Binaural Release from Informational Masking in a Speech Recognition Task

Frederick J. Gallun,
Christine R. Mason
and Gerald Kidd, Jr.

Hearing Research Center
Boston University

How do listeners attend to and extract information from multiple competing sources of acoustic input?

In a complex environment, perceptual interference is due to both "informational" masking (IM) and "energetic" masking (EM). Reducing spectral overlap between sources reduces EM and maintains IM. Perceptual similarity between target and masker has been found to increase IM.

The masking of one speech waveform by another involves a degree of similarity that is not present when the masker is noise. An additional aspect that can reduce similarity is the binaural character of the target and masker. These experiments explore the ways in which these two types of similarity interact.

METHODS

LISTENERS:

Three female graduate students (ages 21-25) with normal hearing

STIMULI: [see Fig. 1]

Speech corpus: Coordinate Response Measure (CRM) (Bolia et al., 2000)
Sentences processed into 15 bands spaced from 215 to 4891 Hz
(see Arbogast et al., 2002)

Target: 8 bands randomly chosen on each trial.

Maskers (equated for rms):

o DBS: Different-band sentence
(CRM sentence containing 6 bands not in target)

o DBN: Different-band noise
(DBS spectrum multiplied by broad-band Gaussian noise)

Sentences are of the form "Ready [callsign] go to [color] [number] now."

TASK: Choose color (set of 4) and number (1 to 8) spoken by talker with callsign ("Baron").

Masker sentence callsign, color and number are different from target.
Target sentence always at 60 dB SPL.
Response feedback given after each trial (correct color and number).

Experiment 1: Monaural masking conditions are compared with binaural. Maskers are DBS and/or DBN. Target is monaural.

Experiment 2: Binaural masking is compared across several ILDs and ITDs. Maskers are DBS. Target is monaural.

Experiment 3: Binaural masking is compared across several ILDs and ITDs. Maskers are DBS. Target is diotic.

Experiment 4: DBS maskers are presented alone at several binaural configurations as well as monaurally. Listeners rate perceived lateralization.

