Selective Attending to Auditory Streams in Complex Sequences: Frequency and/or Temporal Expectations?

Carolyn Drake, Renaud Brochard and Matthieu Adenier

Abstract: The aim of this study was to investigate the conditions under which a cue sequence may facilitate the focusing of attention on a particular subsequence within a complex auditory sequence, and to evaluate the respective roles of frequency and temporal information in this process of stream segregation. Thirty-one listeners detected a temporal irregularity embedded within one of three isochronous subsequences (varying in frequency and tempo) played simultaneously to create a complex sequence. Stream segregation was facilitated by focusing attention on one of the subsequences by preceding the complex sequence with a cue. We systematically varied the type and quantity of frequency and temporal information contained in the cue. The results indicate that, with a large frequency separation between subsequences, frequency information facilitated stream segregation more than temporal information, although the latter did contribute significantly. Stream segregation was considerably reduced with a small frequency separation, and was unaffected by the type of cue.

INTRODUCTION

When listening to a complex sound environment composed of multiple sound sources, listeners must organize incoming information in such a way as to separate the sound mixture into distinct sources and perceptually link over time sound events with similar physical characteristics which are presumed to belong to the same source (1). Once a complex sequence has been perceptually organized into streams, events within a stream can be coded in relation to each other, but not in relation to events in other streams. Previous studies have suggested that stream segregation can be facilitated by focusing listeners' attention on particular aspects of the complex sequence before they hear it. It is well established that frequency information may be an efficient cue, whereas the possible role of temporal information is more contentious. This experiment was designed to evaluate the relative effectiveness of frequency and temporal information on the ability to focus attention on a particular subsequence, and thus facilitate stream segregation.

METHOD

Procedure. Listeners heard two complex sequences, each composed of three isochronous subsequences defined by a specific tempo (300, 500, or 700 ms IOI) and frequency (see later). One of the complex sequences contained a local temporal irregularity created by advancing or delaying the onset of one tone in one of the subsequences by 15%. Listeners were required to detect this temporal change which was only detectable if they focused on the appropriate subsequence. The two complex sequences were preceded by a cue sequence in order to facilitate this focusing. Seven cue sequences were used which varied in the type and quantity of information provided: 1) both frequency and temporal information (FT = pure tone isochronous sequence), 2) reduced frequency and temporal information (FTR = two tones provided one interval), 3) only frequency information (F = continuous pure tone), 4) only temporal information (T = isochronous chord sequence), 5) reduced temporal information (TR = two chords provided one interval), 6) irregular temporal information (TI = irregular chord sequence), and 7) no information (S = silence). The tones within a complex sequence could be close in frequency (separated by 1 ERB: 568, 659, 760 Hz) or far apart (separated by 6 ERBs: 234, 659, 1435 Hz). Each subject did the 126 trials in a different order (7 cues, 9 tempo/frequency combinations, 2 frequency separations), over 4 blocks lasting 1.5 hours.

Apparatus. Sequences were generated by a synthesizer (Oros) controlled by a PC. Subjects sat in a sound-proof room and listened to sequences through headphones (TDH 49). A programmable attenuator (Charybdis D) controlled sound levels. Sequences were composed of 50-ms tones, presented binaurally at 70 dB SPL.

Subjects: 31 subjects participated in the experiment. They all reported normal hearing.

2351
RESULTS

Figure 1 shows the percentage of correct irregularity detections in the 7 cue conditions for the large and small frequency separations. An ANOVA revealed significant main effects and interaction between the two factors. As predicted, performance was poor with a small frequency separation and was unaffected by the type of cue. However and contrary to expectations, the performance always differed from chance level, even in the Silence condition. This suggests that listeners were less good at stream segregation: performance only differed from chance level in certain frequency/tempo combinations (an interesting finding beyond the scope of the present paper). Performance was much higher when there was a large frequency separation, and as predicted, was greatly affected by the information contained in the cue sequence. By construction, optimal performance was observed when the cue contained both frequency and temporal information (FT). Performance did not deteriorate when the temporal information was removed (FT = F), whereas it did when frequency information was removed (FT > T). Very little frequency information is sufficient as performance was a good with two tones as it was with a whole sequence (FTR = FT). However, we cannot conclude that temporal information does not play a role because, whereas FT > T, performance was better with a full temporal sequence than with a reduced temporal cue (T > TR), an irregular temporal cue (T > TI) and silence (T > S). Thus, sufficient regular temporal information facilitates stream segregation. Performance was above chance with the silent cue, confirming that stream segregation was possible with the wide frequency separation, even without a focusing aid.

CONCLUSION

This study has demonstrated that stream segregation can be facilitated by focusing listeners' attention on particular aspects of the complex sequence before they hear it. Frequency information is sufficient and the most efficient. However, contrary to some previous results, temporal information can, to a lesser degree, facilitate stream segregation with better performance for regular than irregular sequences, and for longer than shorter sequences.

REFERENCES