Music 175: Auditory Streaming

Tamara Smyth, trsmyth@ucsd.edu
Department of Music,
University of California, San Diego (UCSD)

May 21, 2019

Grouping into Streams

- Recall Gestalt principles of grouping: proximity, similarity, symmetry, continuity, and common fate.
- Principles of grouping enable parsing of streams of information.
  - If a sequence of tones is played with tones far enough apart in time, a melody can be tracked.
  - If the sequence is sped up, it becomes more difficult to track the transitions between large pitch leaps; you begin to hear tones in streams.
- The visual analog is *apparent motion*: objects tend to be conserved and the mind will construct whichever process is most probable.

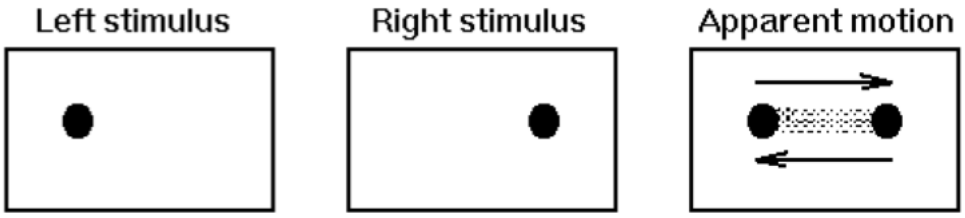

Figure 1: Dots alternating at sufficient speed can create apparent motion.

- Click to view

Stream Segregation

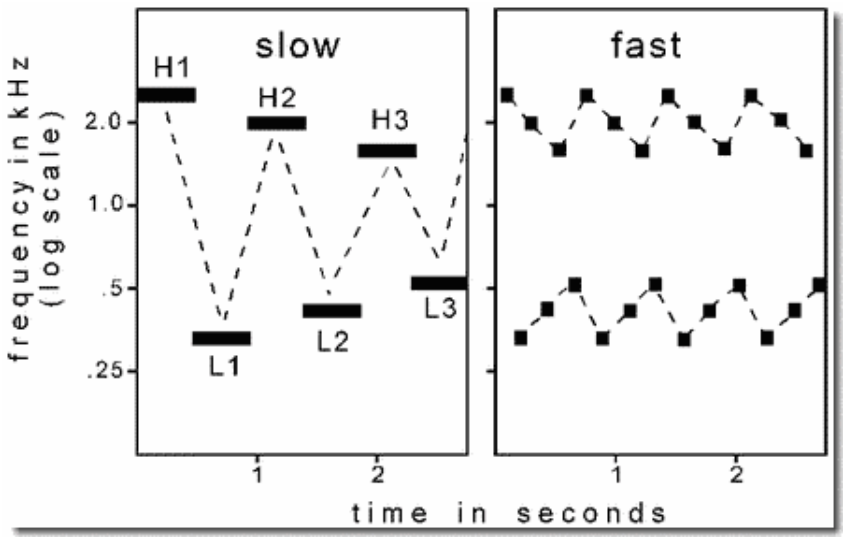

Figure 2: Stream segregation in a cycle of six tones.

- Sequence consisting of 6 tones, 3 high and 3 low, is repeated slowly (left) then fast (right):
  - When played slowly, alterations of high and low tones can be heard.
  - When played fast, two melodic streams develop (see dashed lines, right), one high and one low.
- The ability to hear the order of the tones is also affected: half of subjects heard that a set of three high tones preceded a set of low ones, or vice-versa.
- Click to Listen

Streaming: loss of rhythmic information

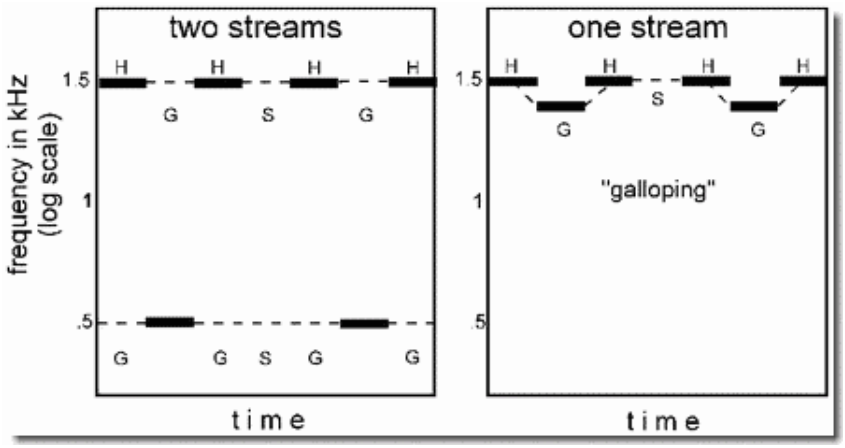

Figure 3: Loss of rhythmic information as a result of stream segregation.

