Relative Weight Estimates for a Variety of Informational Masking Studies

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Acknowledging the Assistance of Rong Huang,
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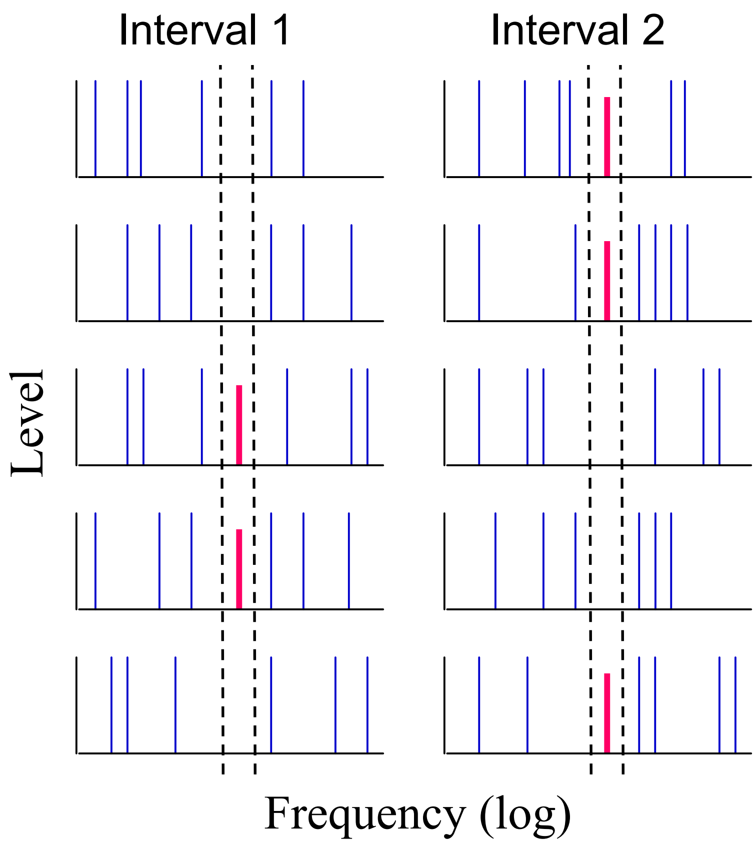
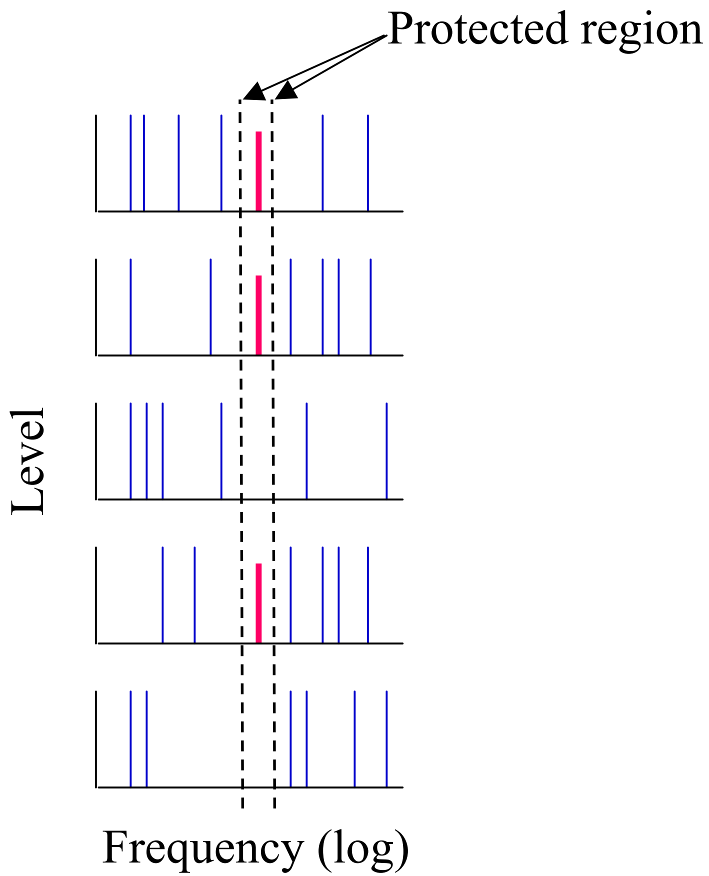
Supported by NIH

The detection of a tone added to random multi-tone maskers (introduced by Neff and Green in 1987)

