The influence of frequency on perceived temporal rate is larger in demanding listening situations

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Introduction

- Co-variations of acoustic features are common in the sounds humans experience in everyday life, such as speech and music.
- For example, temporal modulation rate and frequency change together in consistent ways: increases in the rate of speech and music are associated with increases in fundamental frequency (Broze & Huron, 2013; Topbas et al., 2012).
- Co-variations of acoustic features are thought to provide redundancy in rapidly changing soundscape and to support perception.

- However, it is unknown whether the attentional state of an individual affects the degree to which co-variations influence perceptual inferences.
- We exploited a perceptual interdependency between modulation rate and frequency in Experiment I and examined whether prior information about the degree to which a sound changes in modulation rate or frequency (Exp. III) or a concurrent distractor task (Exp. III) would alter the degree to which people rely on frequency information to make decisions about modulation rate.

Methods: Stimulus Materials

- Amplitude-modulated sounds of 4 s duration.
- The modulation rate of the sounds either decreased or increased over time (5-Hz starting modulation rate; 8-10 levels).
- Sounds also changed in carrier frequency over time; the sound-initial carrier frequency was always 1300 Hz and changed over time (5-Hz starting modulation rate; 8-10 levels).

Participants (N=23) performed an AM-rate change discrimination task. Results: The PSE differed between frequency decreases and frequency increases (P < 0.001; AM-rate change illusion; difference of curves in x). The illusion is larger for frequency changes

![Image](Image 1)

Frequency change

- Modulation rate change (JND unit)

![Image](Image 2)

Experiment I: Influence of Frequency on AM-Rate Change Discrimination

Experiment II: Cue Benefit

- Experiment I demonstrated that AM-rate changes are more likely to be perceived as slowing down when the sound frequency decreases and as speeding up when frequency increases. This illusion is in line with previous studies using frequency-modulated sounds or pieces of music (Boltz, 2011; Herrmann et al., 2013).
- The illusion is probably the result of extensive experience of co-variation in modulation rate or tempo and frequency, common in natural sounds (Topbas et al. 2012; Broze & Huron 2013).

In addition to performing the AM-rate change discrimination task, participants (N=15) performed a concurrent multiple-object tracking (MOT) distractor task (3 levels: track one stationary dot [Stationary1]; track one moving dot [Moving1]; track five moving dots [Moving5]).

Participants (N=33) were presented with an informative or an uninformative cue prior to each sound. The informative cue predicted the sound's difficulty (easy 'E' or difficult 'D') regarding the modulation-rate change or the frequency change. Informative cues aimed to enable participants to titrate their level of attention. The uninformative cue was neutral (‘N’) with respect to modulation-rate or frequency changes. Results: The AM-rate change illusion was larger for uninformative compared to informative cues (P < 0.001).

Discussion

- In Experiment II, the influence of frequency on AM-rate change discrimination increased when uninformative cues (compared to informative cues) prohibited titration of attention to sounds.
- In Experiment III, a concurrent multiple-object tracking distractor task—drawing attention away from the AM-rate change discrimination task—led to an increased influence of frequency on AM-rate change discrimination.

These data suggest that when the listener is not optimally attentive, he or she might rely more strongly on learned featural co-variations for sound perception.

References:


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