Auditory Stream Segregation (Sequential Integration)

David Meredith
Department of Computing,
City University, London.
dave@titanmusic.com
www.titanmusic.com

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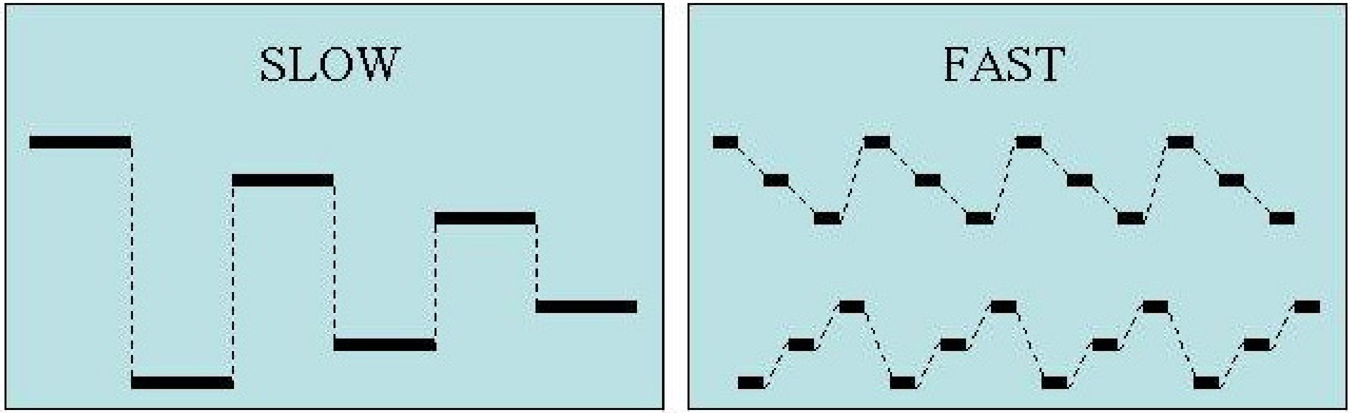
1. Sequential integration

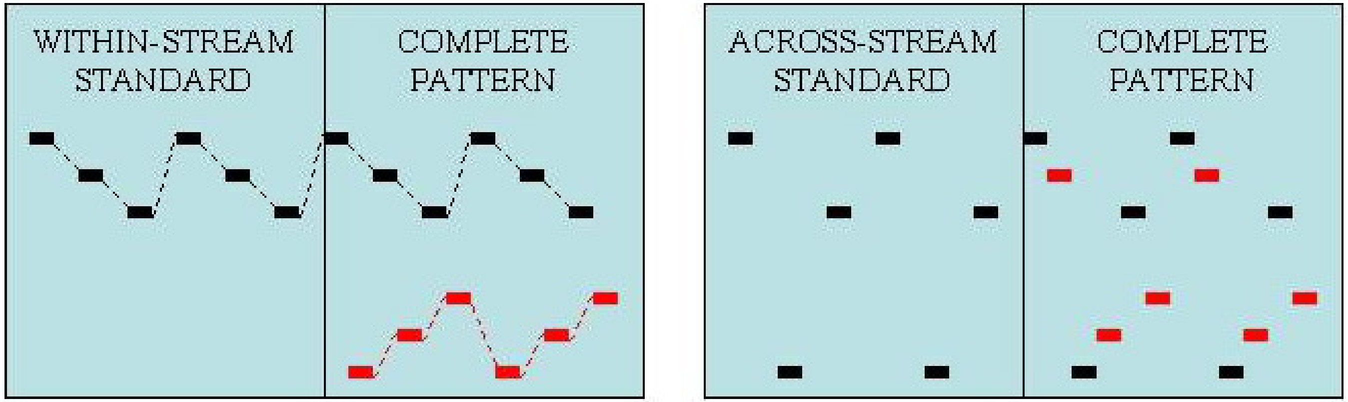
- *Sequential integration* is the connection of parts of an auditory spectrum over time to form concurrent streams (Bregman and Ahad, 1995, p. 7).
- The connection of consecutive tones played on a single instrument to form a single percept (stream) that we call a melody is an example of sequential integration.
- Another example of sequential integration occurs when we hear a sound to continue even when it is joined by other sounds to form a mixture.
- Sequential integration occurs until a sound changes suddenly, for example, in frequency content, timbre, fundamental, amplitude or spatial location.
- Compare with the way the Gestalt principle of similarity governs the way we segment musical passages into groups: sudden changes induce us to hear group boundaries (e.g., Lerdahl and Jackendoff's (1983, p. 46) GPR 3).
- Grouping is the segmentation of streams into structural units.
- In everyday sounds, as opposed to musical ones, we associate a separate stream with each separate sound source.
- When the sound of our environment reaches our ear, it arrives as a mixture of sounds from many sources.
- Our brain must process this mixed sound, identify the various sources of the sounds forming the mixture and then assign a stream to each source.
- Each stream can have its own melody and rhythm.
- We are much better at recognizing patterns of sounds and temporal relationships between sounds when the sounds are all in the same stream.