2IFC Trials



Yes/No Trials



Basic Results

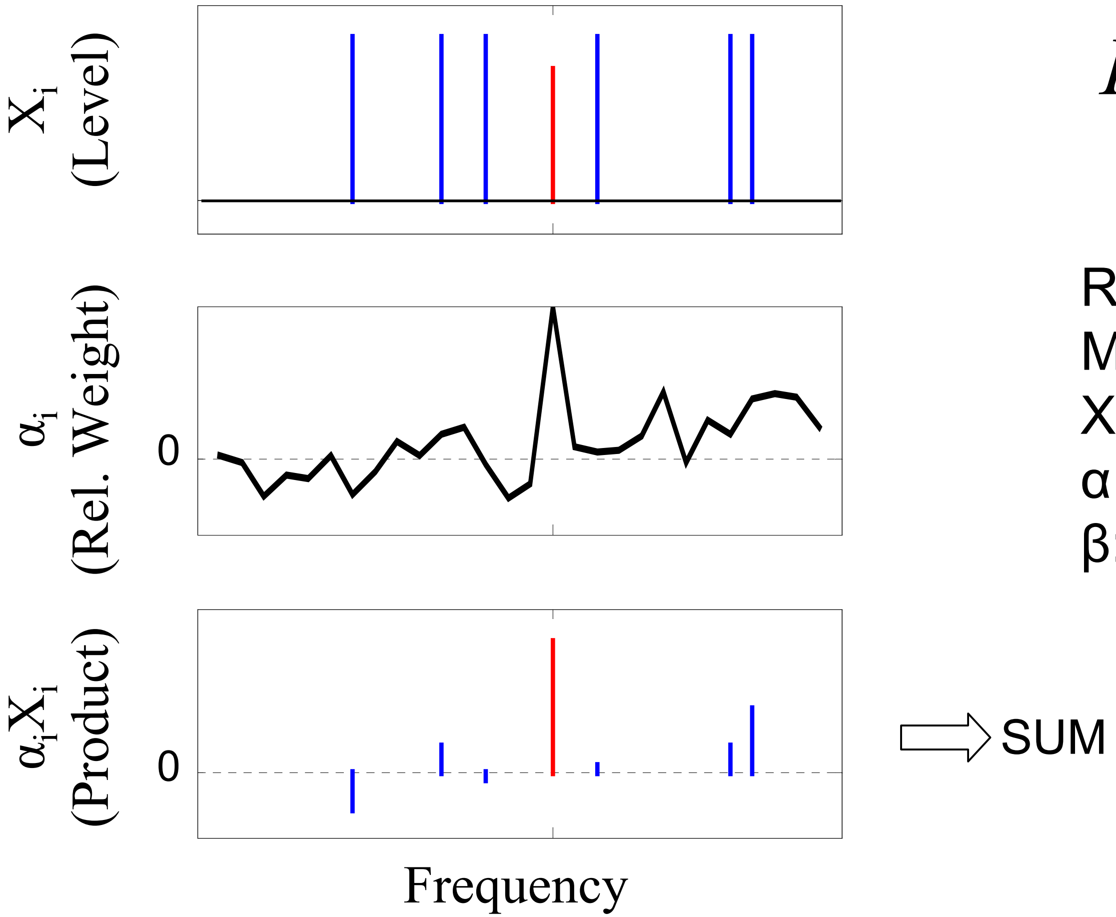
1. There are large individual differences in thresholds, especially for small *N*s. Across observers, a range of 30-40 dB is typical.

2. Thresholds depend (often non-monotonically) on the number of components comprising the masker (*N*). Thresholds are largest for intermediate *N*s (*N*=10~20)

3. Thresholds depend on context – increases in uncertainty tend to increase thresholds.

4. Practice effects can be obtained across weeks of practice.

One approach– Linear/Summation Model based on Power Spectra:



$$RV = \sum_{i=1}^{M} \alpha_i X_i + \beta$$

RV: random variable
M: number of channels
X: level in dB
α: relative weight/contribution
β: bias

Basic Results: Rough Predictions of Linear/Summation Model

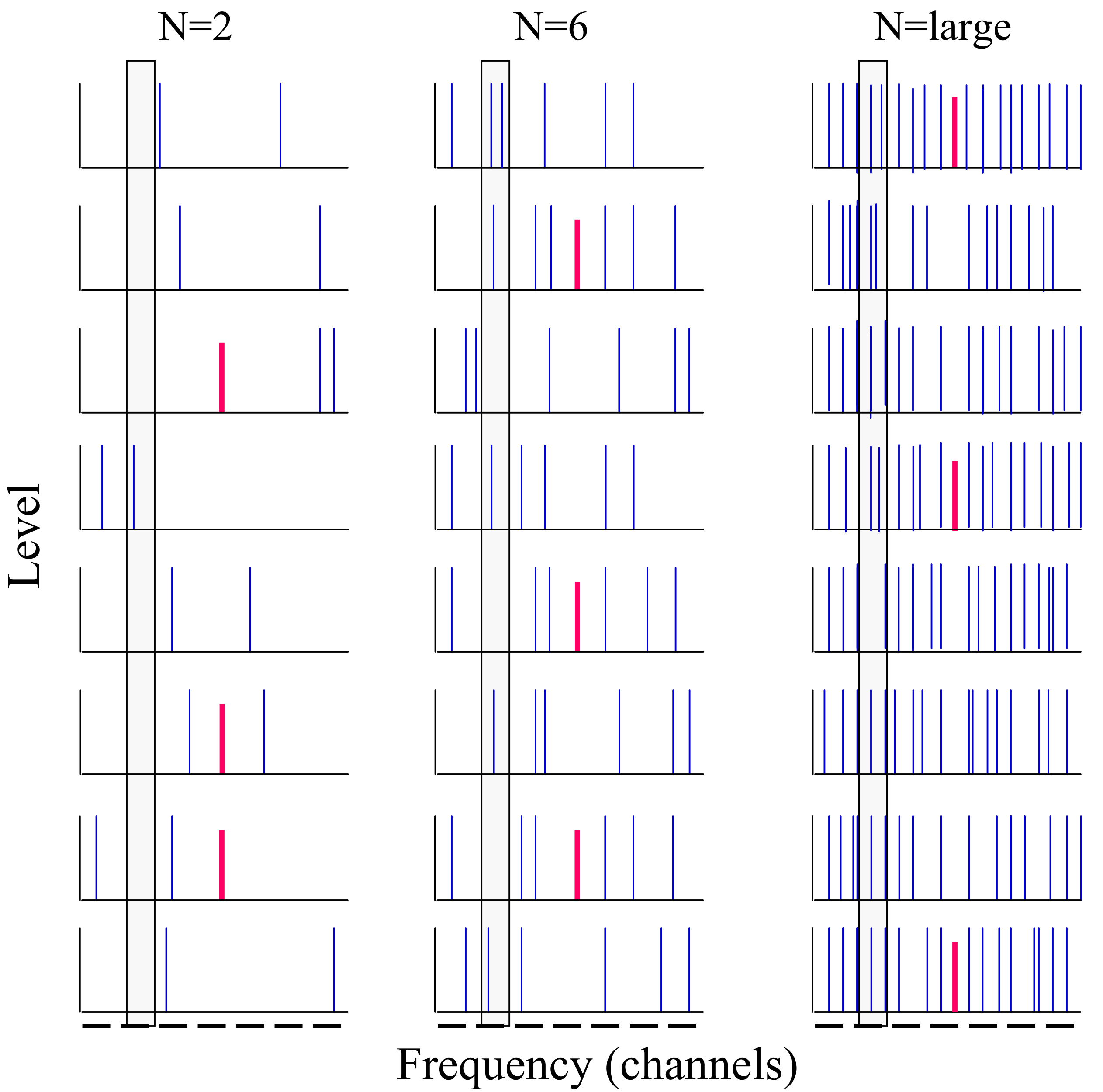
There are large individual differences in thresholds.

