“Glimpsing” a target harmonic complex in a temporally interrupted masker

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Introduction

When listeners detect a target sound in the presence of a concurrent masker that has a temporally fluctuating envelope, do the listeners rely only on glimpses of the target during the temporal gaps of the masker’s envelope? What is the role of the portions of the target that temporally overlap with the masker? How does the efficiency of “glimpsing” the target depend on acoustic properties of the target and masker? The current study addresses these questions by studying the contributions of the masker, the portions of the target overlapping the masker (target-overlap), and the portions of the target presented in the masker gap (target-gap) in the decision-making process during a concurrent profile analysis task.

Methods

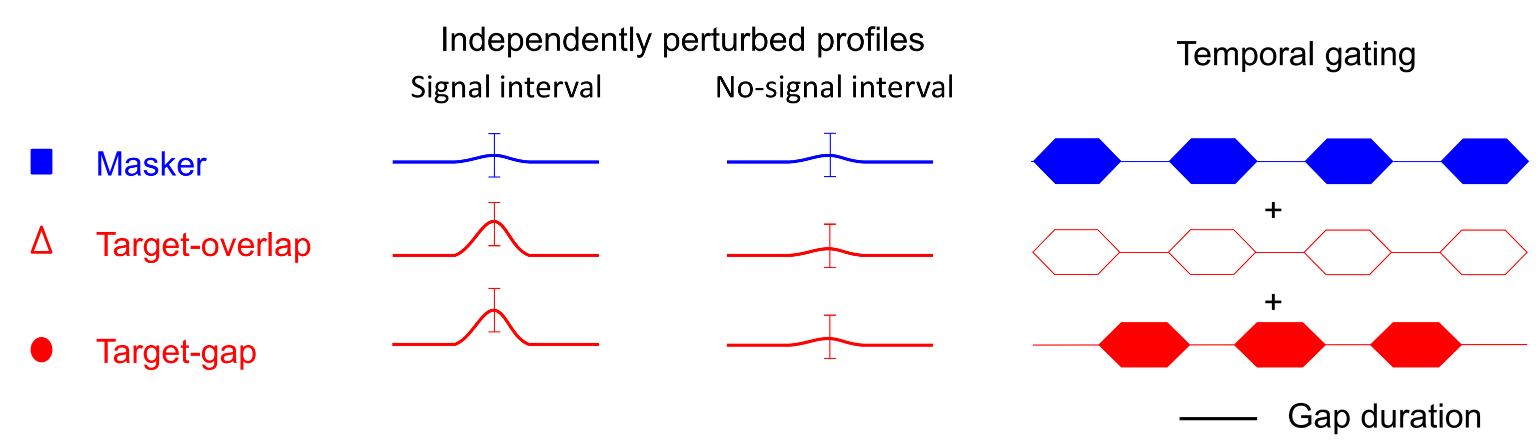

Figure 1: Schematic of spectral profiles and temporal gating properties of the masker (top), target-overlap (middle), and target-gap (bottom) used in the current experiment.

Stimuli:

- Two concurrent harmonic complexes, both with a broad spectral peak at 1 kHz. The prominence of the peak was quantified by a profile strength measure in dB.
- Bandwidth: all harmonics below 4000 Hz with masker f_0 fixed at 200 Hz.
- The masker was periodically gated on and off with 50% duty cycle, which defined the target into the target-overlap and target-gap components.
- Levels: 60 dB SPL for the masker, and 40-70 dB SPL for the target (target-overlap and target-gap shared level).
- Conditions: Δf_0 (0, 0.5, 2, 4, 8, and 10 semitones), target level (40, 50, 60, and 70 dB SPL), and gap duration (25, 50, and 100 ms).