2. Stream segregation in a cycle of six tones
(Bregman and Ahad, 1995, p. 8, Track 1)



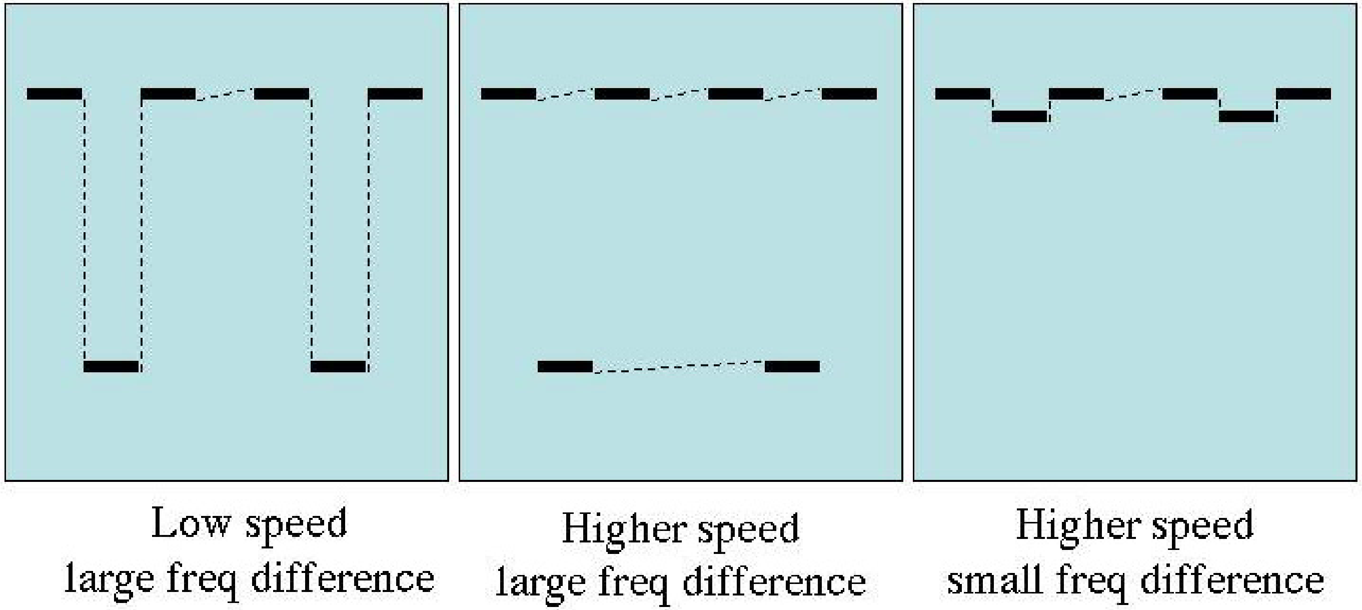
- Based on experiment by Bregman and Campbell (1971).
- When played slowly, all six tones integrate into a single stream.
- When played fast, pattern divides into two streams with the three high tones in one stream and the three low tones in the other.
- In slow version, easy to hear that first low tone comes immediately after first high tone.
- But when played fast, difficult to perceive temporal relationships between tones in different streams.

3. Pattern recognition, within and across perceptual streams (Bregman and Ahad, 1995, pp. 9–10, Track 2)



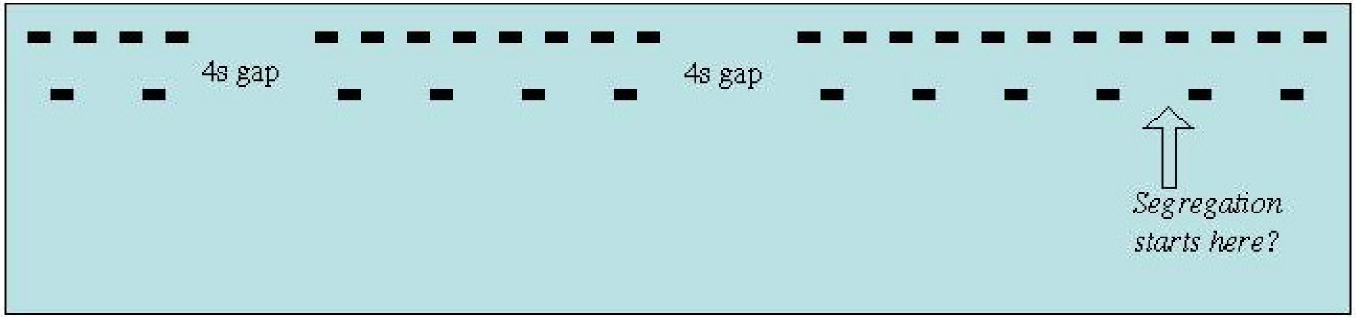
- Easy to hear 'within-stream' standard.
- Very hard to hear 'across-stream' standard.
- Shows that we find it hard to attend to more than one stream at a time.
- We also find it hard to switch our attention quickly back and forth between streams.

4. The effects of speed and frequency on stream segregation (Bregman and Ahad, 1995, pp. 11–12, Track 3)



- When 'galoping pattern' (van Noorden, 1975, 1977) splits into two streams, each of these streams has a different isochronous rhythm.
- Each stream has its own rhythm and melody.
- In galoping pattern, a larger frequency difference between the high and low tones and a faster speed of presentation promote stream segregation.
- Result of Gestalt principle of proximity operating in a two-dimensional space in which one dimension is log-frequency and the other is time.