The values of α_i vary across observers, leading to differences in thresholds.

Thresholds depend on *N*

If observers combine levels at the outputs of different auditory filters, large variations in filter output levels across trials will lead to a RV with a large variance. For very small and very large N, the levels at the output of the auditory filter are relatively less variable.

Change in *N* -- Change in variance for channel *i*



Basic Results: Rough Predictions of Linear/Summation Model (cont.)

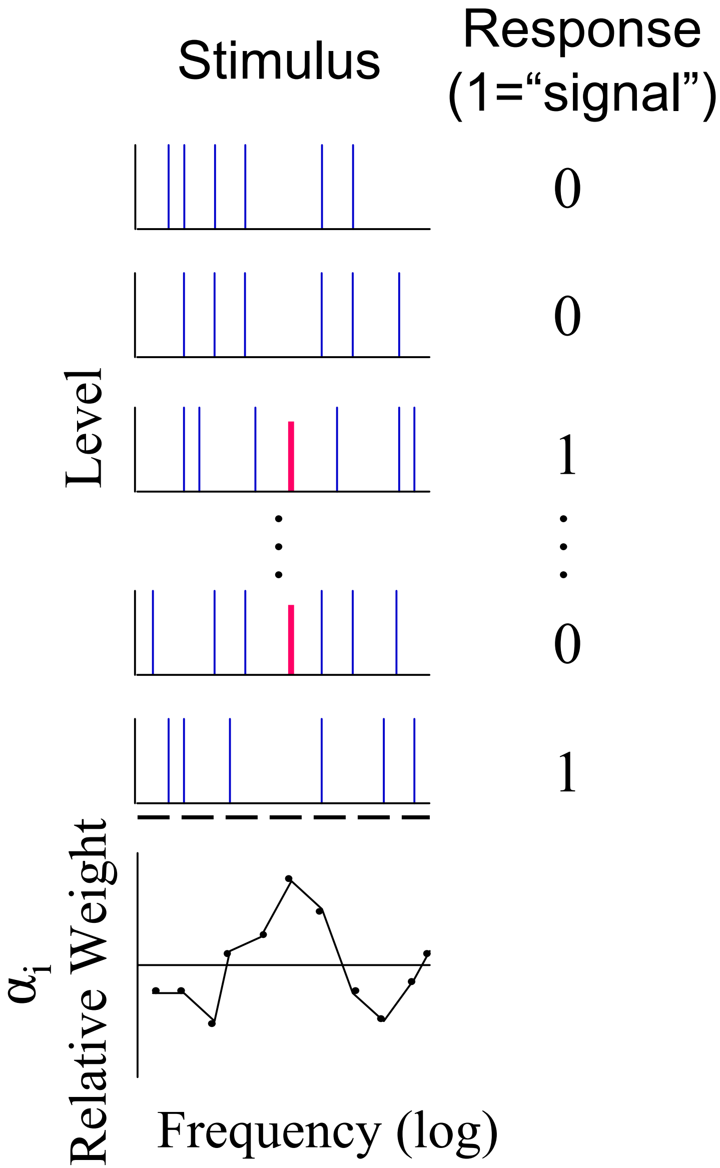
Threshold depends on context – increases in uncertainty tend to increase thresholds

For Example: If the maskers are the same across the two intervals of a 2IFC procedure, thresholds ought to be lower than when the maskers differ. When the maskers are the same, they "cancel" out when the RVs from each interval are differenced.

Practice effects can be obtained across weeks of practice

The linear model provides little help here.

