# Digital Sound Capstone
# DXARTS 460

## Lecture 8:
## Music cognition

Spring 2011

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# Music cognition

• A relatively new (established in the 1980s) interdisciplinary scientific field of investigating human musical comprehension, memory, performance, development of musical abilities and other high-level sound-related behaviors

• However, music cognition phenomena, problems and solutions have been investigated, solved and used artistically by composers for centuries

# Music cognition

• Music psychology is not a regulatory science:

*Much work in perceptual and cognitive psychology has to do with determining limits: limits to the amount of information that can be retained, limits of discriminability, and so on. Taking such "scientifically established limits" too seriously, it is feared, might serve to stultify musical development by creating artificial boundary conditions for acceptable music. For the limitations determined by such experiments might not in fact be fixed but might rather be a function of the type of music to which the listener has been exposed.*

Diana Deutsch, Psychology and Music, Introduction

• E.g. J.S. Bach and Monteverdi were considered to be unacceptable for the contemporary listeners' ears

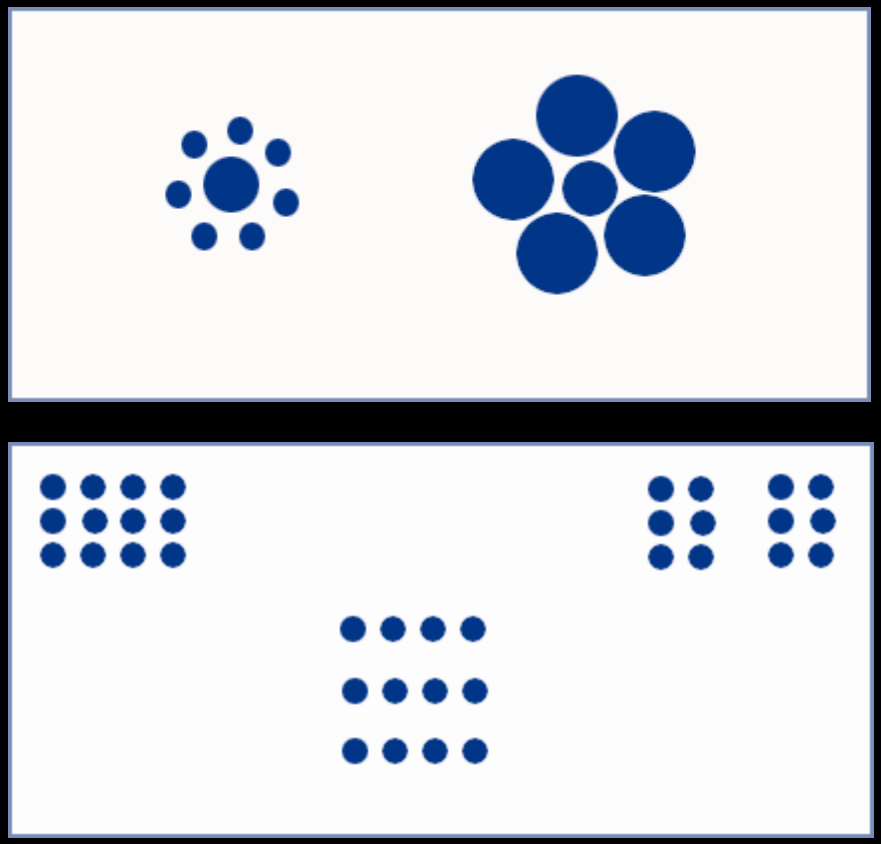
# Gestalt laws

• A set of principles explaining how we perceive patterns as a whole instead of as many separate parts (*Gestalt* is German for *configuration* or *pattern),* established in the early 20th century

# Gestalt laws

- **Law of Proximity**:

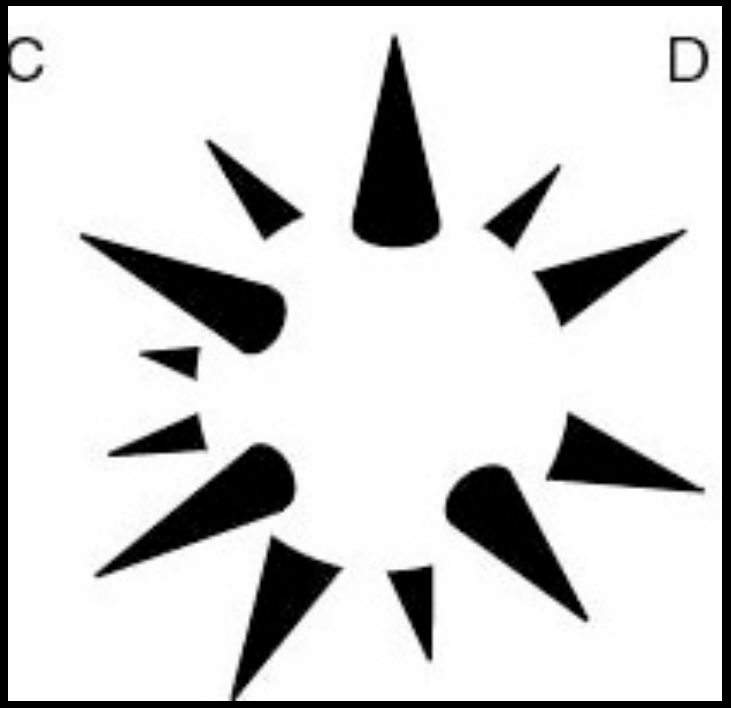
The mind tends to group nearby elements



# Gestalt laws

- **Law of Closure**:

The mind may experience elements it does not perceive through sensation, in order to complete a regular figure (that is, to increase regularity)