5. Effect of repetition on streaming (Bregman and Ahad, 1995, p. 13, Track 4)

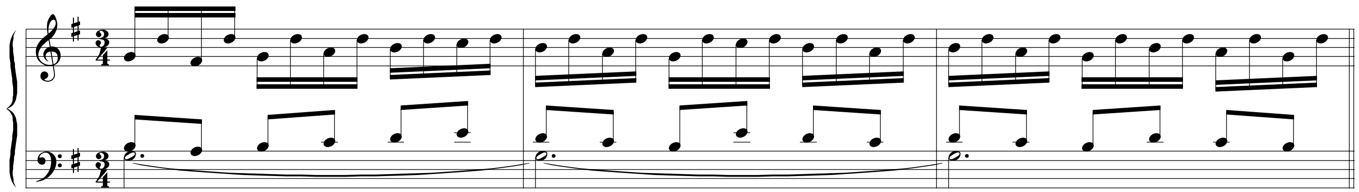


- When we segregate a sequence into two streams, this does not happen immediately—it only happens after we've heard a few cycles of the repeating pattern.
- If we responded too quickly, this would give rise to highly volatile interpretations. We therefore accumulate evidence for a particular interpretation until we have enough to switch to that interpretation (Bregman, 1990, p. 130).
- As the sequence of repeated gallop patterns gets longer, our perception of segregation gets stronger.

6. Segregation of a melody from distractor tones (Bregman and Ahad, 1995, p. 14–15, Track 5)

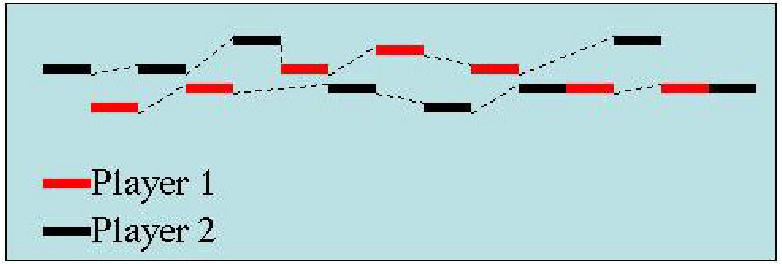
- Segregation also occurs in non-repetitive sequences.
- Demonstration consists of 5 sequences.
- In each sequence, melody tones interleaved with distractor tones.
- In each successive sequence, frequency range of melody pulls further and further away from that of the distractors.
- In first sequence, melody frequency range is the same as that of the distractors therefore one stream is formed and the melody is hard to identify.
- In the fifth sequence, the melody frequency range is far from that of the distractors therefore two streams form and the melody is easy to identify.

7. Segregation of high tones from low tones in a Prelude by Bach (Compound melody)



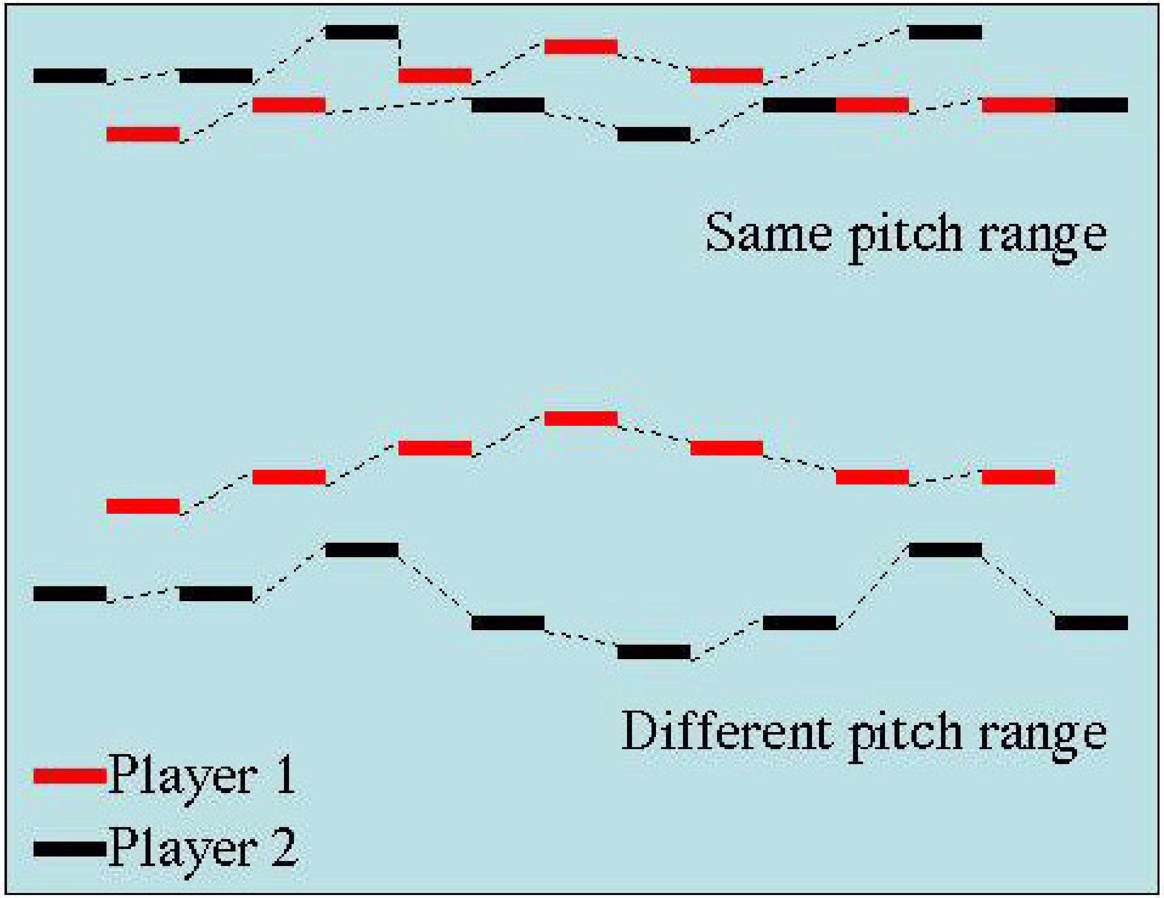
- Right-hand part segregates into two, isochronous streams.

