

# The effect of inter-aural differences of time on speech intelligibility in simulated electric-acoustic hearing

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## Introduction

- Implant patients who retain some residual low-frequency hearing (either in the implanted or the unimplanted ear) often show dramatically improved intelligibility in a competing background due to the ability to combine their electric stimulation with the low-frequency acoustic stimulation (EAS).
- In patients who have some low-frequency hearing in both ears, however, preserving residual hearing in the implanted ear (by inserting a shorter electrode array) may not be a priority, because the benefits of EAS will be available to them contralaterally.
- Patients with low-frequency hearing in only one ear may not benefit from binaural cues.
- Preserving residual hearing in the implanted ear may provide interaural differences of time (ITDs), a low-frequency binaural cue that can significantly improve intelligibility in the presence of a spatially separated masker.

» The purpose of this experiment was to examine the effectiveness of the ITD cue in improving speech intelligibility in a competing background, in simulated EAS.

## Method 1

- 25 individuals with normal hearing participated.
- A 4-channel vocoder simulated electric stimulation, and was presented to the left ear. The contiguous vocoder bands were equally spaced along a log scale between 750 and 5500 Hz.
- Low-pass (500-Hz cutoff) target speech and background were presented to both ears.

## Method 1 (continued)

- The target talker was female, always at an ITD of 0  $\mu$ s.
- The background was either a different female talker, a male talker, or speech-shaped noise.
- An ITD of either 0 (spatial image along midline) or 600  $\mu$ s (image to the right) was imposed on the background.
- Target and background were combined at a -3 dB SNR.
- Symmetrical low-frequency hearing loss was simulated by adjusting the level of the low-pass speech to either 60, 45, 30, or 15 dB SL (re: quiet thresholds of 200-ms 500-Hz low-pass noise).

## Results 1

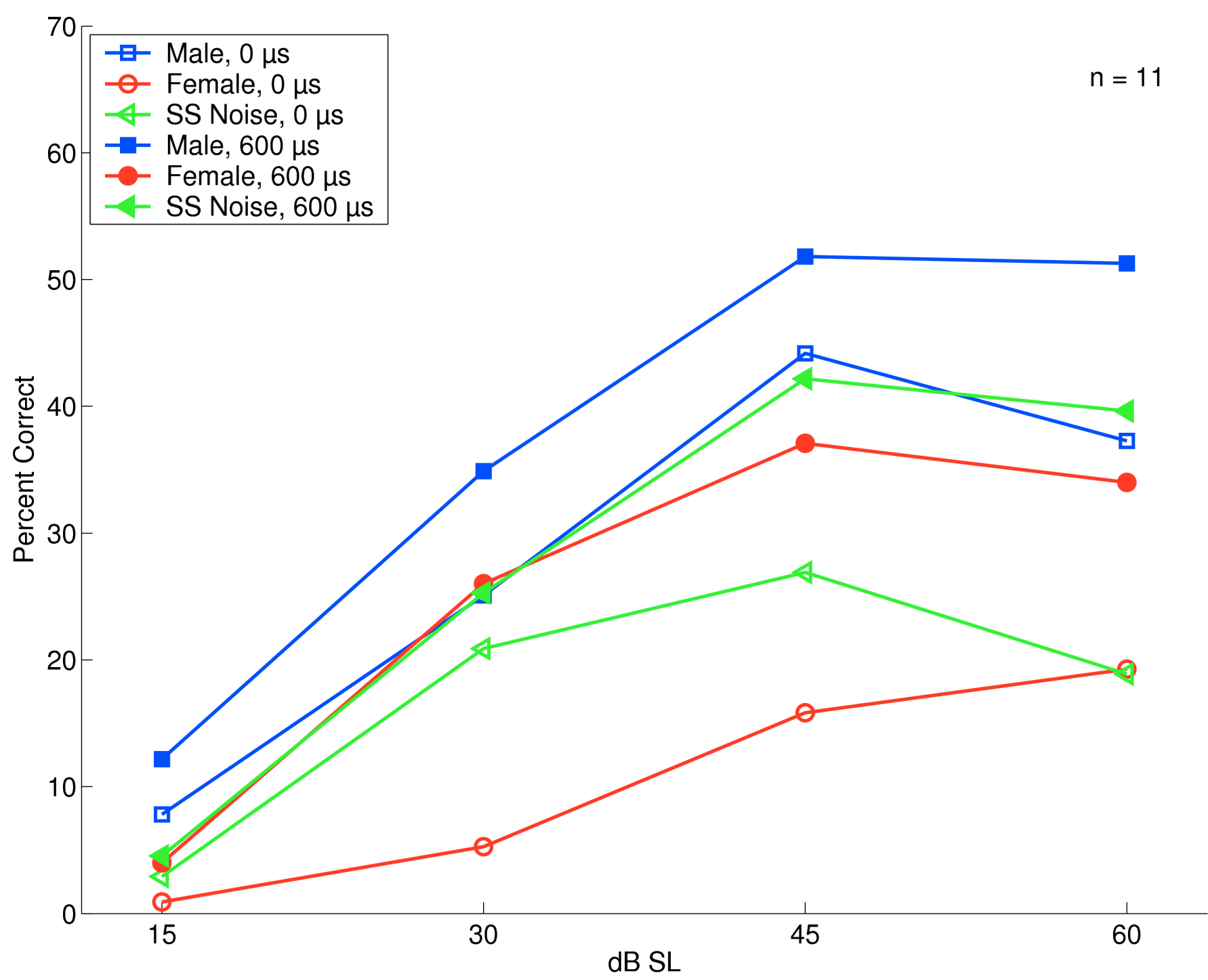


Fig. 1. Mean percent correct scores. Each plot color represents a different background. Unfilled symbols represent performance when no ITD was imposed on the background; filled symbols represent performance when an ITD of 600  $\mu$ s was imposed on the background. The overall level of the low-pass target and background, in dB SL, is along the X axis.