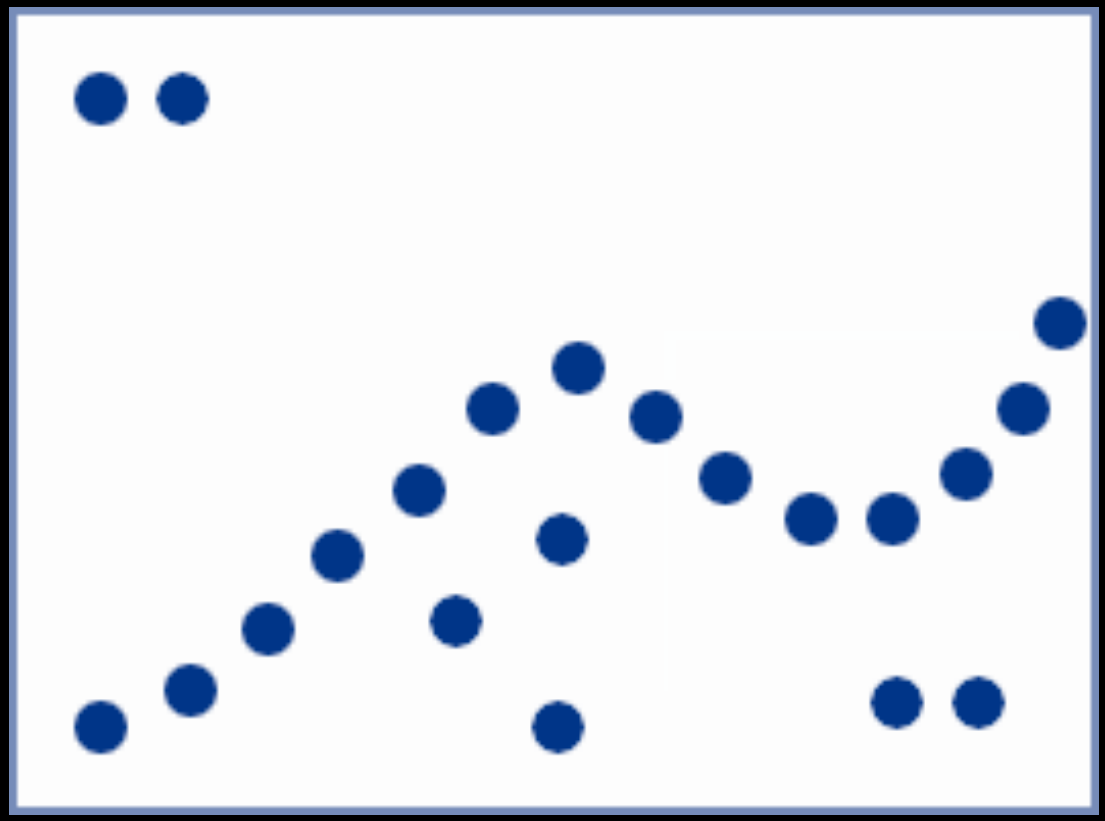


# Gestalt laws

• **Law of Similarity**:
The mind groups similar elements together. This similarity might depend on relationships of form, color, size, brightness, texture

# Gestalt laws

• **Law of Continuity**:
The mind continues visual, auditory, and kinetic patterns (multiple parts perceived as a flowing unit)



# Gestalt laws

• **Law of Symmetry (figure-ground relationships)**:
Symmetrical images are perceived collectively, even in spite of distance:

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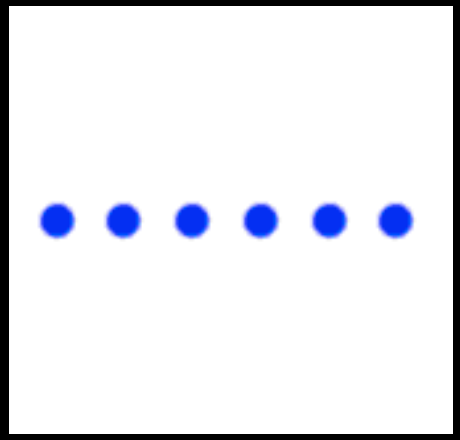
# Gestalt laws

- **Law of Common Fate**:

Elements with the same behavior are perceived as a collective or unit.

http://www.vanseodesign.com/blog/wp-content/uploads/2010/01/gestalt-common-fate.gif



# The importance of context

- Sinewave speech examples

Synthesized

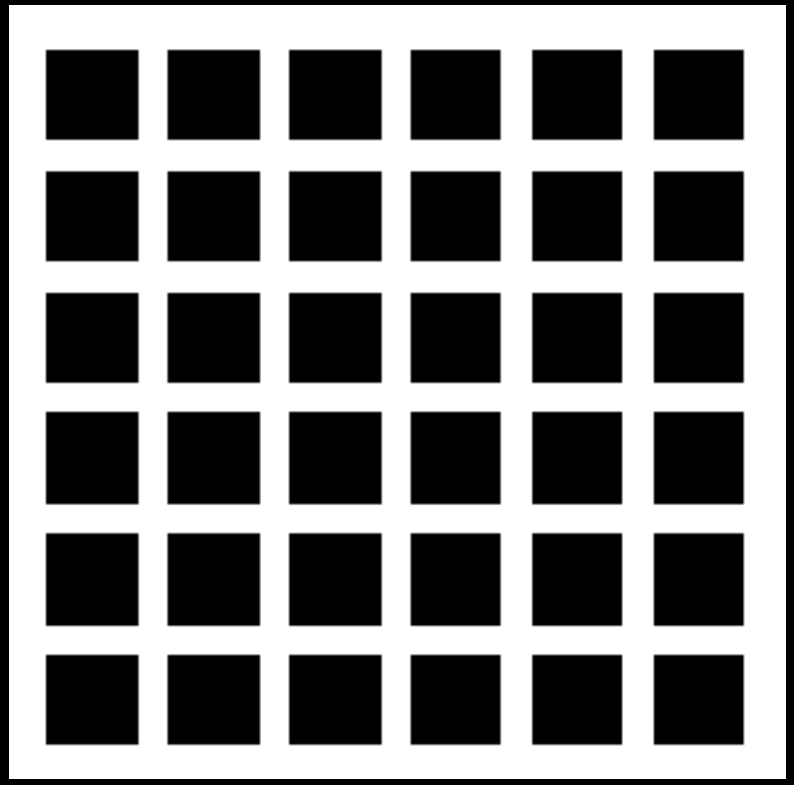
Recorded

*Original sentences from MRC Institute of Hearing Research web site, synthesized with Praat*

