EXPLAINING AND PREDICTING THE PERCEPTION OF MUSICAL STRUCTURE
OUTLINE

• What is musical structure?
• How do people perceive structure?
  • Gestalt-based theories
  • Implication-Realization theory
  • Listener considerations
• Conclusion
“Shake It Off” by Taylor Swift
WHAT IS STRUCTURE?

• How did you **hear** this piece of music?

• How did you **perceive** this piece of music?
WHAT IS STRUCTURE?

- How did you **perceive** this piece of music?

horns

voice

drums
WHAT IS STRUCTURE?

- How did you **perceive** this piece of music?
WHAT IS STRUCTURE?

- How did you **perceive** this piece of music?
HOW DO PEOPLE PERCEIVE STRUCTURE?

• Gestalt-based theories
• Implication-Realization theory
• Listener considerations
GESTAL-T-BASED THEORIES

Proximity

Similarity
GENERATIVE THEORY OF TONAL MUSIC

3.7
a
○ ○ |
○ ○

3.8
a
\[\text{\textit{\(\text{\textbullet \textbullet \textbullet \textbullet} || \text{\textbullet}\)}}\]

b
\[\text{\textit{\(\text{\textbullet\textbullet\textbullet\textbullet || \text{\textbullet\textbullet\textbullet\textbullet}}\)}}\]

Principle of Proximity

Lerdahl and Jackendoof 1983

image credit: http://noike.info/~kenzi/roughly/paper/GTTM/12/12_Psychological_and_Linguistic_Connections.html
**Principle of Similarity**

Lerdahl and Jackendoof 1983

image credit: http://noike.info/~kenzi/roughly/paper/GTTM/12/12_Psychological_and_Linguistic_Connections.html
GENERATIVE THEORY OF TONAL MUSIC

Two rules:

Cooperation

Conflict
GENERATIVE THEORY OF TONAL MUSIC

Conflict of Rules

Lerdahl and Jackendoof 1983

image credit: http://noike.info/~kenzi/roughly/paper/GTMM/12/12_Psychological_and_Linguistic_Connections.html
GENERATIVE THEORY OF TONAL MUSIC

Goal of GTTM: to devise a set of rules from which a complete hierarchical grouping structure can be inferred

Lerdahl and Jackendoof 1983

image credit: http://noike.info/~kenzi/roughly/paper/GTTM/12/12_Psychological_and_Linguistic_Connections.html
GESTALT-BASED THEORIES

Proximity

Similarity
GENERATIVE THEORY OF TONAL MUSIC

- Fred Lerdahl and Ray Jackendoff, 1983

- Goal of GTTM: to devise a set of rules from which a complete hierarchical grouping structure can be inferred

- Inspired by Gestalt theory and by ideas of “universal grammar” in language

- Assumes an ideal listener familiar with Western tonal music
Good Continuation
MELODIC EXPECTATION
MELODIC EXPECTATION
MELODIC EXPECTATION
IMPLICATION-REALIZATION THEORY

• Eugene Narmour, 1990

• Goal of I-R Theory: to devise a set of rules from which a complete hierarchical grouping structure can be inferred

• …using explicit reference to human cognitive processes

• …while carefully separating what is universal from what is culturally learned
Two expectations are universal:

- \( A + A \rightarrow A \)
- \( A + B \rightarrow C \)
Refinements of these expectations, based on interval size and direction, are culturally learned. For example:

- Large intervals usually followed by smaller intervals
- Large intervals usually followed by a change in direction
IMPLICATION-REALIZATION THEORY

• How does expectation lead to structure?
  • Surprise leads to boundaries
  • Closure leads to boundaries
WHAT IS STRUCTURE?

- How did you **perceive** this piece of music?
IMPLICATION-REALIZATION THEORY

- I-R model focuses almost exclusively on melody as a sequence of intervals.

- What about harmony, rhythm, timbre?
  - Narmour hinted at theory in 1977…
  - Parts 2–4 forthcoming…
LISTENER CONSIDERATIONS

• Previous theories all posit ideal listeners
  • i.e., for a given melody, there is a “best” analysis.
• But, listeners differ in many ways!
  • Cultural knowledge
  • Level of musical training
  • Listening context
  • Familiarity with the music
EXPERIMENTS ABOUT LISTENER DIFFERENCES

• Elizabeth Margulis:
  What is the effect of repeated listenings?

  • Listeners heard the same piece four times in a row
  
  • Each time, they indicated every single literal repetition they identified
  
  • Margulis tallied the correct indications and their lengths
Suite en mi

Tambourin

Jean-Philippe Rameau
(1683-1764)
EXPERIMENTS ABOUT LISTENER DIFFERENCES

Elizabeth Margulis: What is the effect of repeated listenings?