Procedure:

- Discriminate changes in target profile strength across the two intervals in a 2AFC task.
- Profile strength in the no-signal interval: $0+\varepsilon_M$ dB for the masker, $0+\varepsilon_{TO}$ dB for the target-overlap, and $0+\varepsilon_{TG}$ dB for the target-gap. ε_M, ε_{TO}, and ε_{TG} were three random values drawn from a normal distribution with a mean of 0 and a standard deviation of 6 dB.
- Profile strength in the signal interval: $0+\varepsilon_M$ dB for the masker, $S+\varepsilon_{TO}$ dB for the target-overlap, and $S+\varepsilon_{TG}$ dB for the target-gap. The random values ε_M, ε_{TO}, and ε_{TG} were drawn independently with respect to the no-signal trial.
- The nominal target profile strength S was adaptively varied using 2-down,1-up algorithm to obtain threshold estimates at 70.9% correct.
- Various conditions were tested using a randomized block design. Five young, normal-hearing listeners participated.

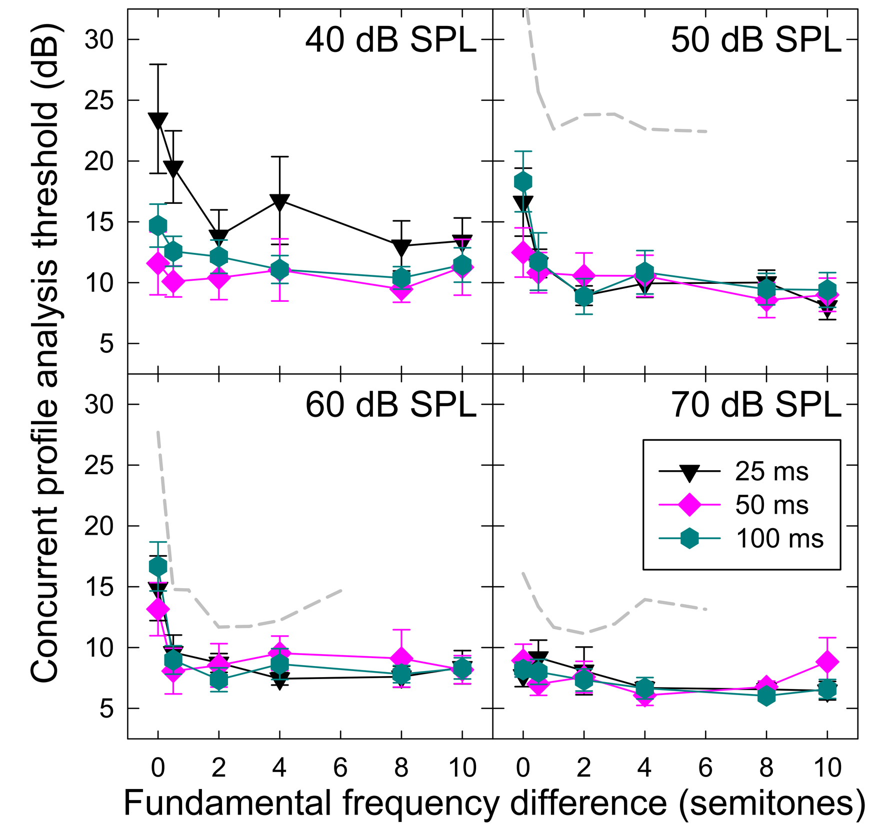

Figure 2: Average concurrent profile analysis thresholds, in terms of profile strength, across five young, normal-hearing listeners. The thresholds for different target levels are arranged in separate panels, and in each panel, the threshold is plotted as functions of fundamental frequency difference. Error bars indicate ± one standard errors of the mean. The gray dashed curves indicate the thresholds when no gap is present in the masker. These data are from a previous study with four different normal-hearing listeners.

