Concurrent profile analysis: The effect of segregation cues on spectral-shape comparisons for simultaneous stimuli

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Introduction

The auditory system's sensitivity to changes in spectral shapes can be assessed using profile analysis tasks (e.g., Green, 1983). Here, we develop a concurrent profile analysis paradigm to study spectral processing capability during the presentation of two simultaneous stimuli. Using this method, the benefits from segregation cues (fundamental frequency, onset asynchrony, interaural time difference) on spectral sensitivity can be investigated. Different from the concurrent vowel identification experiments (e.g., Assmann and Summerfield, 1989; Culling and Darwin, 1993) extensively studied previously, the current experiment uses non-linguistic stimuli; hence vowel-specific effects are eliminated and closed-set stimulus design are no longer required.

Methods

Stimuli:

•Two concurrent harmonic complexes, one with a flat spectral profile, the other with a spectral peak at 1 kHz.

•Fundamental frequencies (f_0): 200-400 Hz, randomized trial by trial.

•Bandwidth: all harmonics below 4000 Hz.

•Presentation levels:50-70 dB SPL, randomized for each presentation.

•Segregation cues: Δf_0 (0.5, 0.75, 1, 1.5 2 semitones), onset asynchrony (0, 40 80, 120, 160 ms), interaural time difference (0, ±400 μs).

Procedure:

•Identifying *different* trials from *same* trials (see Figure 1).

•*Same* trials: The profiles of the two complexes were consistent across the two intervals. *Different* trials: The two complexes exchanged profiles across the intervals.

•This task was identical to classical profile analysis experiments if listeners could focus on one of the two complexes and completely ignore the other.

•Thresholds were collected using 2-down,1-up algorithm as function of segregation cues. Five young, normal-hearing listeners participated.

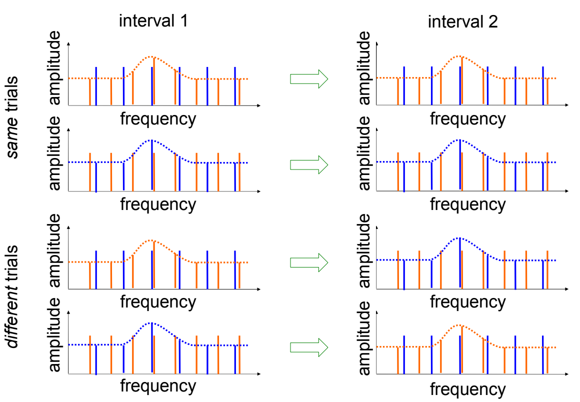

Figure 1: Schematics of stimulus spectra in same trials and different trials of the current experiment.

Results and Discussion

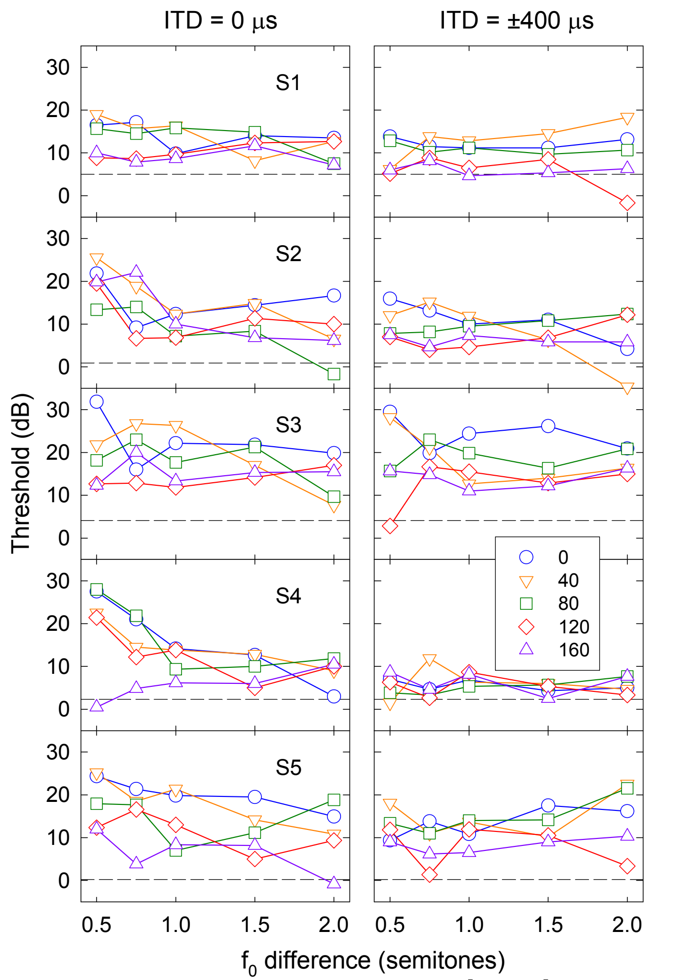

Figure 2: Individual thresholds, in terms of profile strength ($PS = 10\log\left[\sum_{i=1}^{N}\Delta A_i^2 / NA^2\right]$), from the current experiment. Results for the 0- and ±400-ITD conditions are shown in the left and right columns respectively, and results for different listeners are in different rows. In each panel, thresholds are plotted as functions of f_0 difference, and various onset delays are indicated by different symbols. Dashed lines denote the thresholds in isolated profile analysis task using only one of the complexes in each trial.

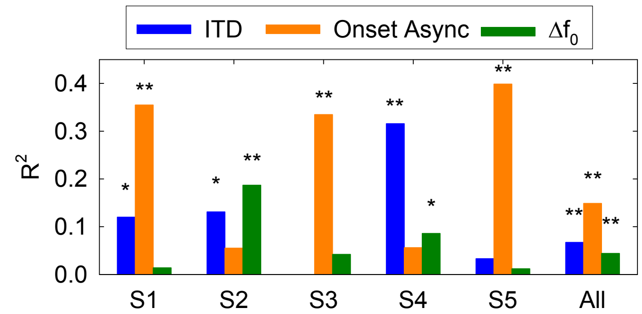

Figure 3: The amount of variances in the concurrent profile analysis thresholds accounted for by the three types of segregation cues (in different colors) calculated using step-wise multiple linear regressions. Asterisks indicate whether the regression coefficients are different from zero (* $p < .05$; ** $p < .001$).

•A repeated-measure ANOVA based on the obtained thresholds revealed significant main effects of Δf_0, onset asynchrony, and ITD, and a significant interaction between Δf_0 and ITD.

•All three types of segregation cues tended to benefit performance in the concurrent profile analysis task.

•The relative importance among these cues was studied using step-wise multiple linear regression (see Figure 3).

•Different listeners seemed to adopt different listening strategies and rely on different cues when multiple segregation cues were available.

Conclusions

•A new experimental paradigm, concurrent profile analysis, was developed, from which spectral processing of concurrent sound sources could be assessed.

•Similar effects of Δf_0, onset asynchrony, and ITD, compared to previous double vowel studies, were observed using the concurrent profile analysis task.

•Large individual differences in threshold were found, presumably due to the different listening strategies adopted by the listeners.

References

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Acknowledgment

This work was supported by NIH Grant No. R01DC02012 and Grant No. R21DC010058. The authors would like to thank Eva Maria Carreira and Andrew Silva for their assistance in data collection.