Excessive Auditory Backward Masking and its Potential Remediation in Children with Specific Language Impairment

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Abstract: Approximately five percent of children who are otherwise unimpaired have marked difficulties perceiving and producing spoken language. This disorder is typically labelled specific language impairment. Recent psychoacoustic tests indicate that children with specific language impairment have excessive auditory backward masking, as demonstrated by their extreme difficulties detecting brief tonal signals followed by longer noise maskers. These results are consistent with the hypothesis that specific language impairment results from an auditory perceptual deficit that makes difficult the discrimination of brief, rapidly presented sounds, including phonemes in speech. Subsequent studies using adults with normal hearing and language skills indicate that the interference from a backward masker can be reduced with practice. This learning generalizes from trained to untrained backward-masking conditions and appears to result from improvements in temporal rather than spectral processing. Taken together, these data imply that training in auditory backward-masking conditions may be a useful intervention for children with specific language impairment.

AUDITORY BACKWARD MASKING IN CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT

Introduction: Specific language impairment is a disorder in which children who otherwise appear to be developing normally have marked difficulties perceiving and producing spoken language. Around five percent of children are affected. In a recent psychoacoustic experiment (1), my collaborators and I observed that children with specific language impairment have strikingly abnormal auditory masking in particular listening conditions. Our results support the view that auditory perceptual deficits contribute substantially to language deficiencies. In this paper I will first describe a portion of those masking data.

Stimuli and Procedure: The signal was a 1000-Hz tone with a total duration of 20 or 200 ms. The masker was either a bandpass noise that ranged from 600 to 1400 Hz or a notched noise comprising two noise bands ranging from 400 to 800 Hz and 1200 to 1600 Hz. Both maskers had a total duration of 300 ms, shaped with 10-ms cosine-squared envelopes, and a spectrum level of 40 dB SPL. The onset of the 200-ms tone came 50 ms after masker onset. The onset of the 20-ms tone came either 20 ms before masker onset (backward masking), at masker onset, 200 ms after masker onset, or immediately after masker offset. Stimuli were presented to the right ear over headphones. The signal level necessary for 94% correct detections was measured using an adaptive maximum-likelihood method in a two-interval forced-choice procedure.

Subjects: Sixteen 8-year-old children participated. Eight were diagnosed with specific language impairment. The remaining eight had normal language skills and matched the impaired children in age and nonverbal intelligence.

Results and Discussion: Masked threshold for the long tone in the bandpass noise did not differ across the two groups. In contrast, the short tones in the bandpass noise were consistently more difficult to detect for the impaired than the control children. Most remarkably, the mean threshold in the backward-masking condition was 42 dB higher for the children with specific language impairment than for the control children. It is important to note that the impaired children had less, though still excessive, backward masking with the notched than the bandpass noise, indicating that that the perceptual deficit of these children is spectrally as well as temporally specific.

TRAINING-INDUCED REDUCTIONS IN AUDITORY BACKWARD MASKING

Introduction: The previous experiment showed that children with specific language impairment have extreme amounts of backward masking. This demonstration raises the possibility that impaired children might benefit if the amount of their backward masking could be reduced with training. As a first step toward testing this idea, my collaborators and I began a series of experiments on perceptual learning in auditory backward masking using adults with normal hearing and language skills. In the second half of this paper I will present a brief overview of two of our experiments (2,3). Our primary questions were whether listeners could improve their performance in auditory backward-masking tasks through training, and, if so, how this learning would generalize to other masking tasks.
Stimuli and Procedure: In both experiments, the subjects practiced detecting a 10-ms tone at 1000 Hz presented immediately before the onset of a 300-ms noise band ranging from 200 to 1800 Hz. This training phase lasted one hour per day for ten days. Before and after the training phase, the detection threshold for a 10-ms tonal signal masked by a 300-ms noise was measured in a variety of untrained conditions to determine whether performance in those conditions changed following practice on the trained condition. In all conditions, the masker spectrum level was 40 dB SPL, the stimuli were shaped with cosine-squared envelopes of 5 ms, and the stimuli were presented to the left ear over headphones. Signal thresholds were estimated as described above.

Subjects: All of the fifteen subjects were psychoacoustically naive adults with normal hearing and language skills.

Results and Discussion: Our first question was whether the amount of backward masking could be reduced through practice. This was clearly the case. The mean signal threshold of the fifteen subjects in the trained condition decreased from 62 dB to 51 dB over the ten days of training.

Our second question was how learning in the trained backward-masking condition generalized to other masking tasks. This issue was explored using different conditions in the pre and post-tests in the two experiments. The main aim of the first experiment (2) was to determine whether learning in backward masking would generalize to conditions in which the signal was presented at untrained times relative to masker onset. Signal threshold decreased significantly in the trained condition and in two other backward-masking conditions. In one, the signal was simply presented 10 ms earlier than in the trained condition. In the other, the signal was a 3800-Hz tone presented immediately before a masking noise ranging from 3000 to 4600 Hz. There were, however, no significant threshold reductions following practice in backward masking in three other conditions in which the signal and masker had the same spectra as in the trained condition, but the signal was presented at masker onset, 200 ms after masker onset, or after masker offset. These data thus appear to indicate that training in a backward-masking task generalizes to the detection of backward-masked signals presented at untrained times and frequencies, but does not influence performance in simultaneous and forward masking.

Our primary goal in the second experiment (3) was to determine whether the training-induced reduction in backward masking was accompanied by a corresponding improvement in the spectral resolution of the signal and masker. This issue was addressed by measuring in the pre and post-tests the threshold for a signal backward masked by the trained masker and by three other maskers that contained spectral notches of 200, 400, and 800 Hz centered on the signal frequency (4). A greater decrease in threshold with the wider than the narrower spectral notches would indicate an improvement in spectral resolution following training. If anything, the opposite occurred. The mean threshold decrease following training was greater for the narrower spectral notches. Thus, it appears that spectral resolution does not improve during learning in backward masking. An intriguing alternative hypothesis is that such training increases processing speed.

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REFERENCES