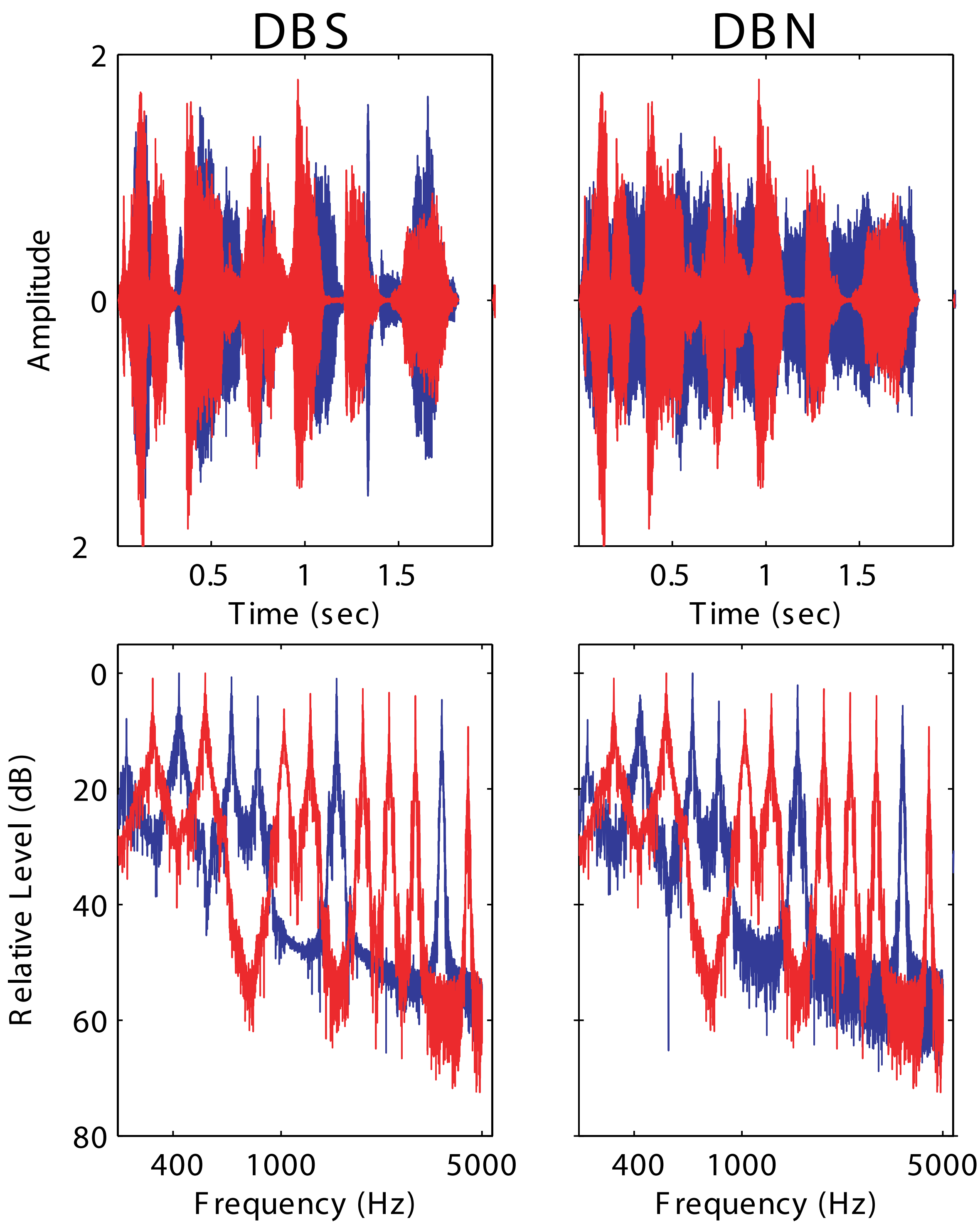


Fig. 1. Temporal (top) and spectral (bottom) representations of Different-Band Speech (DBS) and Different-Band Noise (DBN) maskers.

Six-band maskers are plotted in blue and eight-band targets in red.