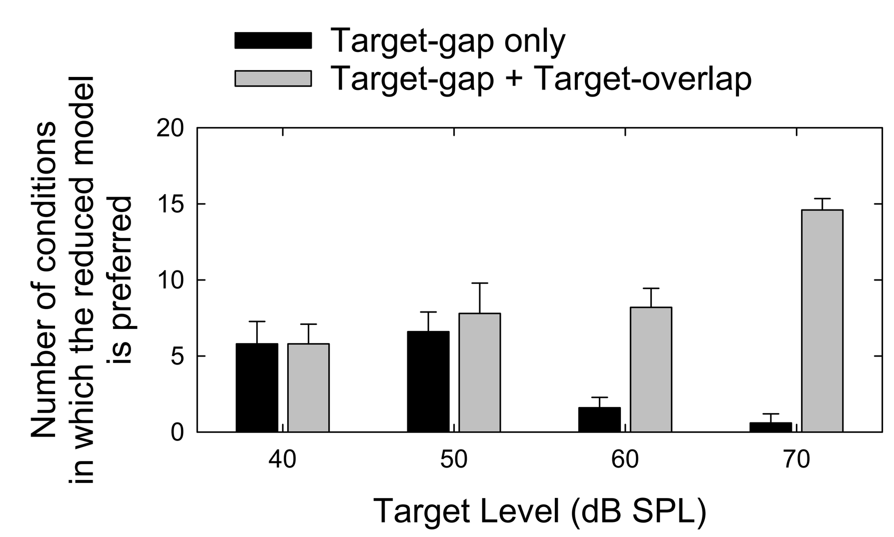

Figure 4: The average number of conditions in which a reduced generalized linear model of concurrent profile analysis is preferred over the full model, as a function of target level. Mean results across the five listeners are shown. Error bars indicate ± one standard errors of the mean. Two reduced models were implemented, one used only the weights for the target-gap (black), the other used the weights for both the target-gap and target-overlap (gray). After fitting the models to the data, the increment in deviance from the reduced model to the full model was evaluated using a χ^2 test. This test asks whether at least one of the extra parameters in the full model was significantly different from zero. If so, the full model was considered the preferred model. Otherwise the reduced model was preferred. This test was conducted for the two reduced model, for each experimental conditions, and for all listeners. The number of times that the reduced model was the preferred was counted for each target level and collapsed across gap durations and Δf_0’s.