8. Streaming in African xylophone music
(Bregman and Ahad, 1995, pp. 15–16, Track 7)

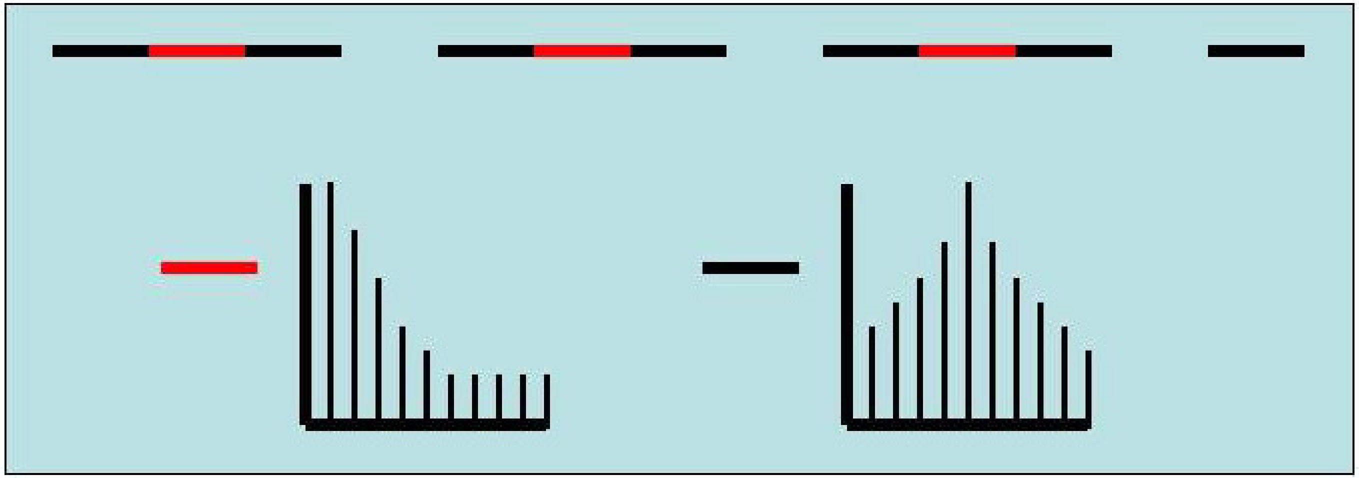


- Wegner (1990, 1993) identified some interesting instances of streaming in Ugandan amadinda music.
- Each of two players plays a repeating pattern, the notes of one player interleaved between those of the other.
- When heard separately, each part is isochronous.
- When heard together, combined sequence is segregated into two streams on the basis of pitch proximity giving rise to two streams with irregular rhythms.
- The perceived streams do not correspond to the individual parts played by the performers.