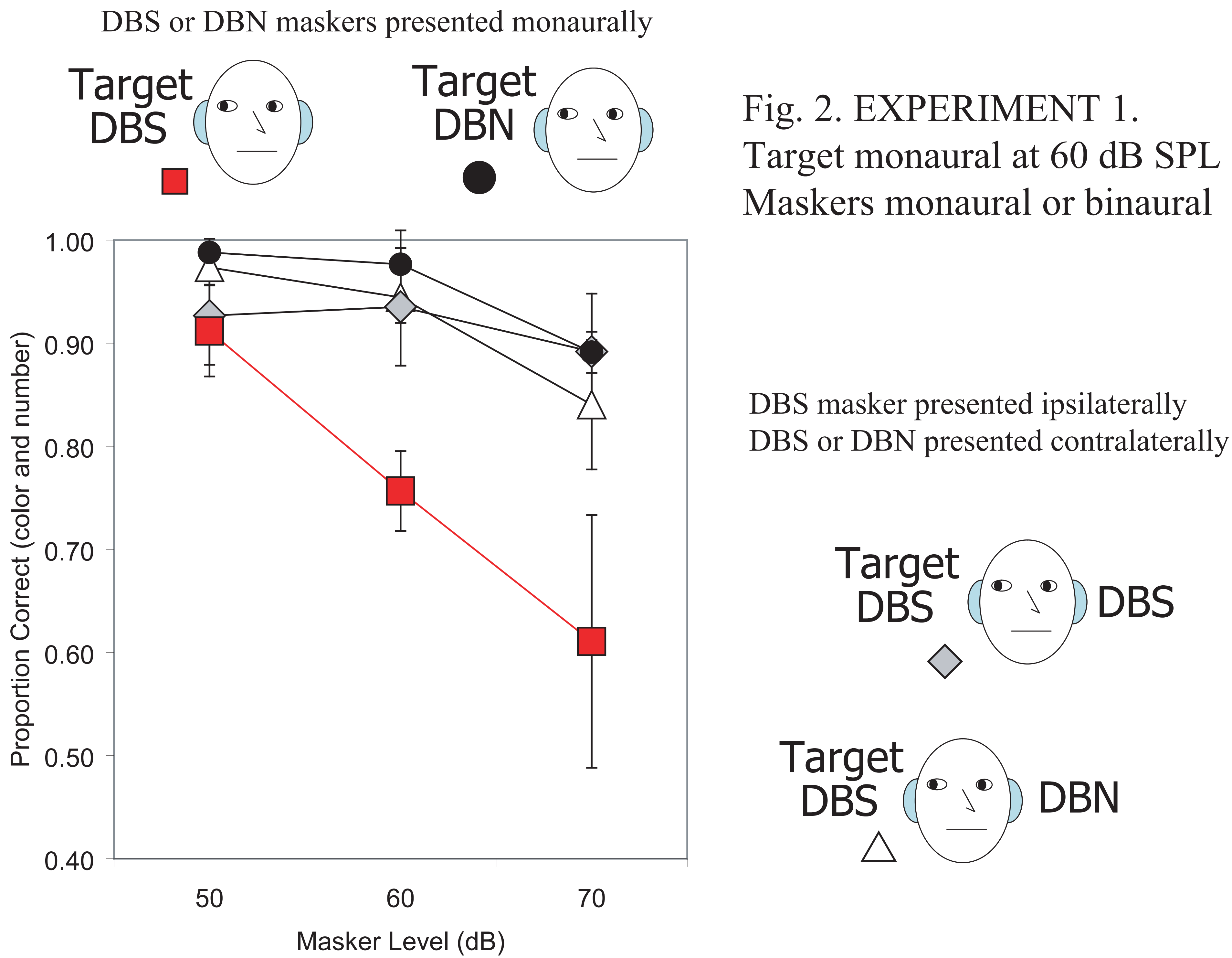


Fig. 2. EXPERIMENT 1.
Target monaural at 60 dB SPL
Maskers monaural or binaural

Results, Experiment 1

Performance suffered more from DBS than from DBN presented monaurally. This suggests that in addition to the fairly small energetic masking, DBS maskers produce informational masking. Performance was improved considerably by adding either the DBS or the DBN masker to the opposite ear.

Why should adding a masker to the opposite ear improve performance?

Is a binaural masker more easily segregated from a monaural target? Is it based on perceived location?

For DBN masker, ipsilateral DBS masker could be made slightly less intelligible, thus reducing its effectiveness as a masker.