Method for estimating relative weights (α_i) – trial-by-trial analysis



$$RV = \sum_{i=1}^{M} \alpha_i X_i + \beta$$

RV: random variable
M: number of channels
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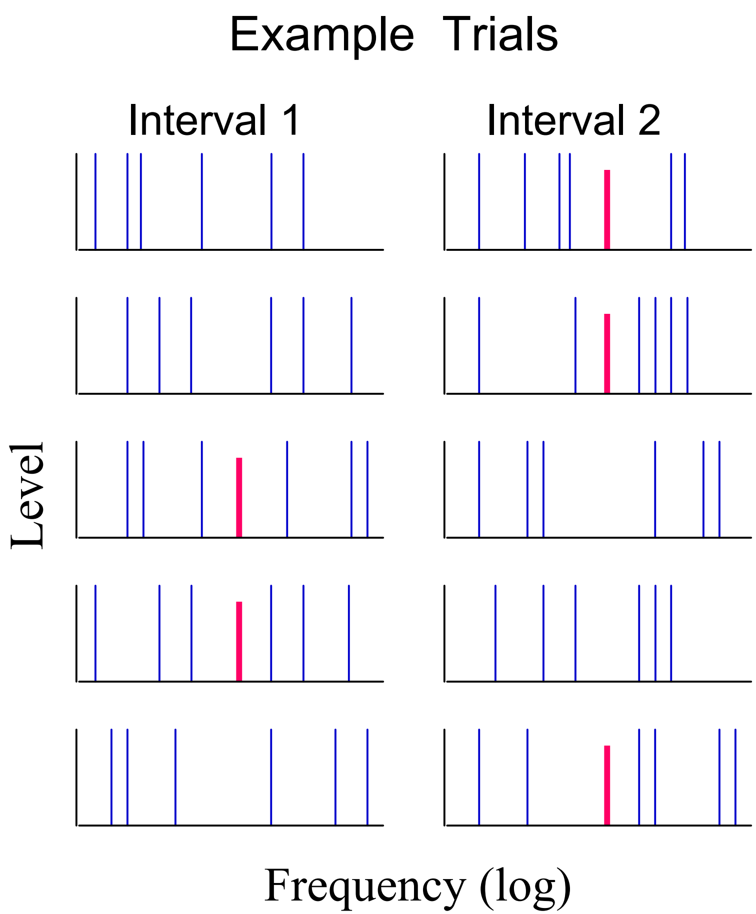
α: relative weight/contribution
β: bias