9. Segregating the two players' parts in Ugandan amadinda music (Bregman and Ahad, 1995, p. 19)

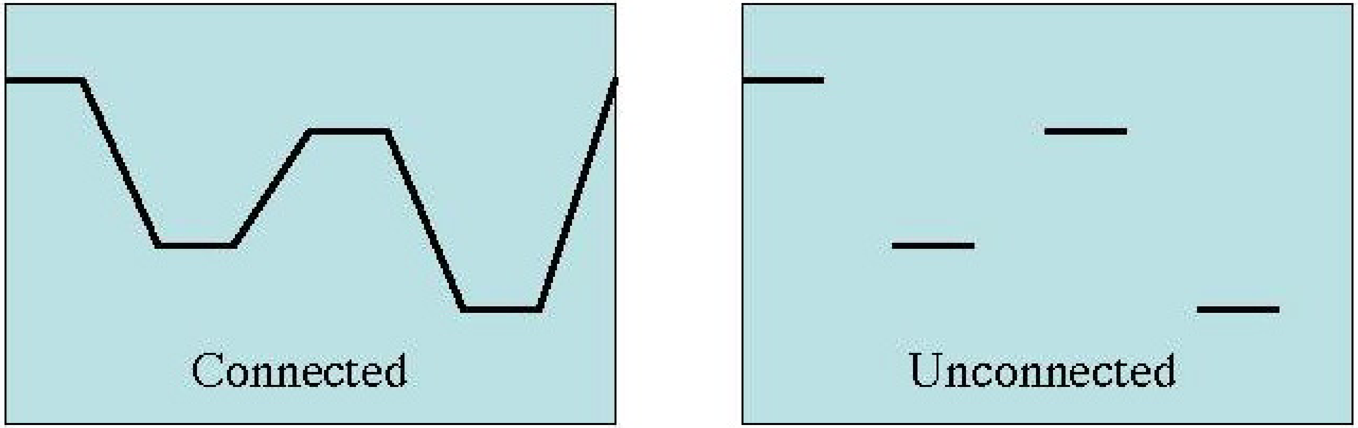


10. Stream segregation based on timbre difference (Bregman and Ahad, 1995, p. 21, Track 10)



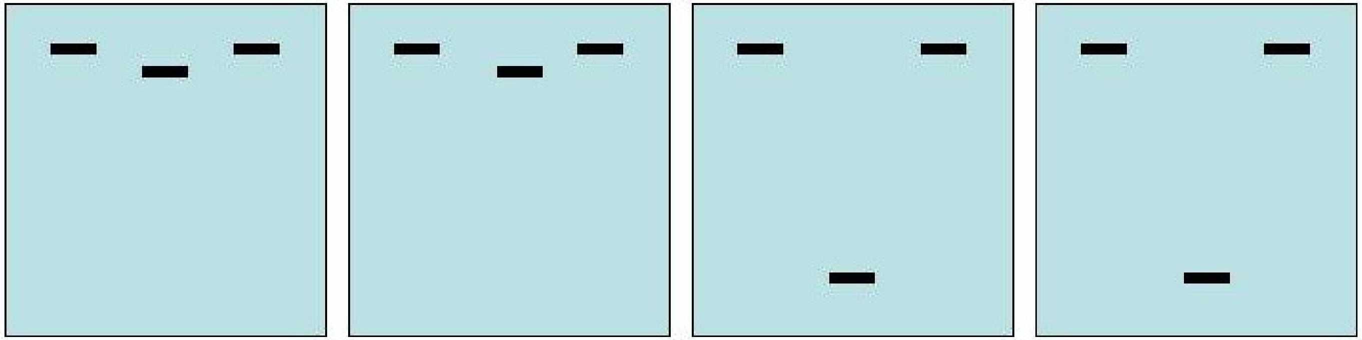
- If all three tones in the galloping pattern have the same fundamental but the middle tone has a different timbre from the first and third tones, then, at a particular speed of presentation, the sequence will split into two streams, each stream containing tones with a particular timbre.

11. Effects of connectedness on segregation (Bregman and Ahad, 1995, pp. 23–24, Track 12)



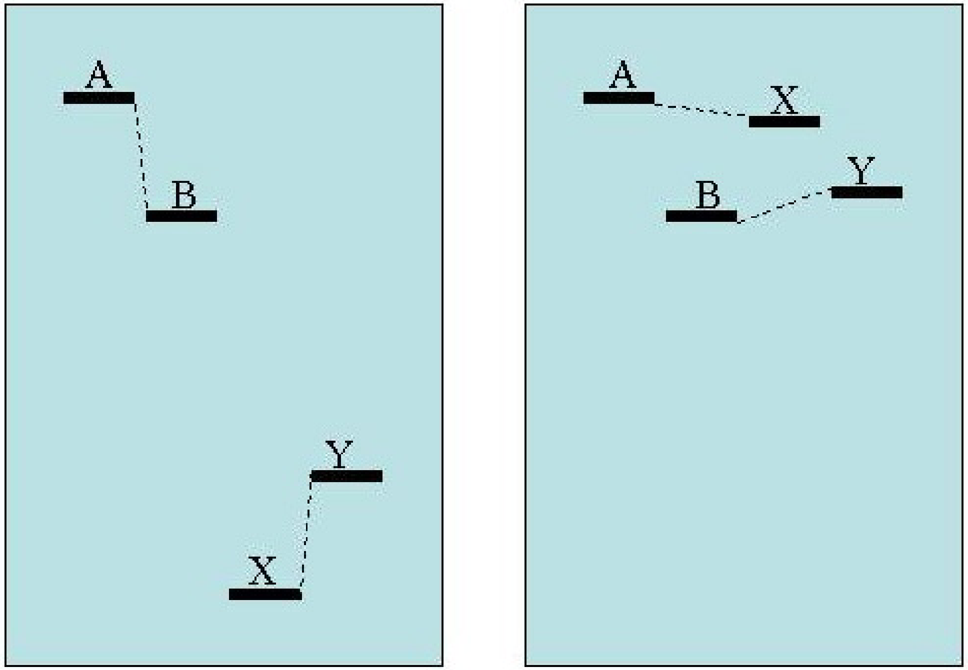
- Gestalt principle of good continuation also influences way we hear streams.
- Bregman and Dannenbring (1973) showed that inserting frequency glides between tones in a sequence promotes sequential integration.
- Could be just another manifestation of grouping by similarity or proximity.