For DBS however, listeners could exploit a difference in perceived location between masker and target.

If DBN release was based on binaural cue, it is unlikely to be strongly correlated with perceived location. Since the envelopes at the two ears are uncorrelated, DBN contra causes a "muddy" or moving image for the combined masker. It could be a binaural/monaural difference, however.

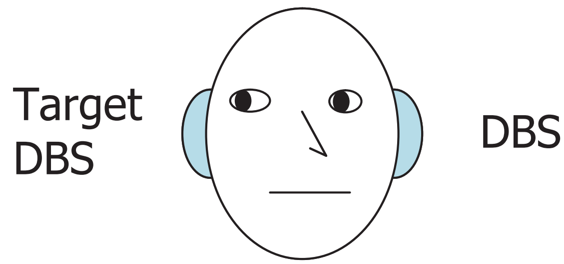
The following experiments were designed to examine the role of perceived lateralization in binaural release for DBS maskers.

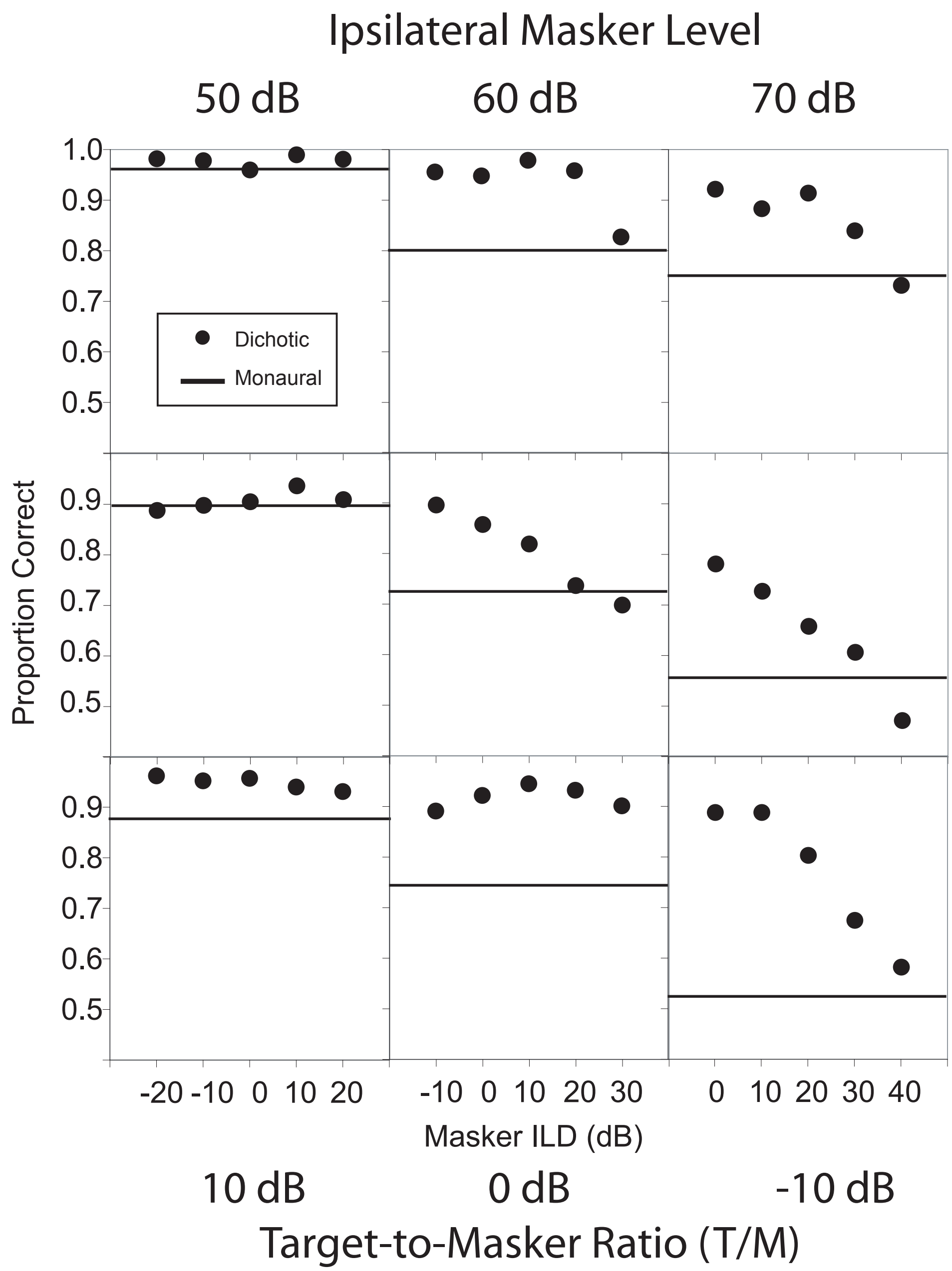
Experiment 2 begins by comparing the amount of release that occurs when the interaural differences are varied for the masker while the target remains monaural.