*Source: http://www.lifesci.sussex.ac.uk/home/Chris_Darwin/SWS/*

# Auditory illusions

• A system can be better understood through its behavior under stress, i.e through its glitches



# Auditory illusions

• Similarly to visual perception, many auditory illusions exist (Psychologist Diana Deutsch has found quite a few of them)

• Some include:

-the missing fundamental
- temporal induction (filling in the blanks)
- binaural beating
- Deutch' scale illusion
- glissando illusion
- octave illusion
- the tritone paradox or Shepard tones
- phantom melodies
- phantom words
- scheme-based illusions: phantom phone rings
- multimodality of perception: McGurk effect (interaction between hearing & vision)

# Auditory scene analysis

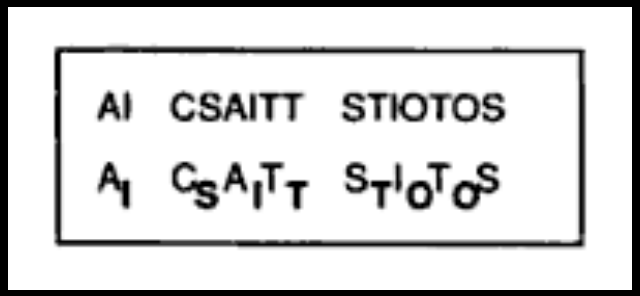
- The ‘cocktail party’ problem:

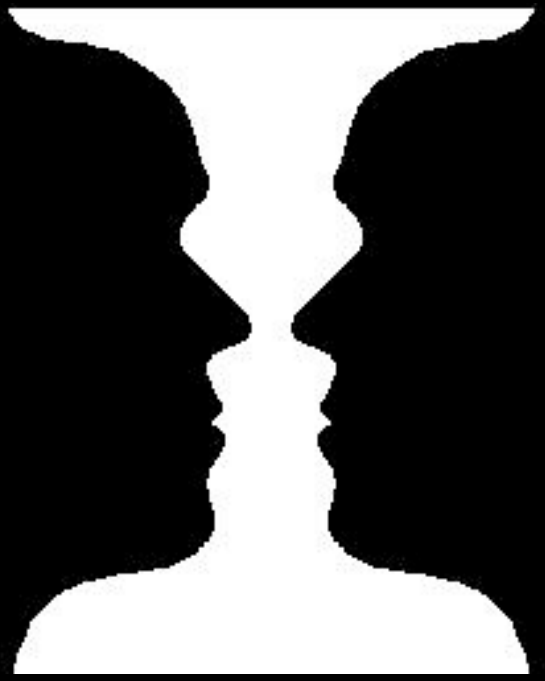
  How can a listener follow a single voice in a mixture of conversations and music?

  Through its distinctive qualities: pitch, spectrum, location, rate, rhythm

# Auditory scene analysis

- A term introduced by psychologist Albert Bregman. Explains how the human auditory system organizes sound into perceptually meaningful elements.
- Bregman's theory foundations lie in Gestalt psychology



# Auditory scene analysis | Auditory streams

- An auditory stream is a group of acoustical events that is perceived by the human mind as an entity

- *”An auditory stream is our perceptual grouping of the parts of the neural spectrogram that go together”*

A. Bregman, Auditory Scene Analysis

# Auditory scene analysis | Auditory streaming

- How it works:

Two modes:

➢ **Primitive auditory scene analysis**:

First, the 'scene' is broken down into separate analysis areas

in time

in spectrum

Then, the various perceptual events are grouped into units

➢ **Schema-based stream segregation**:

The experience of a listener with particular signals is an important factor (speech, music, machine sounds, etc). Schemas may become activated through detection of a particular pattern / sonority, etc, and can override or complement the primitive analysis

# Auditory scene analysis | Primitive analysis

- Two main processes are involved in the primitive auditory scene analysis:
  - Sequential integration
  - Spectral integration

# Auditory scene analysis | Sequential integration

- **Sequential integration,** or **temporal grouping:**

  Refers to putting together events that follow each other in time

  e.g.: rapid alteration of high & low tone (baroque music pseudopolphony, and phantom melodies)