12. Effects of stream segregation on timing judgements (Bregman and Ahad, 1995, pp. 25–26, Track 13)



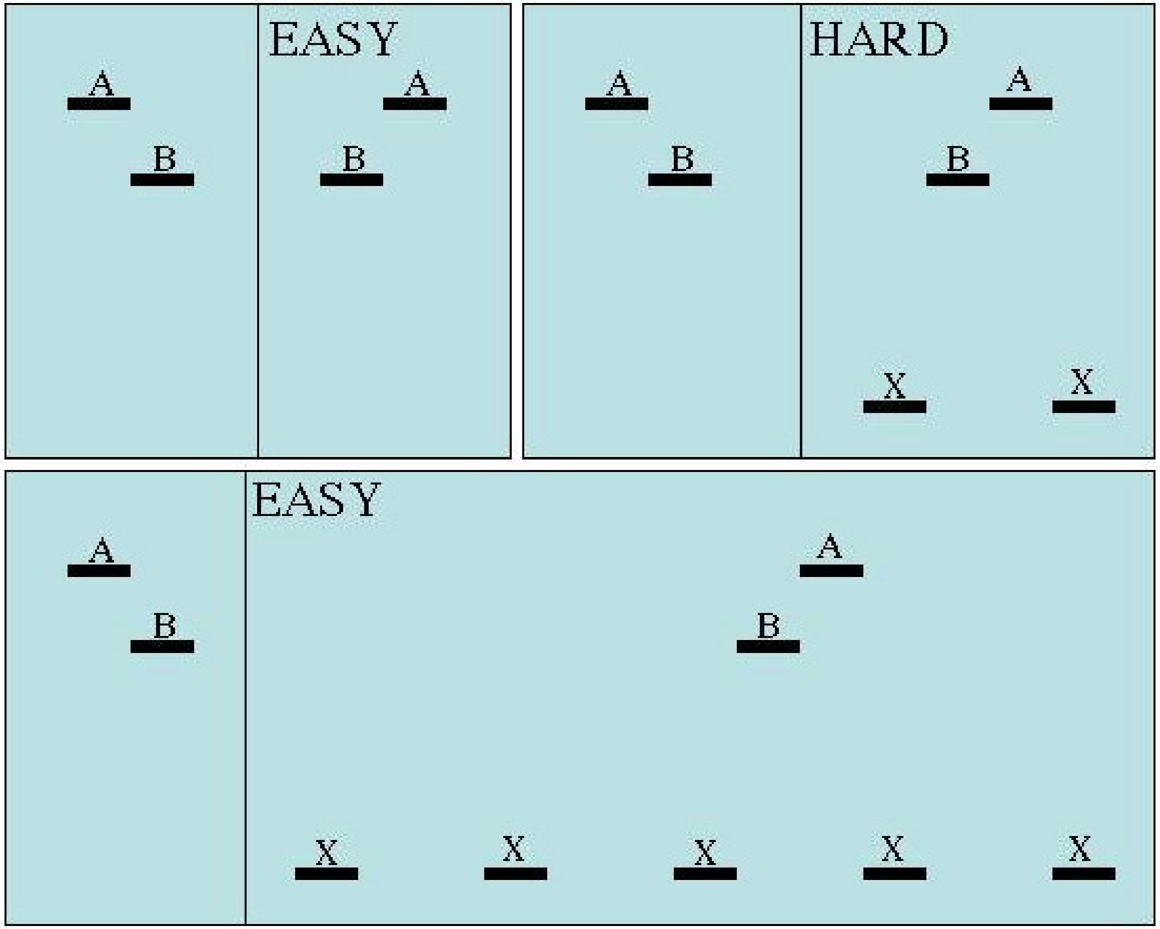
- It is much harder to perceive temporal relationships between tones when they are in different streams than when they are in the same stream.
- Demonstration based on experiment by van Noorden (1975).