FIGURE 3. Probability of correct response by exposure for repetitions with LRU of 1, 4, and 8 s.

Margulis 2012
LISTENER CONSIDERATIONS

• Some listener disagreements seem less predictable...
Heart to hurt

Rel. number of indicated boundaries

Bruderer, McKinney and Kohlrausch 2009
WHAT CAUSES A LISTENER TO HEAR A BOUNDARY?

Clarke and Krumhansl 1990:
- pause (silence)
- return of material (chordal)
- change of dynamic
- new material
- change of rhythm
- change of pitch content
- change of articulation
- start of development
- change of register (expansion)
- change of dynamic contour
- change of texture

Bruderer et al. 2009:
- change in harmonic progression
- change in melody
- change in tempo
- change in rhythm
- change in timbre
- change in loudness / dynamics
- breaks
- global structure
- repetitions
WHAT CAUSES A LISTENER TO HEAR A BOUNDARY?

1. Were listeners paying attention to these features, or were these features attention-grabbing?

2. Can we trust the listeners to self-report the correct features?
WHAT CAUSES A LISTENER TO HEAR A BOUNDARY?

image credits: various from Google Images

Aviezer, Trope and Todorov 2012
What is the viewer paying attention to?

What is the listener paying attention to?
EXPERIMENTS ABOUT LISTENER DIFFERENCES

• I ran an experiment last year on...
EXPERIMENT 1:
ATTEND TO THE PATTERN

Part 2 of 4: Does the pattern occur?

In this set of questions, a musical pattern of some kind will be shown to you. Your goal is to judge whether this pattern occurs in the longer musical excerpt that follows. We then ask you to re-listen to the excerpt, and state whether you prefer form AAB or ABB.

This section should take less than 12 minutes.

Now, please listen to the excerpt again. (The following clip is identical to the previous clip.)

[Audio clip]

Question 2. Which of the following analyses do you think best fits the excerpt?

- [ ] A A B
- [ ] A B B

Question 3. How certain are you about your choice of analysis?

- [ ] Totally certain
- [ ] Very certain
- [ ] Both certain and uncertain
- [ ] Very uncertain
- [ ] Not at all certain

Next >>
EXPERIMENT 1: ATTEND TO THE PATTERN

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Part 3 of 4: Salience of change

Every excerpt in this part has a single pattern repeated 4 times, with a change in some feature between the 2nd and 3rd instances; i.e., it has form AABB. We ask you to focus on a particular aspect of the music while listening, and tell us: how significant was the change at the half-way point?

This section should take less than 6 minutes.

Trial 4 of 12

Please pay attention to the chords of the following excerpt.

Question 1. How strong is the change at the midpoint of the excerpt?

- 5. Extremely strong
- 4.
- 3.
- 2.
- 1. Not strong at all

Next >>
EXPERIMENT 2: BOUNDARY SALIENCE

- Hypothesis: focusing on a feature makes changes in that feature more salient.

- Participants focused on a single feature while listening to an AB-pattern clip, then rated salience of the change they heard.

- Independent variable: Match between focal and changing feature varies: match, convolved, or wrong.
EXPERIMENT 2: BOUNDARY SALIENCE

• Result: Yes, attention did affect the salience of the changes!
EXPERIMENT 1: ATTEND TO THE PATTERN

• Hypothesis: focusing on a feature makes one more likely to perceive groups according to that feature.

• Participants *secretly primed* to focus on a feature with a distractor task: detect whether a pattern occurs.

• Then they indicated their preferred grouping.

• Independent variables: relevance of probe; presence of probe.
EXPERIMENT 1: ATTEND TO THE PATTERN

Organ

50/50

65/35

present, relevant:

absent, relevant:

present, irrelevant:

absent, irrelevant:
EXPERIMENT 1: ATTEND TO THE PATTERN

• Result: Yes, attention did influence the perceived groupings!
• Effect varied with feature
EXPERIMENT 1: DEPENDENCE OF GROUPING STRUCTURE ON ATTENTION

![Mean pattern identification accuracy vs. Musical training score](image1)

![Mean confidence in grouping preference vs. Musical training score](image2)
EXPERIMENT IMPACT

• Attention impacts the perception of groupings for listeners

• Disagreements between listeners could be caused by differences in attention

• Add it to the (growing) list: familiarity, training,
CONCLUSION

• **Generative Theory of Tonal Music**
  - Explicit set of rules for generating hierarchical analyses of tonal music

• **Implication-Realization Theory**
  - Expectation has a central role in music perception
  - Founded in cognitive science; makes testable claims

• **Listener differences challenge both theories**
  - Consider the non-ideal listener


THANK YOU!