Experiment I: Detect a tone added to Random 6-tone maskers

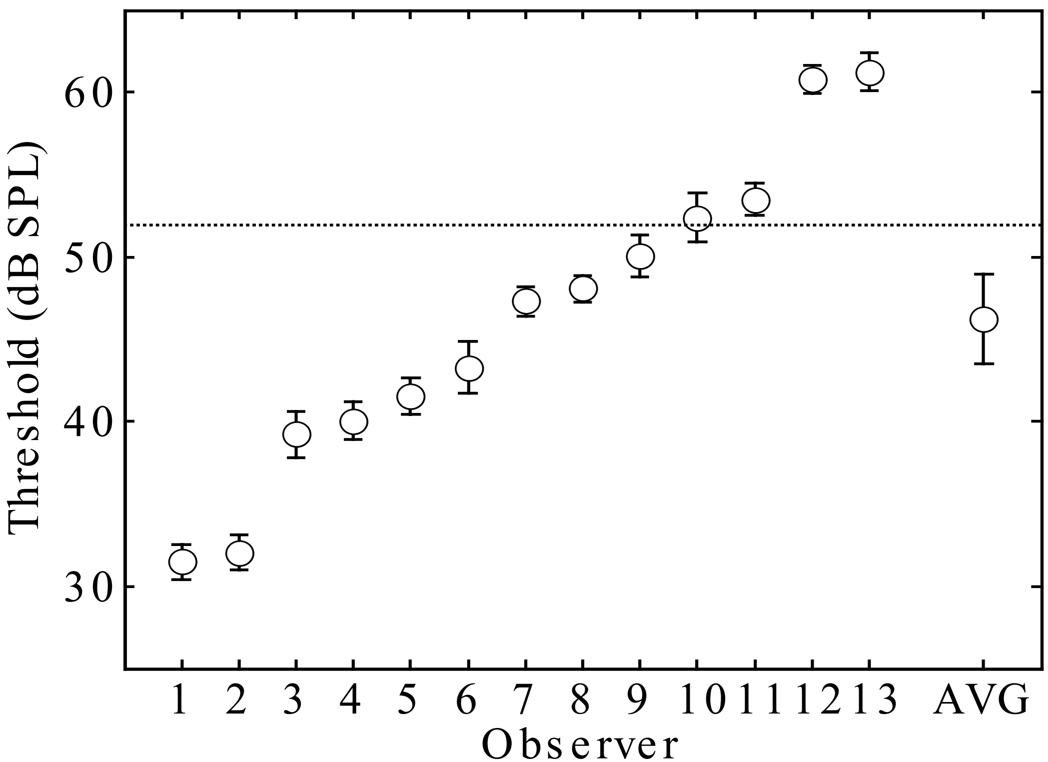


-- Two-interval, forced choice

-- 6 masker components, randomly drawn on each interval

-- 13 observers

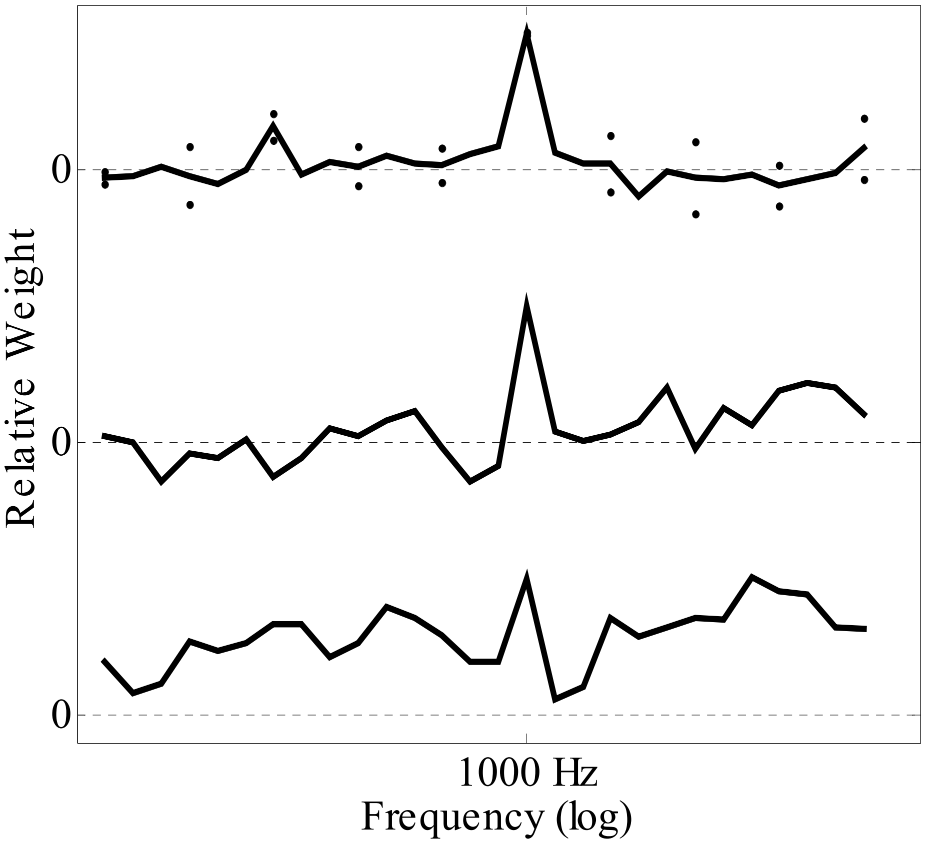
Experiment I: Results



Wide range of Thresholds
~30 dB range

Most thresholds fall below the "loudness" limit (dashed line)

Experiment I (cont.) : Relative weights for 3 observers



The relative weights is largest at the signal frequency

Relative weights tend to be larger for higher frequencies than low frequencies (across obs)

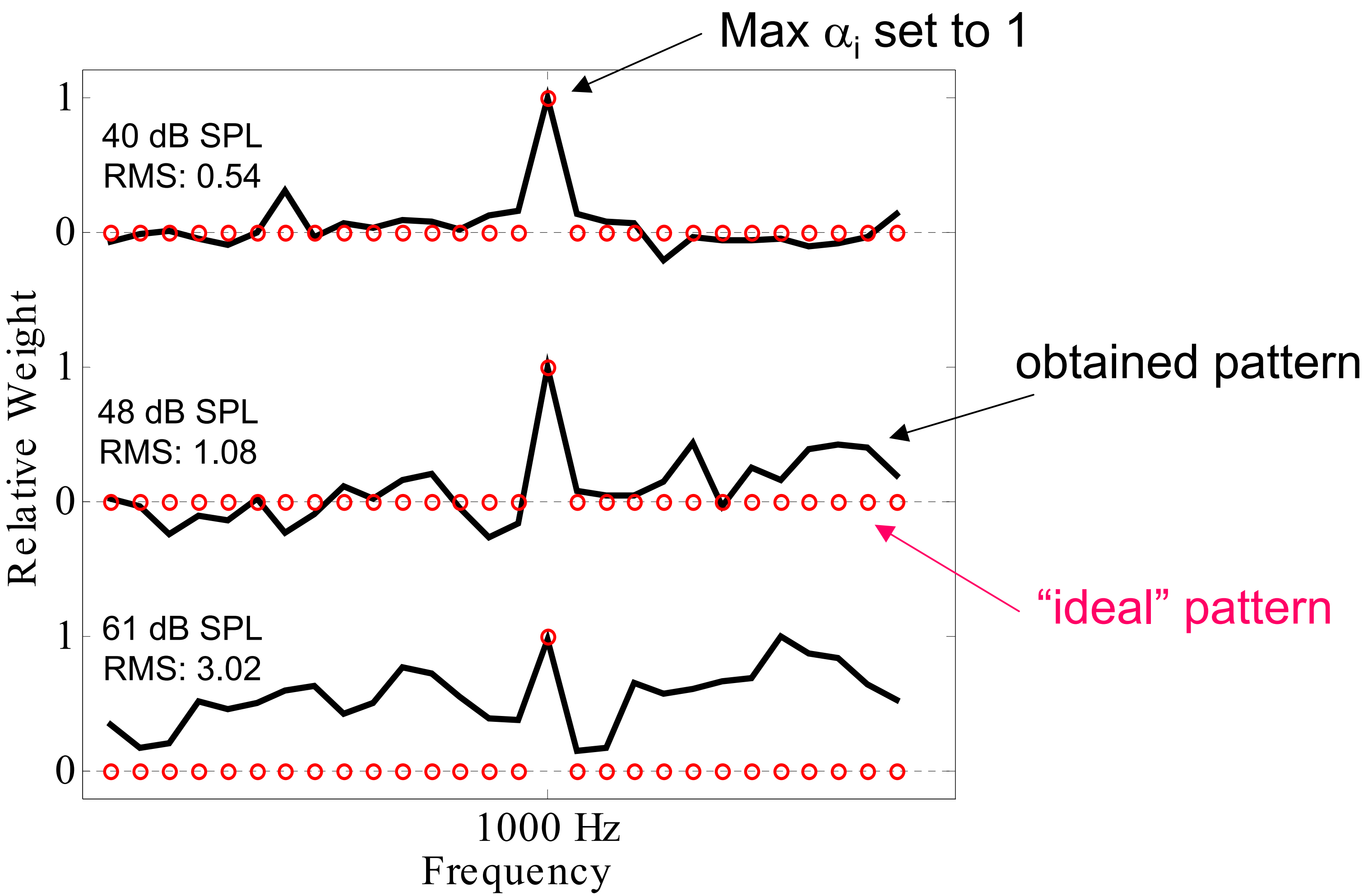
The fits are reasonably good, i.e., the patterns of relative weights is stable

Does the fitted linear/summation model capture the variation in thresholds across observers?