13. Competition of frequency separations in the control of grouping (Bregman and Ahad, 1995, pp. 28–29, Track 15)

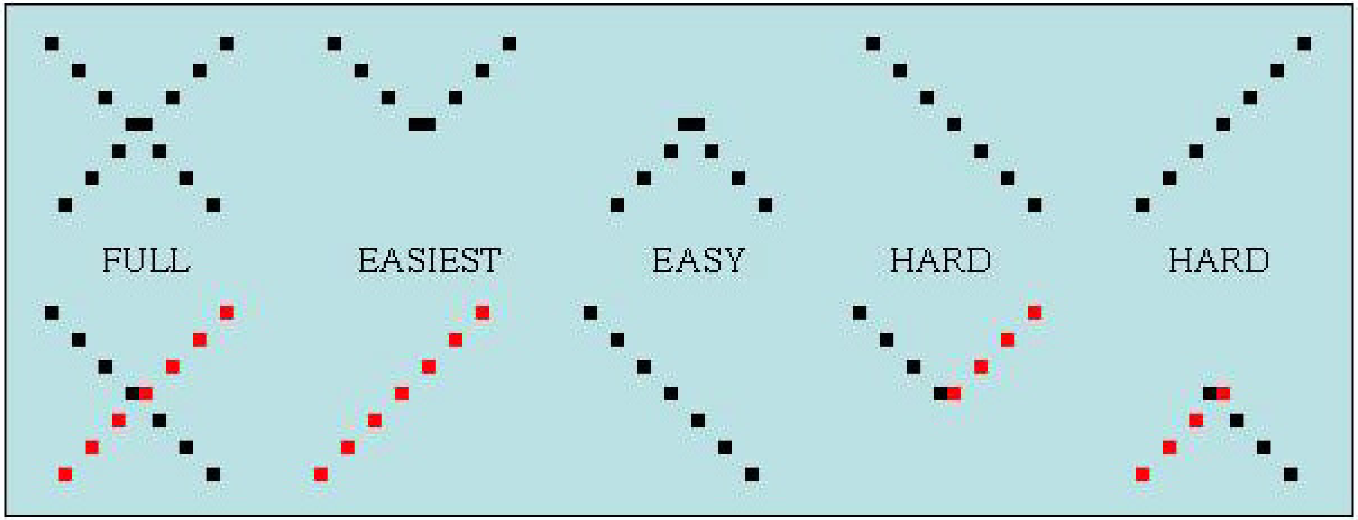


- When XY are far away from AB in frequency, it is easy to hear AB in ABXY.
- When X is integrated with A into the same stream and Y is integrated with B into a different stream, it is hard to hear AB in ABXY.

14. The release of a two-tone target by the capturing of interfering tones (Bregman and Ahad, 1995, pp. 29–30, Track 16)



15. The perception of ‘X-patterns’ (Bregman and Ahad, 1995, pp. 31–32, Track 17)

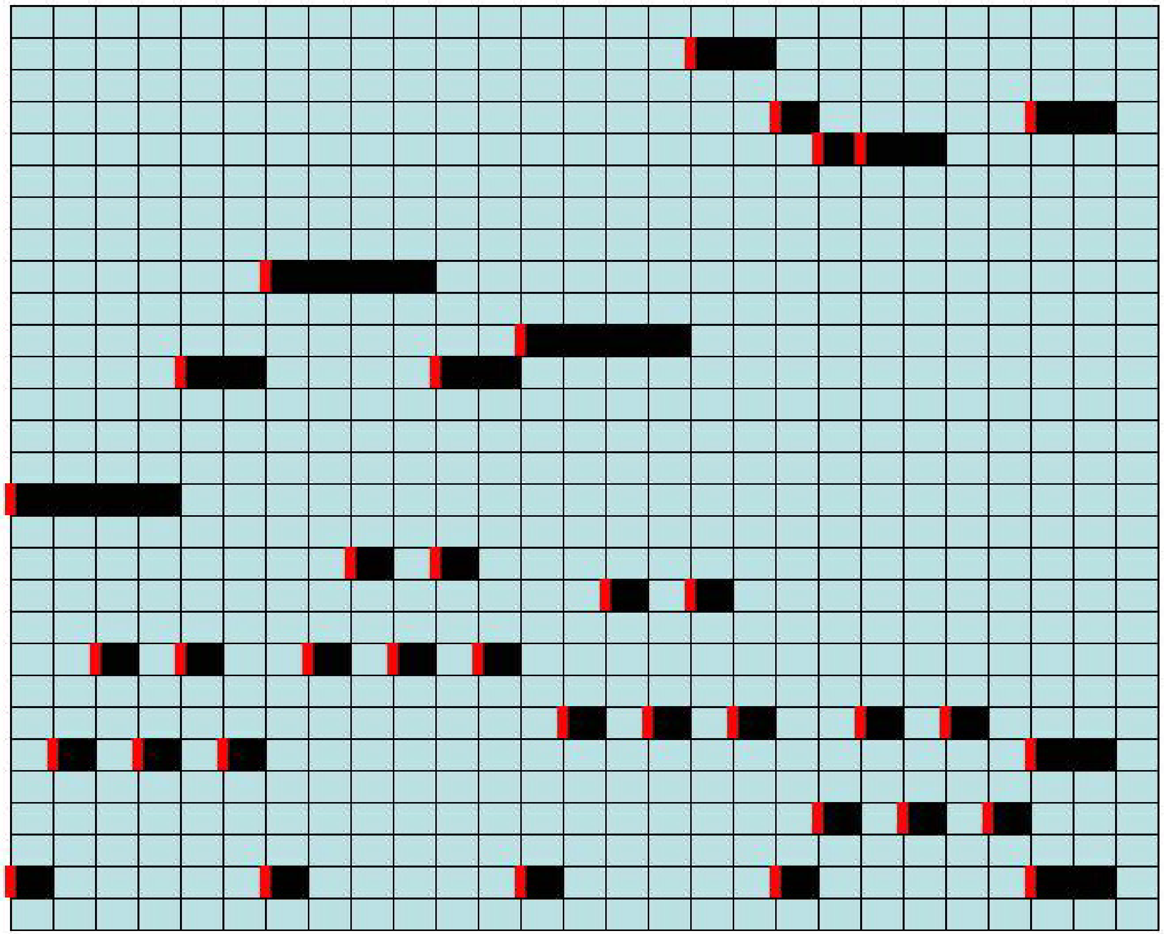


- Tougas and Bregman (1985) studied perception of X-patterns.
- Listeners hear a ‘bouncing percept’ unless forced to hear a crossing percept by emphasizing either the descending or the ascending sequence of tones by, for example, timbral differences between the sequences.