Fig. 3a EXPERIMENT 2

DBS masker binaural with ILDs.

Target monaural.



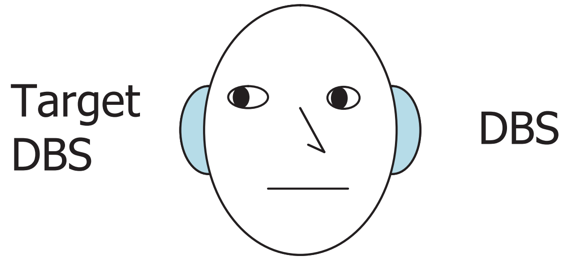


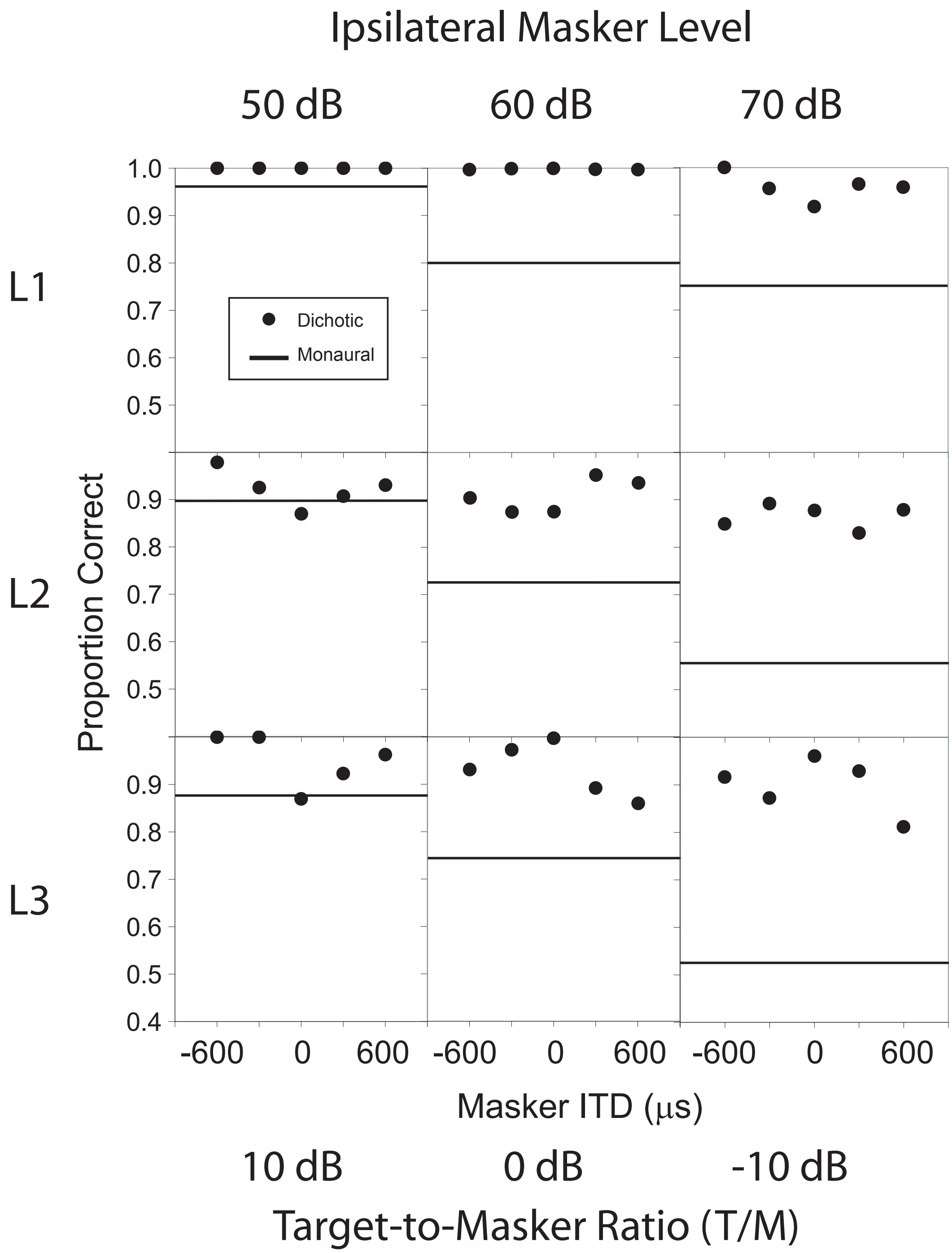
Various ILDs were imposed on the DBS masker by adjusting the level of the masker at the left (non-target) ear. Negative values indicate that the level was higher at the left ear.