- There was little improvement due to ITD at 15 dB SL, which is likely due to the overall poor intelligibility.
- When averaged across background, improvement due to ITD was 11.6 percentage points at 30 dB SL, 14.7 at 45 dB SL, and 16.5 at 60 dB SL. The effect of ITD was statistically significant,  $p < .001$ .
- Performance as a function of SL appeared to asymptote at 45 dB SL.

## Method 2

- The same processing and stimuli (female target, female background) from experiment 1 were used.
- Asymmetrical low-frequency loss was simulated by fixing the level of the low-pass speech in either the left or right ear at 60 dB SL, and manipulating the level in the opposite ear to 50, 40, 30, or 20 dB SL.

## Results 2

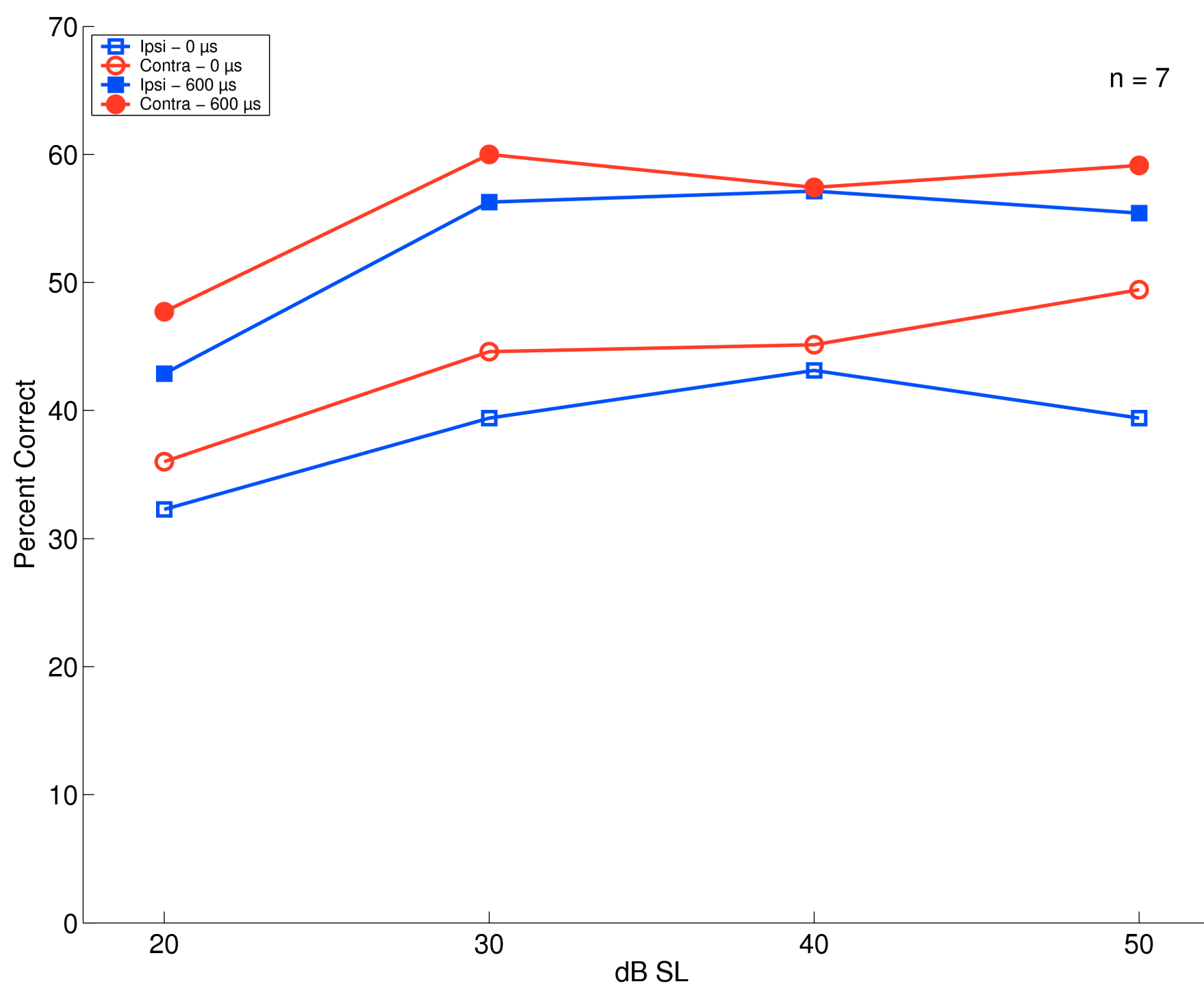


Fig. 2. Mean percent correct scores. The blue plots represent performance when the low-pass speech to the left ear (ipsilateral to the vocoder) was manipulated in SL, and the red plots represent performance when the low-pass speech to the right ear (contralateral to the vocoder) was manipulated. Unfilled symbols represent performance when no ITD was imposed on the background; filled symbols represent performance when an ITD of 600  $\mu$ s was imposed on the background.

- The effects of SL and side were not significant.
- The effect of ITD was significant,  $p < .001$ , and averaged about 13 percentage points of improvement across SL.
- The effect of ITD was not influenced by SL,  $p = .96$ .

## Discussion

- Intelligibility improved consistently by 10-20 percentage points in simulated EAS due to ITD.
- This effect was observed across different backgrounds, as well as for severely asymmetrical simulated losses.
- ITD is an effective cue in simulated EAS, so long as an adequate SL is achieved in at least one ear.