- When sped up, a triplet pattern is replaced by two isochronous rhythms (left).
- Intermediate silences are a result of actual silence 'S' and gaps 'G' created by tones being "removed from the stream".
- The change also affects the perceived melody.
- Click to Listen
- Segregation is favored both by faster sequences and by larger separations between the frequencies.

Streaming: cumulative effects of repetition

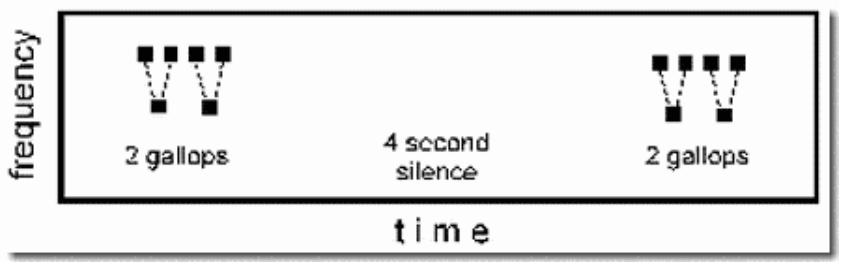

Figure 4: Groups of tones consists of 2, 4, 8, 16 and then 32 cycles, separated by silence.

- The auditory system tends to wait and only gradually increase the tendency for streams to segregate.
- In this example, listen to how tendency towards segregation builds during the cycle, and then dissipates during silences.
- Click to Listen

Streaming: effect of spectral peak

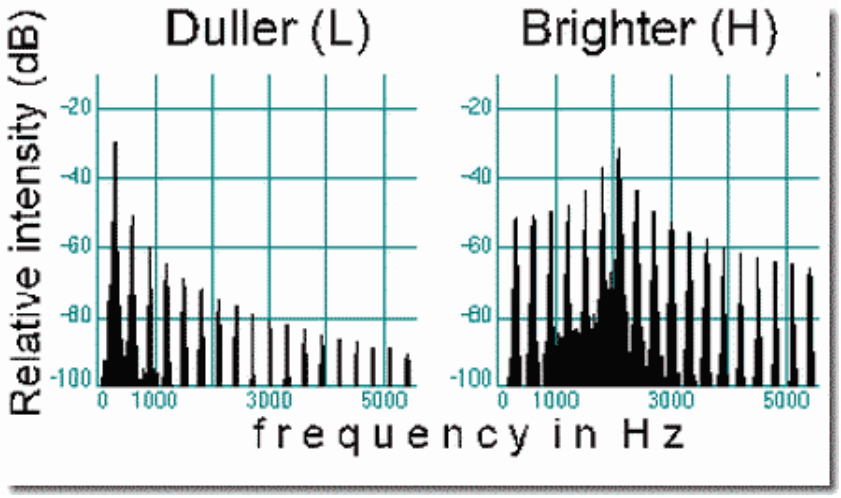

Figure 5: Segregation based on spectral peaks.

- Two tones with the same fundamental but with different spectral peaks are used to show stream segregation.
- Click to Listen

Streaming: effect of connectedness

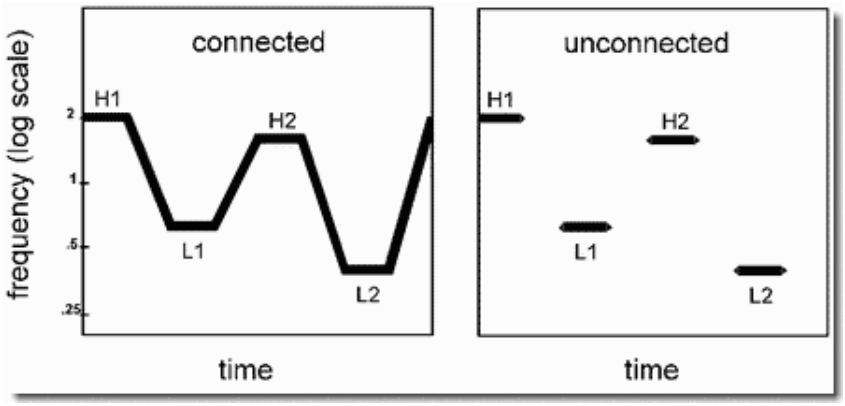

Figure 6: Segregation based on connectedness.