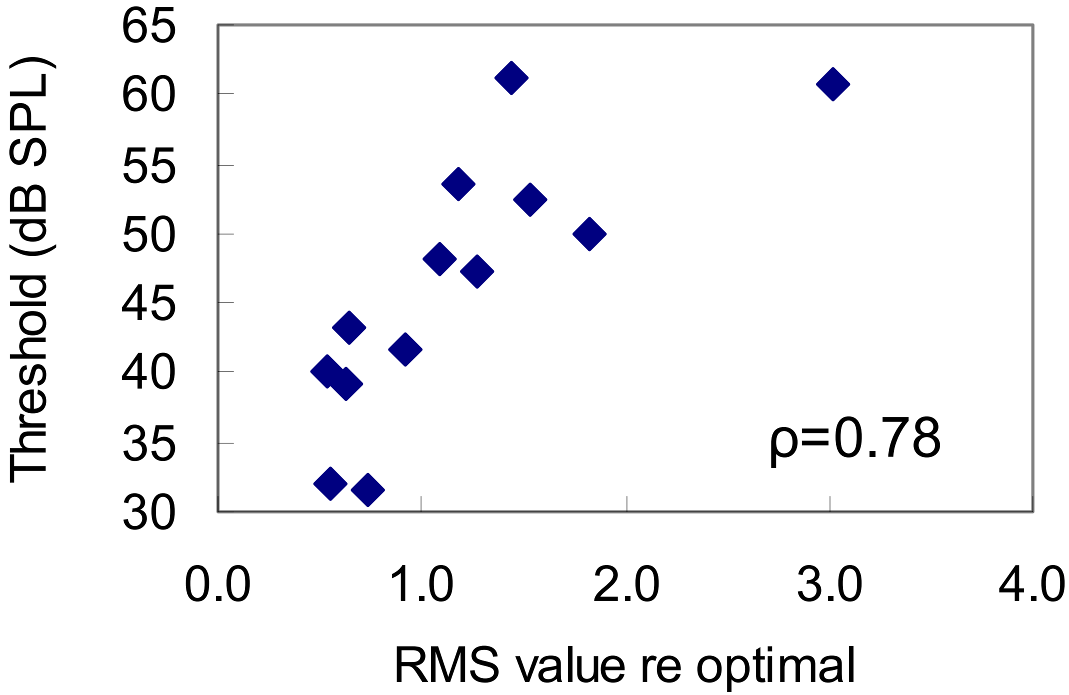
Three-step evaluation.

1. Compare weights relative to an “ideal” pattern: a weight of one at the signal frequency and a weight of zero elsewhere.
2. Estimate the RMS difference between the obtained weighting patterns and the “predicted” patterns
3. Across 13 observers, determine correlation between RMS difference and thresholds.

Comparison with “ideal”



Threshold vs RMS error



Deviation from “ideal” is correlated with thresholds.

Summary:

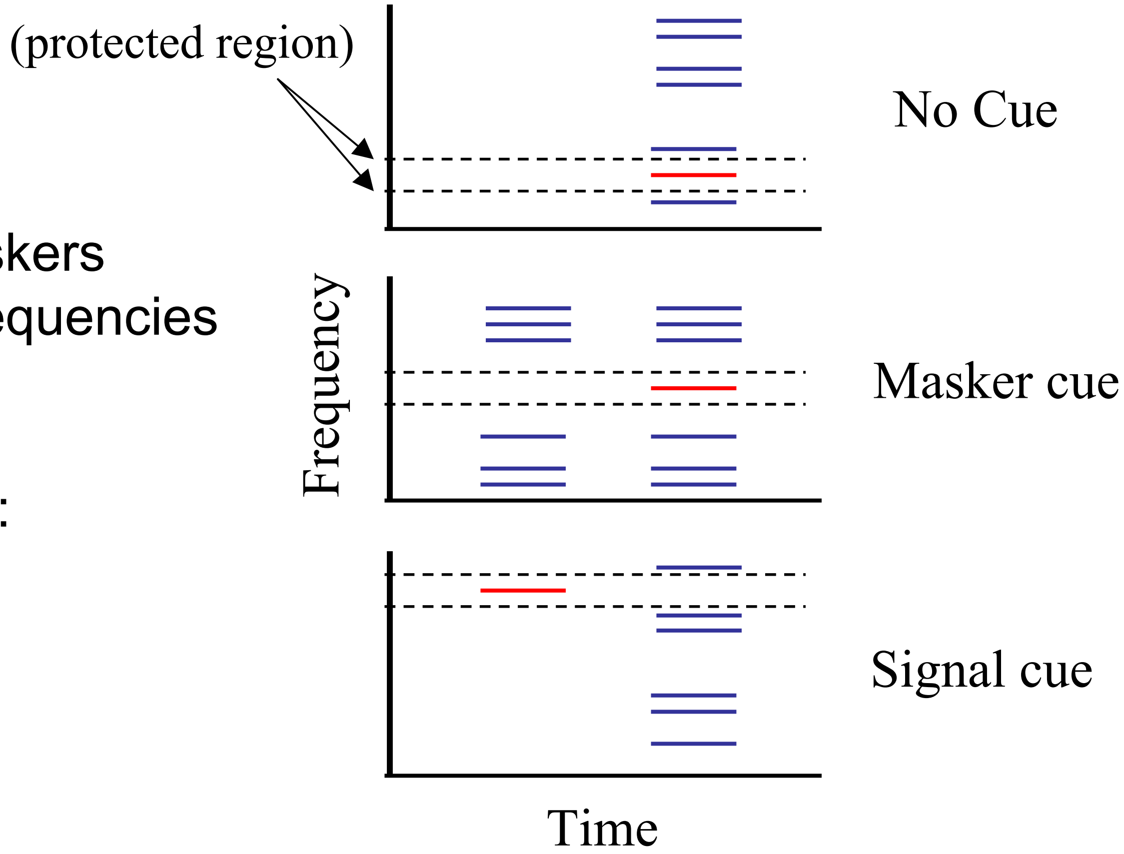
-- Trial-by-trial responses provide reasonably accurate estimates of the parameters of a linear/summation model

-- Across observers, the resulting models captures some of the individual differences in thresholds.