Fig. 3b EXPERIMENT 2

DBS masker binaural with ITDs.

Target monaural.





Various ITDs were imposed on the DBS masker by delaying the masker at one ear and advancing it at the other.

Results, Experiment 2

While binaural performance was generally superior to monaural for all ITDs, this was only the case for ILDs less than 20 dB.

Is release based on a monaural versus binaural difference?

Would the same release be found for binaural targets?

EXPERIMENT 3

Masker and target both presented binaurally.
Target always identical in both ears.

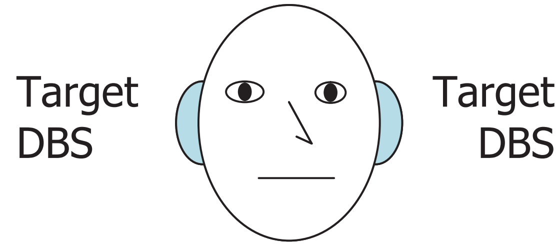
DBS masker had either an ILD or an ITD imposed on it.

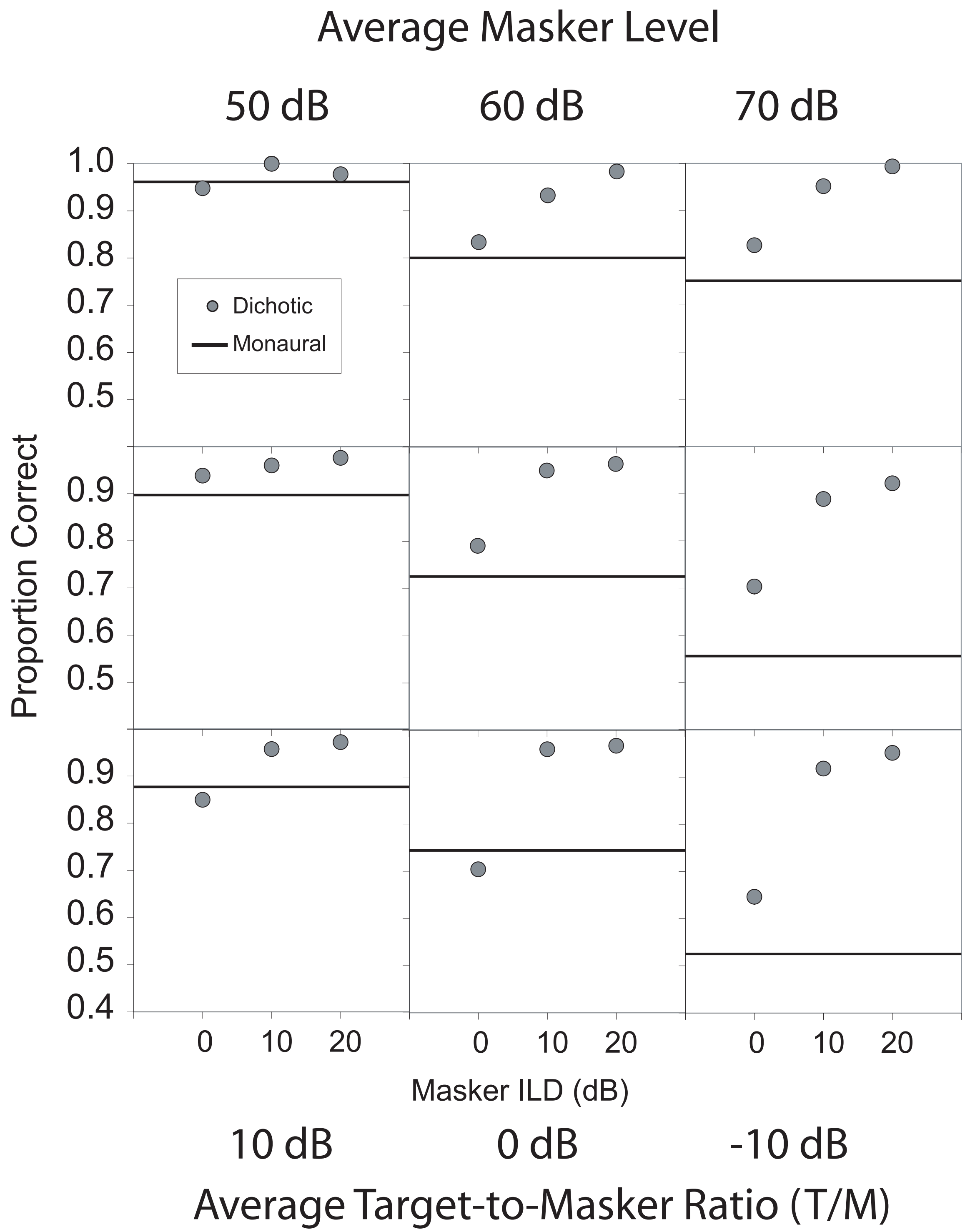
ILDs and ITDs imposed as in experiment 2.

When the level differed between the ears, the average masker level is reported.

Fig. 4a EXPERIMENT 3
DBS masker binaural with ILDs.

Target diotic.