- A smooth continuous change helps the ear track a rapid frequency transition.
- Click to Listen

Applications

- Melodies tend to move in small steps.
  - In a sample of 3000 English folk songs, 68% of melodic transitions were no large than one diatonic step
  - 91% were no larger than two diatonic steps.
- If steps are larger and more rapid, melody would segregate into separate streams.
- Example: Yodeling (alternating between head and chest voice): Click to Listen
- Bach Chaconne For Solo Violin (exerpt). Click to Listen (start 4:50).
- Example: fast complex rhythms in tabla playing Click to Listen (start 21:35)
- Steve Reich: Come Out: Click to Listen

Ambiguity

- In the image below, we see either two faces or a candlestick—not both at the same time.

Figure 7: Reverse optical illusion.

- Phantom words by Diana Deutsch (UCSD):
  - what word is heard and does it change? sound
- Mysterious Melody by Diana Deutsch (UCSD):
  - Can you identify a well-known melody with notes played in different octaves? scrambled / unscarambled

  - This demonstrates use of previously acquired knowledge in peception.
  - Visual example: an ambiguous image may be interpreted in a number of ways; (see here).
  - Once told it is a dalmation, shapes of identifiable characteristics (ears, nose, tail etc.) begin to emerge to make it so.
  - Audio example: shows importance of pitch (height) vs pitch class in melody.

- Two melodies may seem scrambled if not separated by some feature (pitch height or timbre).

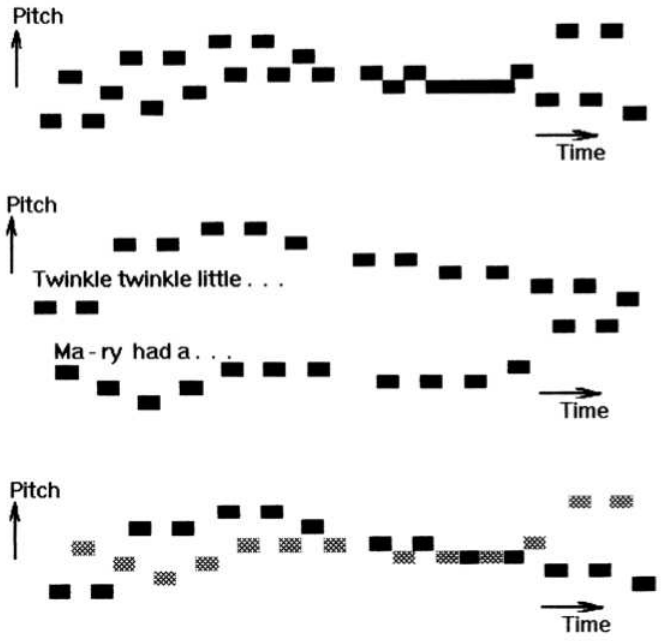

Figure 8: Overlapped melodies may be separated with timbre or register (pitch height).

Shepard Tones

- Tones consist of a number of sinusoidal components, an octave apart, with a fixed spectral envelope that goes to zero at low and high frequencies.

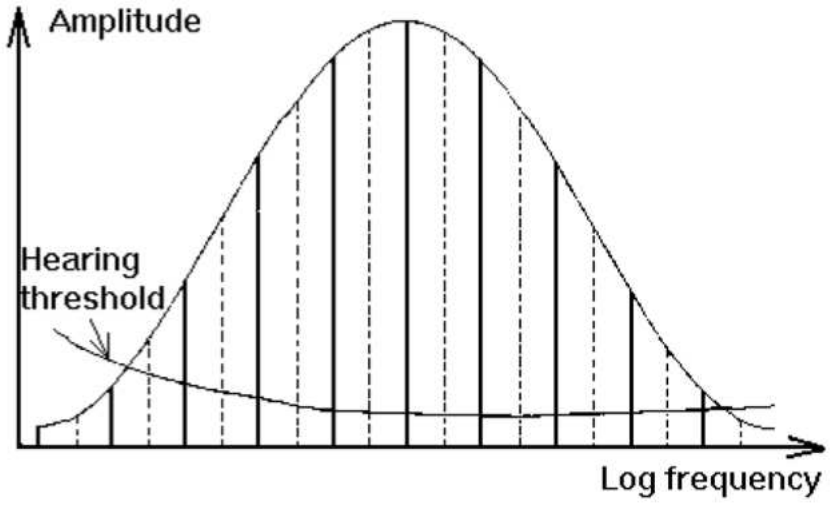

Figure 9: Shepard tone spectrum.