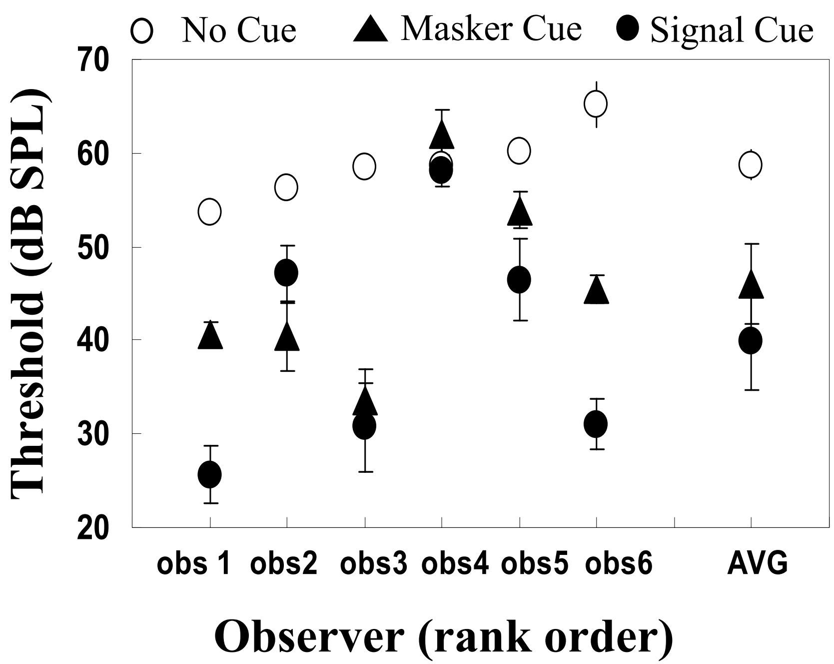
Experiment II: Impact of pre-trial cue as a means of reducing uncertainty/thresholds

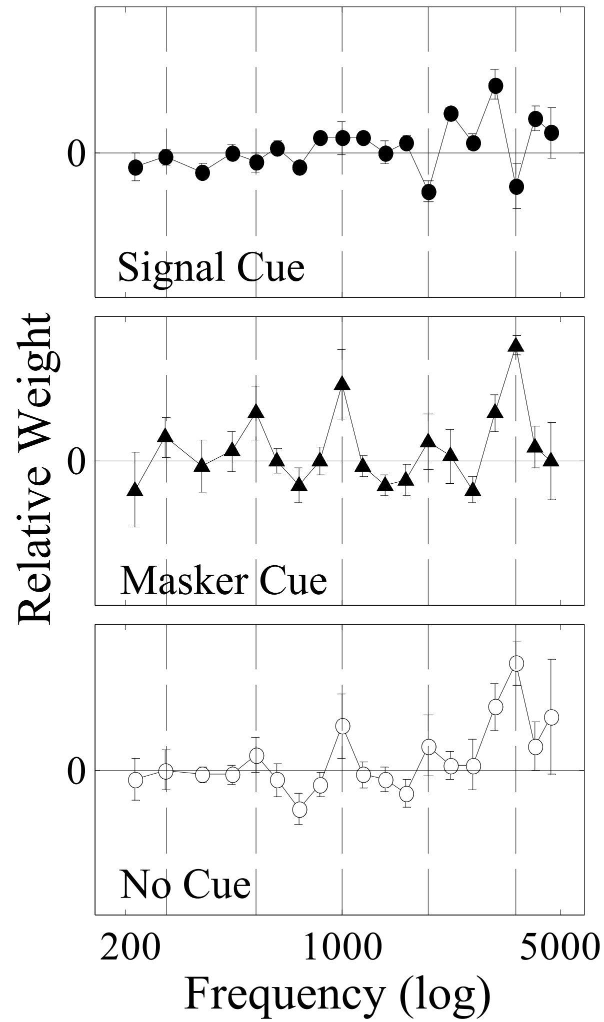
-- Yes/No task
-- 6 component, random maskers
-- one of 5 possible signal frequencies
-- 6 observers

-- Two types of pre-trial cues:
  a preview of the masker
  a preview of the signal



Experiment II (cont.) : Results





Experiment II (cont.) : Summary

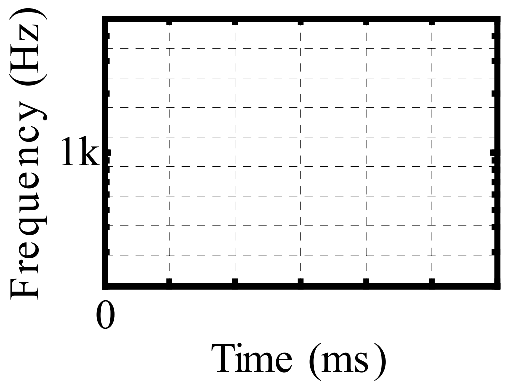
Pre-trial cues reduce thresholds.