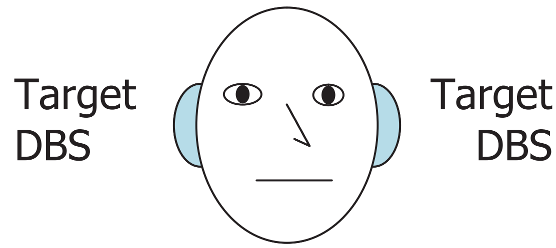


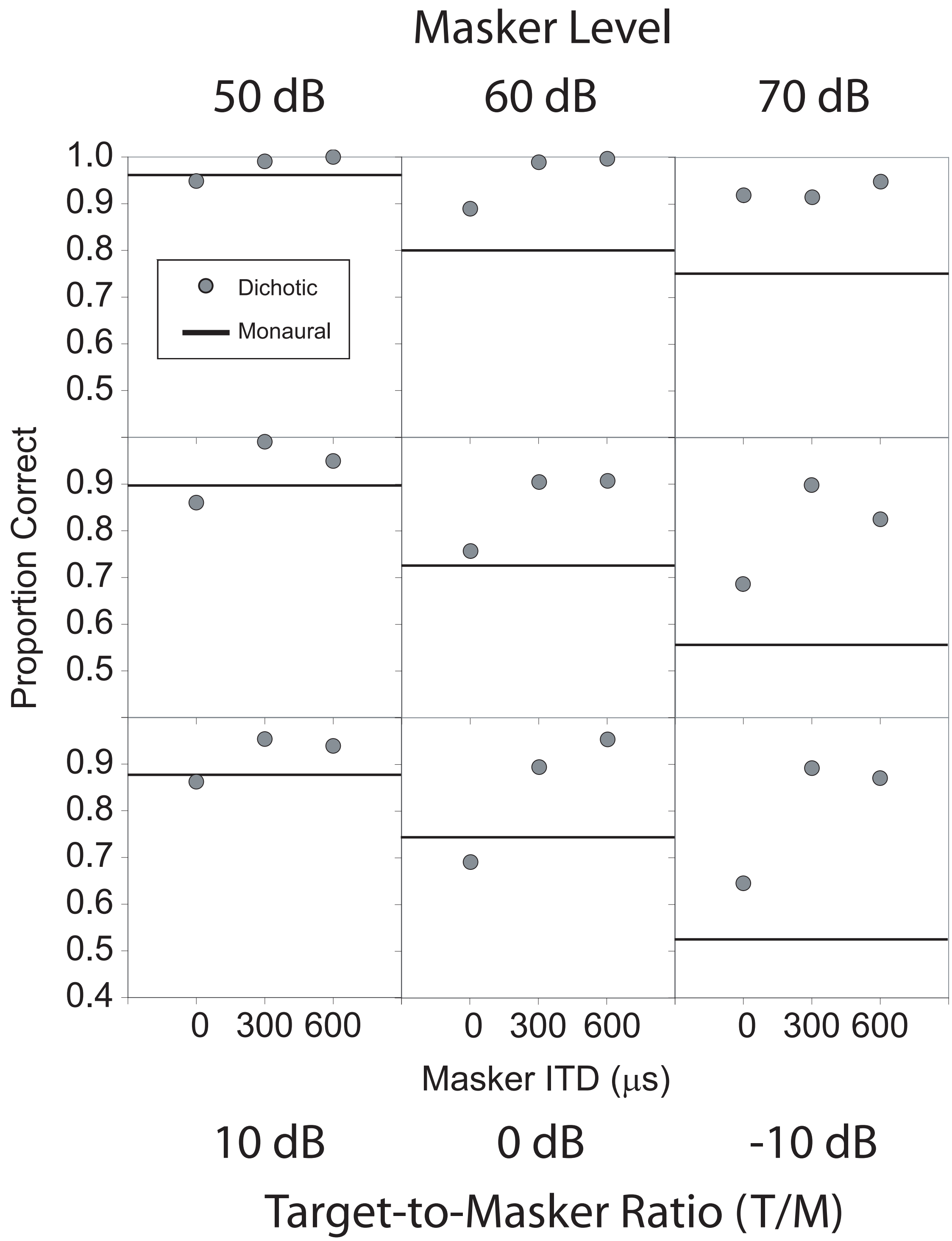


Various ILDs were imposed on the DBS masker by lowering the level of the masker in the left ear and raising it in the right. The average of the two levels is reported.

Fig. 4b EXPERIMENT 3
DBS masker binaural with ITDs.

Target diotic.





Various ITDs were imposed on the DBS masker by delaying the masker at one ear and advancing it at the other.

Results, Experiment 3

ITDs and ILDs greater than zero all led to improvements in performance relative to monaural.

Surprisingly, even values of zero sometimes resulted in improvements. This was not predicted and is difficult to explain.

The main finding is that even both are binaural, listener performance improves when the interaural parameters between target and masker are varied.

Does perceived location correlate with performance?