- When frequencies of the sinusoidal components are raised, we get the sense of an increase in pitch.
- Shepard tone:
  - sinusoidal components are raised repeatedly (or continuously) such that the pitch seems to rise;

  - new low-amplitude components appear at the lowest frequency according to the sound's fixed envelope;
  - once 12 semitones is reached the tone is back to the beginning (yet having left the impression it is continually rising) showing the impact of **common fate**.

- The pitch appears to increase endlessly: (play auditory demo: "circularity in pitch judgement").

Distorting Perspective

- Penrose Stairs: Click to watch
- Though impossible in three dimensions, the 2-d figure achieves this paradox by distorting perspective.

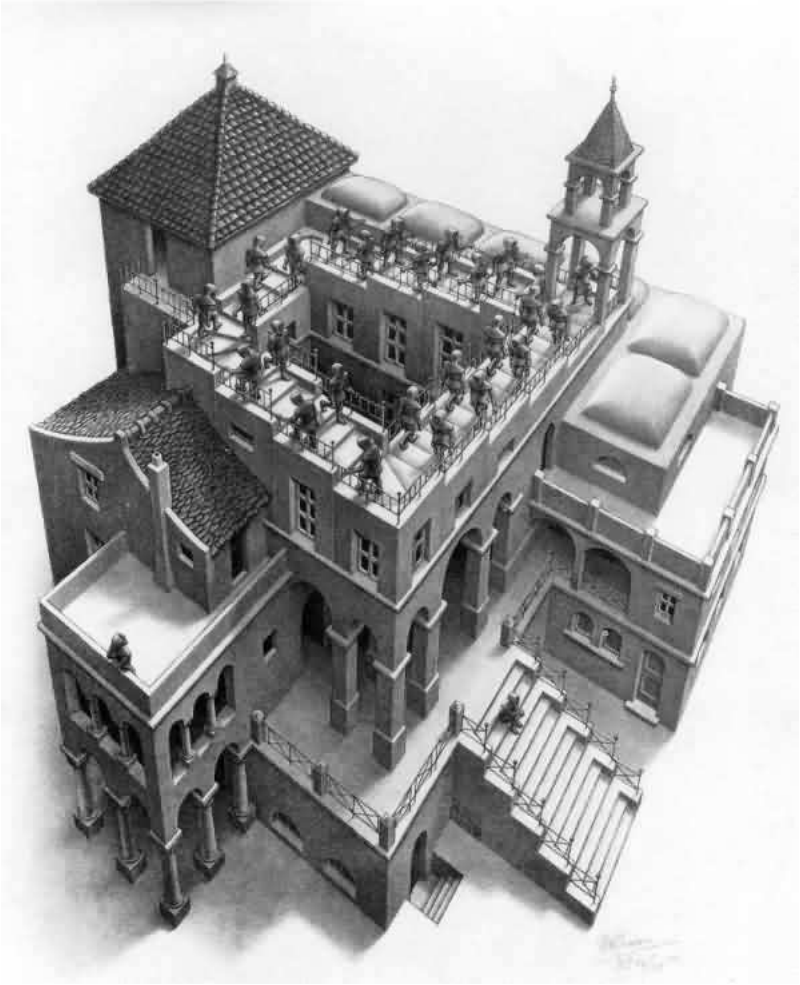

Figure 10: Escher lithograph.

Octave Ambiguity—Circularity in Pitch Judgement

- Tones have clear pitches, but ambiguous octaves—i.e., they are of the same *pitch class*.
- Ambiguous octave tones were used by Shepard and Risset to create illusions of endlessly ascending or descending pitches.
- Risset's Continuous Scale:
  - Click to listen
  - Click to listen
- Example uses:
  - end of "I am the Walrus" (Beatles) Click to listen
  - The Batpod sound effect: Click to listen

Tritone Paradox

- Discovered by Diana Deutsch (UCSD) in 1986.
- Click to Listen
  - Example consists of four two-tone patterns.
  - Decide whether it is going up or down in pitch.
  - When listening in groups, some people hear a pattern as ascending, others descending.
- Two computer-produced tones, a tritone apart, are played in sequence: for some, that pattern has the illusion of ascending, while for others, it's decending.
- Generally, when a melody is transposed, the perceived relationship between tones is unchanged.
  - In the Tritone Paradox, when one pair of notes is played (C followed by F#), a listener might hear a descending pattern.
  - Yet when a different pair is played (G# followed by D) the same listener hears an ascending pattern.