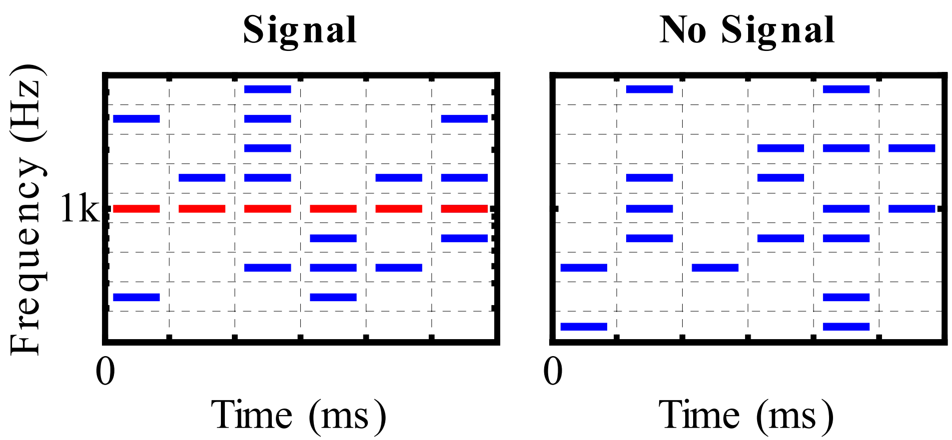
-- the masking release associated with a pre-trial cue is not correlated with the no-cue threshold.

-- The pattern of relative weights is similar for the no-cue and masker-cue conditions.

-- A preview of the signal allows observers to “attend” to the signal frequency.

Application to perceptual organization – pilot work





p: probability a tone falls in a time X frequency cell

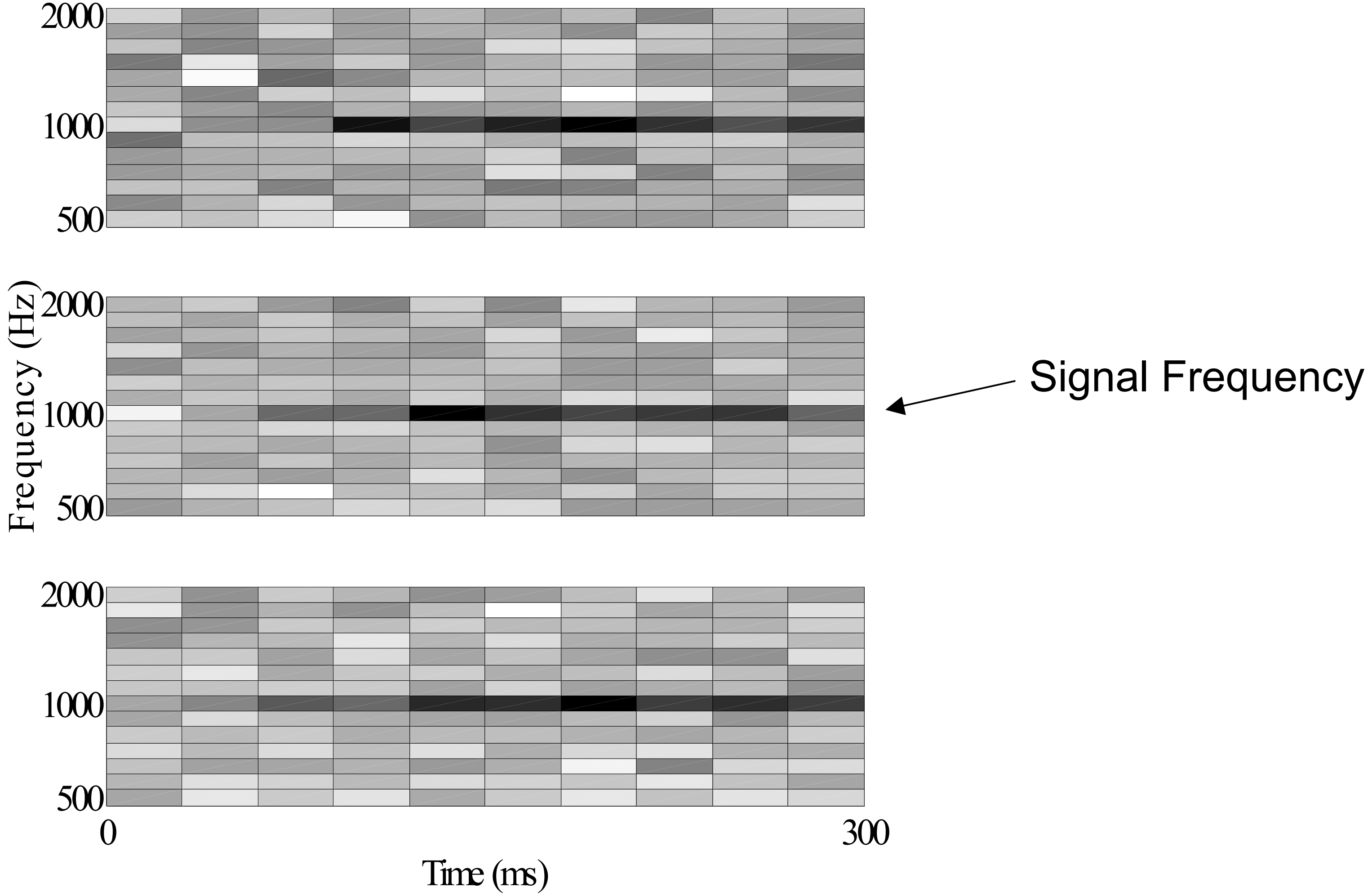
Yes/No trials

As *p* increases, percent correct detection falls

Analysis: estimate relative weights for time-frequency cells using responses to no-signal trials.

Relative weights on a time-frequency grid

Results from no-signal trials



Summary:

A linear “channel” model captures many of the basic phenomena associated with informational masking, and may ultimately prove a useful tool in understanding the perceptual organization of complex sounds.

Two comments / notes of caution:

1. It might be argued that the model is assured to succeed – there are many degrees of freedom and the parameters are estimated separately for each observer.
2. The relative weights are meaningful only if the assumption of linearity is appropriate. Tests of linearity and interactions are rarely provided.