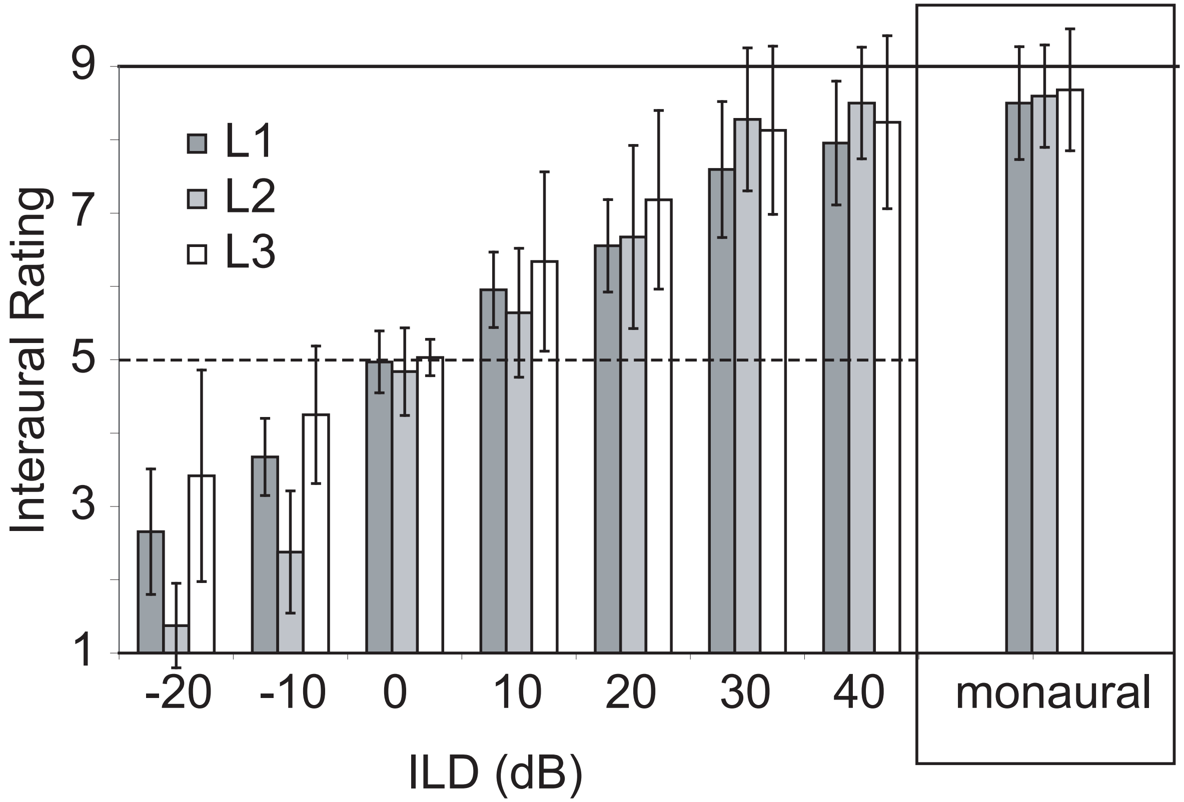
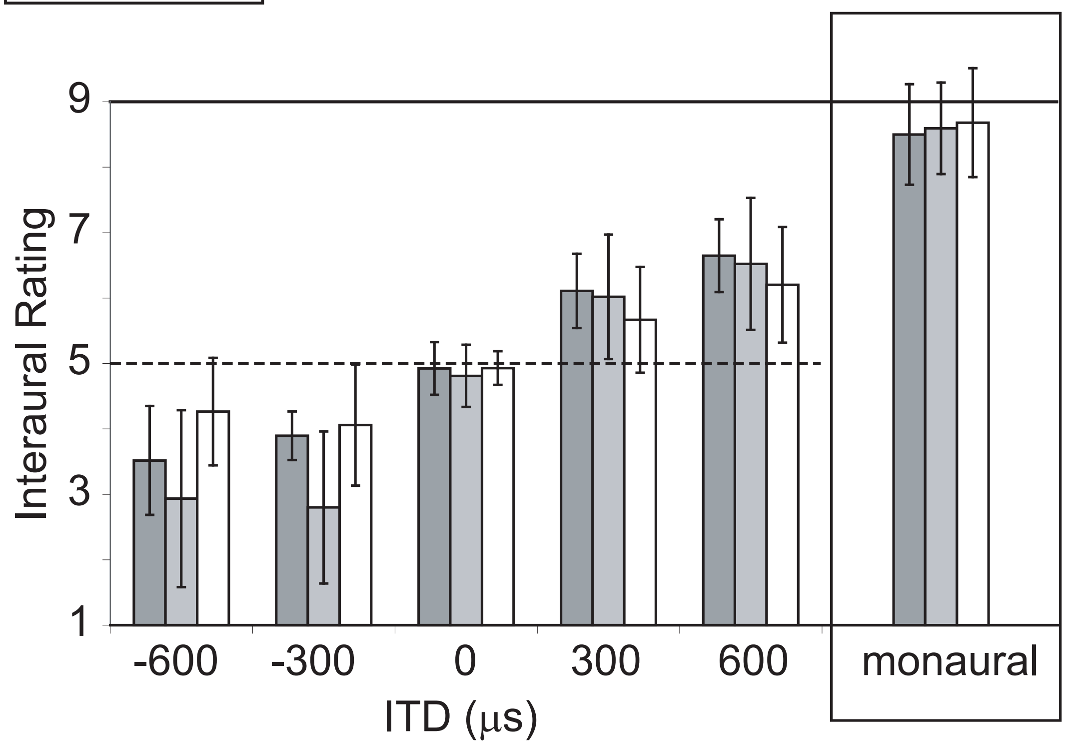


Fig. 5 EXPERIMENT 4
Listeners rate perceived lateralization of binaural and monaural DBS maskers.

Results
The ILD and ITD values that led to release from masking correspond to those that differ in ratings of perceived lateralization.



Summary

Binaural release from IM with sentences spoken over headphones occurs even if target and masker are both binaural.

The amount of binaural release is quite similar as long as the masker is not perceived as occupying the same interaural location as the target.

DBN release could result from the formation of a "muddy" binaural masker image that is perceived as different from a monaural target.

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