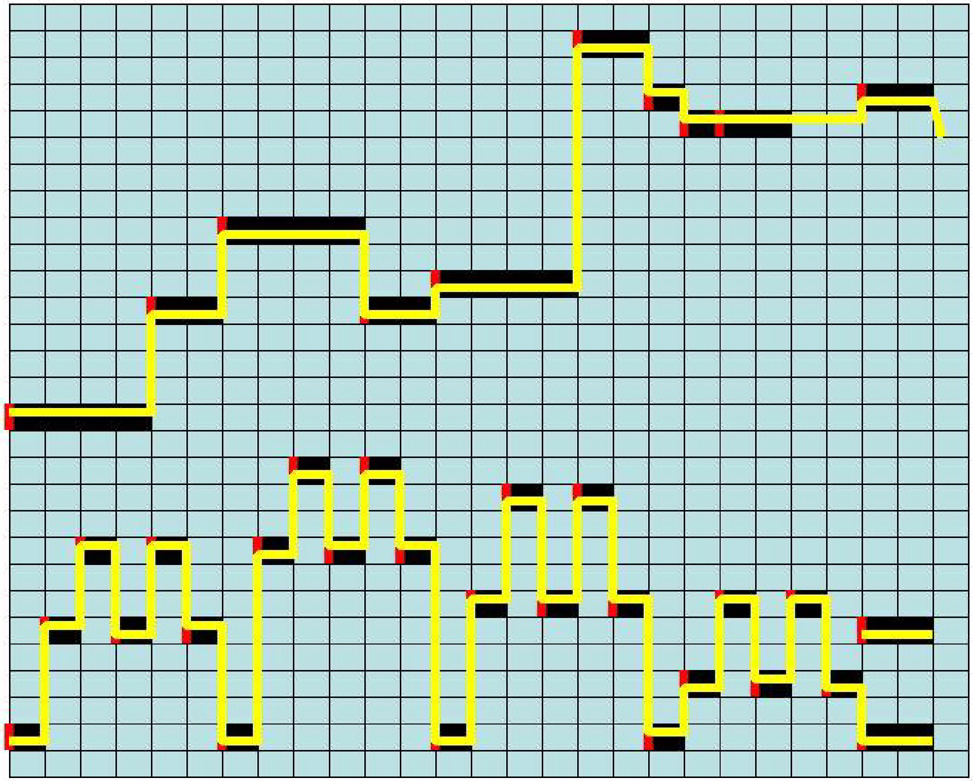
16. Temperley's (2001) Computational Theory of Music Cognition

- Theory is heavily influenced by GTTM.
- Presents models of metre, phrasing, counterpoint, harmony, key and pitch-spelling.
- Each model contains well-formedness rules and preference rules.
- Implemented as computer programs.
- Optimisation problem of finding best analysis solved using dynamic programming technique.

17. Temperley's (2001) Computational Model of Contrapuntal Structure: The Input Representation



18. Temperley's (2001) Computational Model of Contrapuntal Structure: The Well-Formedness Rules



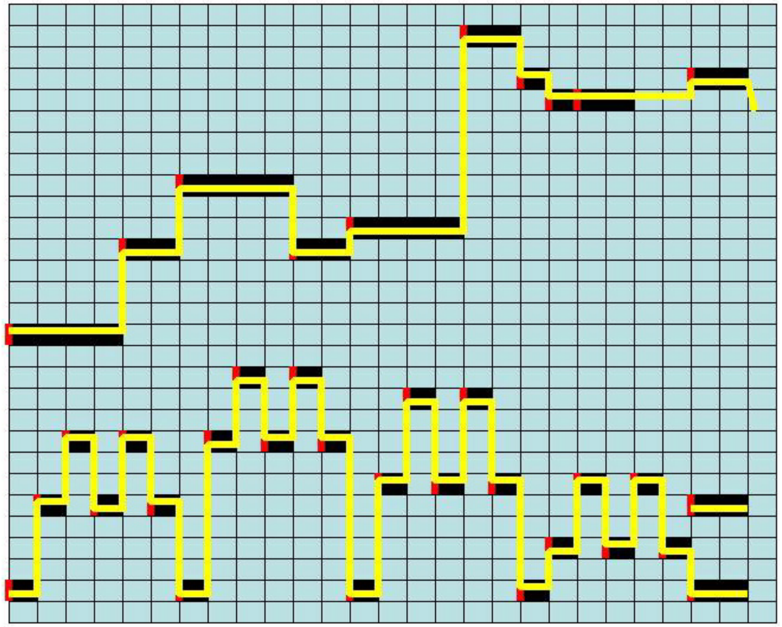
CWFR 1 A stream must consist of a set of temporally contiguous squares on the plane.

CWFR 2 A stream may be only one square wide in the pitch dimension.

CWFR 3 Streams may not cross in pitch.

CWFR 4 Each note must be entirely included in a single stream.

19. Temperley's (2001) Computational model of contrapuntal structure
The Preference Rules



CPR 1 (**Pitch Proximity Rule**) Prefer to avoid large leaps within streams.

CPR 2 (**New Stream Rule**) Prefer to minimize the number of streams.

CPR 3 (**White Square Rule**) Prefer to minimize the number of white squares in streams.

CPR 4 (**Collision Rule**) Prefer to avoid cases where a single square is included in more than one stream.

20. Temperley's (2001) Computational Model of Counterpoint
Testing the theory

- Comparison of predictions of rules with results of experiments on auditory stream segregation.
- Running program on Bach Fugues.

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