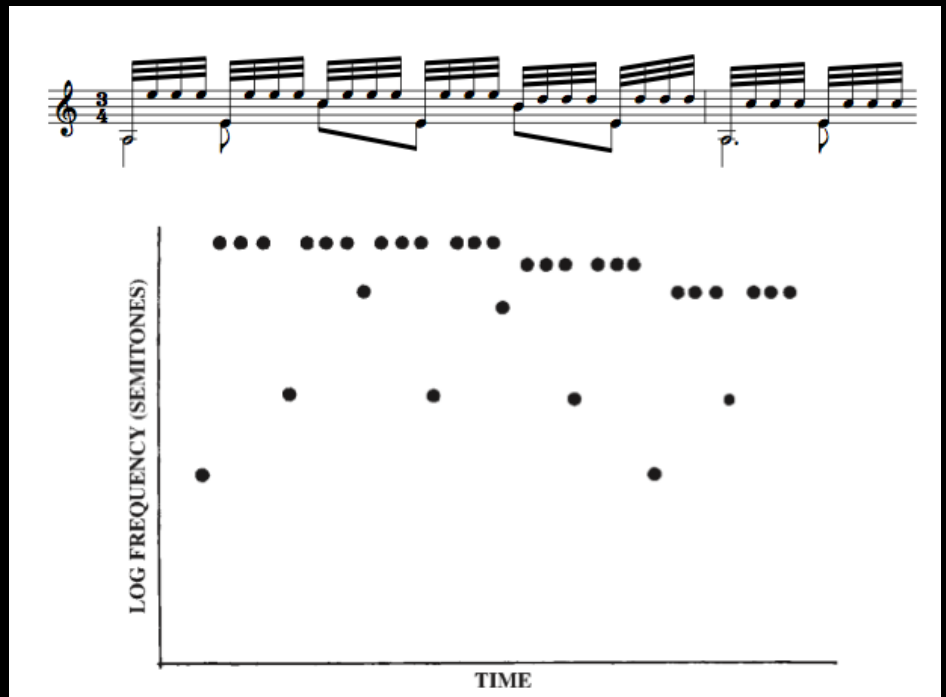



FIGURE 5 The beginning of *Recuerdos de la Alhambra*, by Tarrega. Although the tones are presented one at a time, two parallel lines are perceived, organized in accordance with pitch proximity. (Adapted from Deutsch, 1996.)

# Auditory scene analysis | Sequential integration

- Important factors:
  - frequency separation
  - rate of occurrence
  - spatial separation
  - timbre (e.g. brightness similarity)
  - loudness similarities also help with grouping

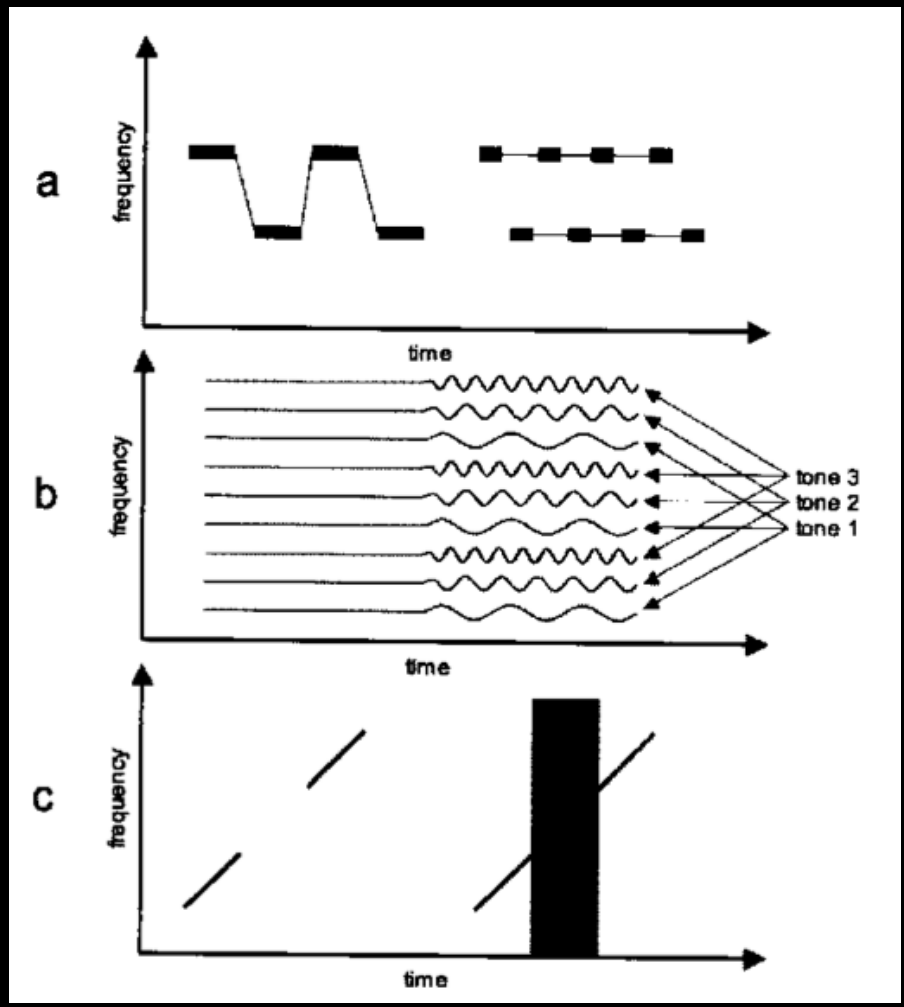
# Auditory scene analysis | Sequential integration

