<	0.001**	0.002**

* satisfies $\alpha < 0.05$ **satisfies $\alpha < 0.005$

Results for this data set: Two Audience Activity

Table of results for coordination of increasing or decreasing activity between the two audiences, against a random model of being independent.

- Implications:
 - Increasing activity seem to be more replicable than decreasing activity.

Two Audience	Increasing	Decreasing
Piece	Aud1/Aud2	Aud1/Aud2
K492	p< 0.001**	0.001**
K16	p< 0.5	0.75
K622	p< 0.02*	0.5
K551	p< 0.02*	0.75

* satisfies $\alpha < 0.05$

**satisfies $\alpha < 0.005$

Conclusions

- Continuous rating data is not always sufficiently coordinated to justify interpreting its temporal variation with respect to the stimulus.
- If participants do not respond in parallel, audiences may or may not be coordinated on a larger scale.
- Different stimuli generate different degrees of coordination in the emotional intensity profiles of audience members-- not all stimuli are created equal!
- Increases in emotional intensity ratings seem to be more coordinated than decreases. This asymmetry should be considered further.
- Considering response patterns across an audience makes it possible to answer the question of coordination and ask many more.

My Thanks

- To Stephen McAdams for letting me play with this data for so long.
- To my current and former lab mates.
- To the various funding bodies that made the collection and analysis of this data possible: NSERC, SSHERC, and CRC.
- To SEMPRE and McGill GREAT travel award for allowing me to be present.
- To you all for sitting through 66 graphs.