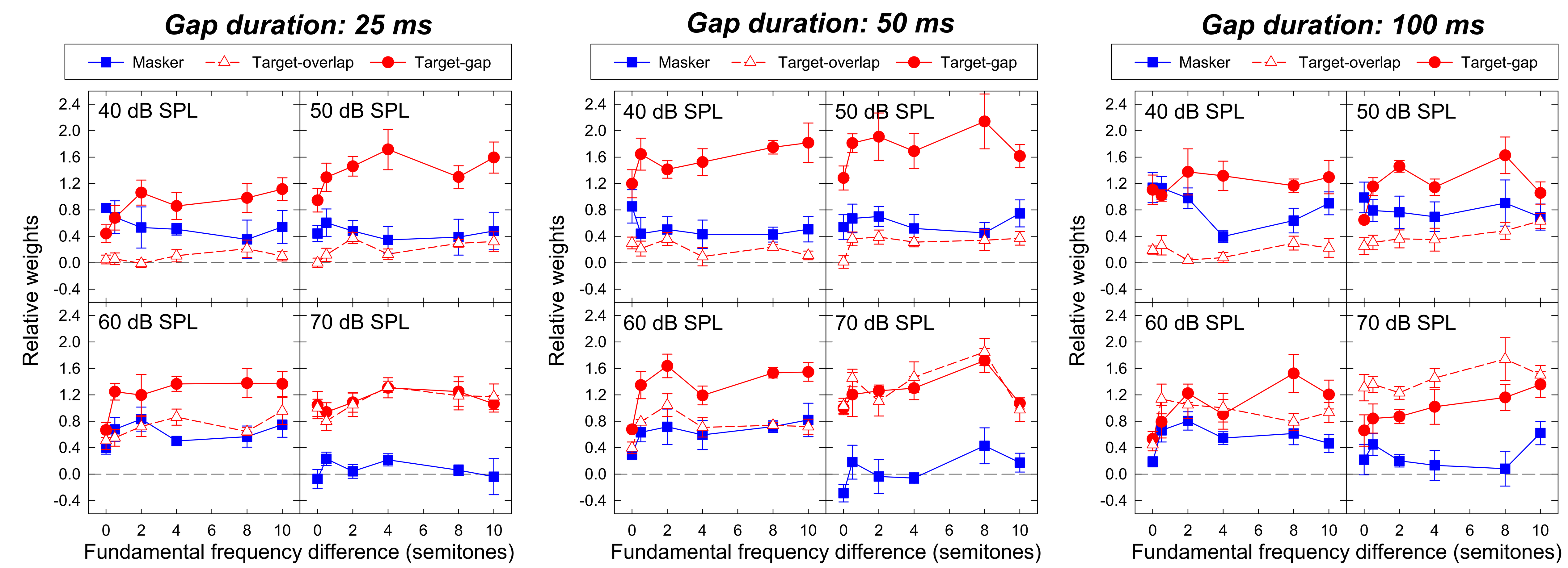

Figure 3: Average relative decision weights, obtained from a logistic regression analysis and normalized to have an rms value of one, across five young, normal-hearing listeners. The left, middle and right panels of the figure correspond to gap durations of 25, 50, and 100 ms, respectively. Within each panel, the weight estimates for the four target levels are arranged in separate subpanels, in which the masker, target-overlap, and target-gap weights are plotted as functions of fundamental frequency difference. Error bars indicate ± one standard errors of the mean.

Results and Conclusions

Thresholds (Fig. 2):

- Below 4 semitones, the threshold improved with increasing Δf_0 and target level.
- Benefits of the temporal gaps in the masker on the threshold were larger at lower target levels.

Relative weights (Fig. 3):

- Evidence of glimpsing: the profile strength of the target-gap was the strongest predictor of responses at low target levels and short gap durations.
- Evidence of a Δf_0-dependency on glimpsing: when the target-gap weights dominated, they tended to increase with increasing Δf_0.
- The masker and target-gap did not overlap in time, yet the target-gap weights were affected by the difference in their fundamental frequencies.

Model comparisons (Fig. 4)

- The weights of the target-gap was poor for predicting responses at high target levels, indicating the role of the target-overlap.
- The role of the masker was negligible only for the 70-dB SPL target level.

Psychometric functions (Table 1):

- Smaller Δf_0’s were associated with lower weights for the target-gap and shallower psychometric functions.

Table 1: The slope of the psychometric function, in the units of %/dB, for all experimental conditions. These slopes were estimated from the psychometric functions of the logistic regression model (Fig. 3) fitted to the experimental data. The slopes were measured at the 75-% correct location on these psychometric functions. Average estimates across the five listeners are listed.

	Gap duration (ms)											
	25				50				100			
	Target level (dB SPL)				Target level (dB SPL)				Target level (dB SPL)			
Δf_0 (semitones)	40	50	60	70	40	50	60	70	40	50	60	70
0	0.60	1.28	1.71	2.35	1.71	1.57	1.59	2.40	1.43	1.21	1.43	2.37
0.5	0.93	1.54	2.08	2.04	2.01	2.13	2.27	2.52	1.52	1.67	2.36	2.39
2	1.33	1.98	2.13	2.67	1.98	2.06	2.52	2.33	1.48	2.06	2.36	2.37
4	1.28	1.81	2.24	2.81	1.90	2.15	2.13	2.74	1.66	1.79	2.18	2.73
8	1.47	1.93	2.15	2.52	2.19	2.42	2.42	3.20	1.67	2.13	2.34	2.49
10	1.40	1.96	2.34	2.55	2.01	2.06	2.23	2.53	1.58	2.10	2.49	2.92

Conclusions:

When it is advantageous to do so (e.g., at low target levels), listeners can perform the profile analysis task using glimpses of the target during the temporal gaps of the concurrent masker. When the gap duration is short and the fundamental-frequency difference between the target and masker is small, the masker cannot be totally ignored. The efficiency of glimpsing the target improved as the fundamental-frequency difference increased.

Acknowledgment

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