- Factors promoting sequential grouping
  - fundamental frequency
  - temporal proximity
  - spectral proximity
  - intensity
  - spatial origin

# Auditory scene analysis | Sequential integration

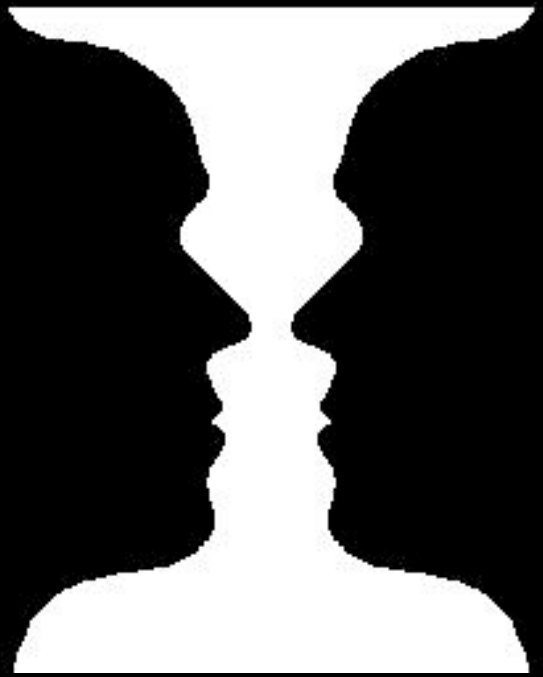
Examples:

- a) grouping by proximity
- b) grouping by common fate
- c) context: ‘old-plus-new’ heuristic



# Auditory scene analysis | Sequential integration

• Sounds can be ambiguous and flow from one group to another. However, usually they only belong to one group at a given moment (with some exceptions)



# Auditory scene analysis | Spectral integration

- **Simultaneous integration / spectral integration**:
  correlations and correspondences between spectral components.
  Memory plays a crucial part here ('old-plus-new' heuristic). Meaning that past events (the context) will influence the grouping and understanding of current events

# Auditory scene analysis | Spectral integration

• Factors promoting spectral grouping (similar - but not identical - to sequential grouping)

- frequency separation
- common fate:
  - direction of frequency change, caused by micromodulation, vibrato, portamento
  - amplitude changes, caused by micromodulation and event enveloping (e.g. ADSR)
- memory of past events
- harmonicity principle (harmonic components get grouped together) - used in orchestration extensively
- spatial separation

# Bibliography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*NOTE: All images were taken from these books, unless otherwise noted. Gestalt images taken from: http://www.sapdesignguild.org/resources/optical_illusions/gestalt_laws.html*