Non-simultaneous Masking of Speech in Noise: Normal-Hearing Children and Adults

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BACKGROUND

Previous psychophysical experiments have demonstrated that children have immature temporal processing when compared to adults for forward and backward masking tasks[1,2].

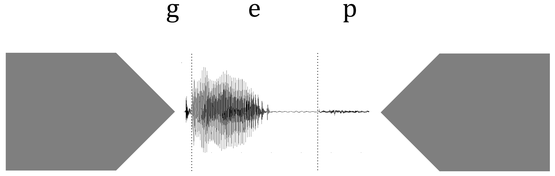
Forward Masking

Forward masking occurs when a noise precedes a signal. Thresholds in this condition are influenced by both peripheral (e.g., "ringing" of the basilar membrane) and central effects (e.g. difficulties differentiating the signal from the masker).

Backward Masking

Backward masking occurs when a signal precedes a noise. The mechanisms of backward masking are unclear but thought to be entirely central, not peripheral.

Children perform poorly in measures of forward masking and even more poorly in measures of backward masking when compared to adults. Previous studies have used unnatural stimuli, typically tones or noise. The purpose of this study was to quantify the amount of forward and backward masking children experience as compared to adults for speech, an ecologically valid stimulus.



METHODS

Participants

Normal hearing listeners ages 5-10 and 18-35 years participated in the study.

Group	*N*	Mean Age (SD)
Children	*19*	7.2 (1.3)
Adults	*20*	24.7 (4.0)

Table 1. Mean age and standard deviation (SD) of child and adult participants.

Test Procedure

Participants heard CVC non-words[3] in between two bursts of speech shaped noise (200ms duration, 5ms raised cosine ramps). Stimuli were presented monaurally via headphones and participants were asked to repeat each word.

The masker was always presented at 70 dB SPL. Target words were presented for all listeners at a fixed level of -30 dB SNR.

In addition, 50% correct performance was estimated for adults using a 1-down, 1-up procedure. These data were used to estimate the SNR required for adults to have child-like performance.

Video recordings of each session were phonetically transcribed to analyze error patterns.

RESULTS

Fixed Level Performance

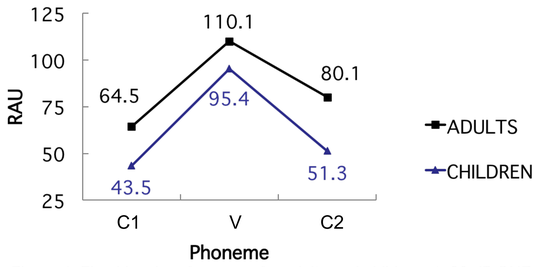


Figure 1. Fixed level performance for adults and children at -30 dB SNR.

Comparisons	Results
Main effect of phoneme	F(1,36) = 90.89, p<0.001
Main effect of age group	F(1,36) = 58.18, p<0.001
Age group x phoneme Interaction	F(1,38) = 9.24, p=0.004

Table 2. Results of ANOVA comparison

Psychometric Functions for Adults

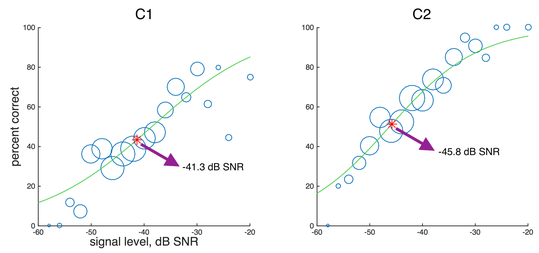


Figure 2. Psychometric functions were fitted to adult data obtained using the adaptive threshold procedure. The goal was to estimate the SNR corresponding to children's performance with a -30 dB SNR stimulus (43.5% for C1 and 51.3% for C2). Those levels were 41.3 dB and 45.8 dB SNR, respectively.

Error Patterns

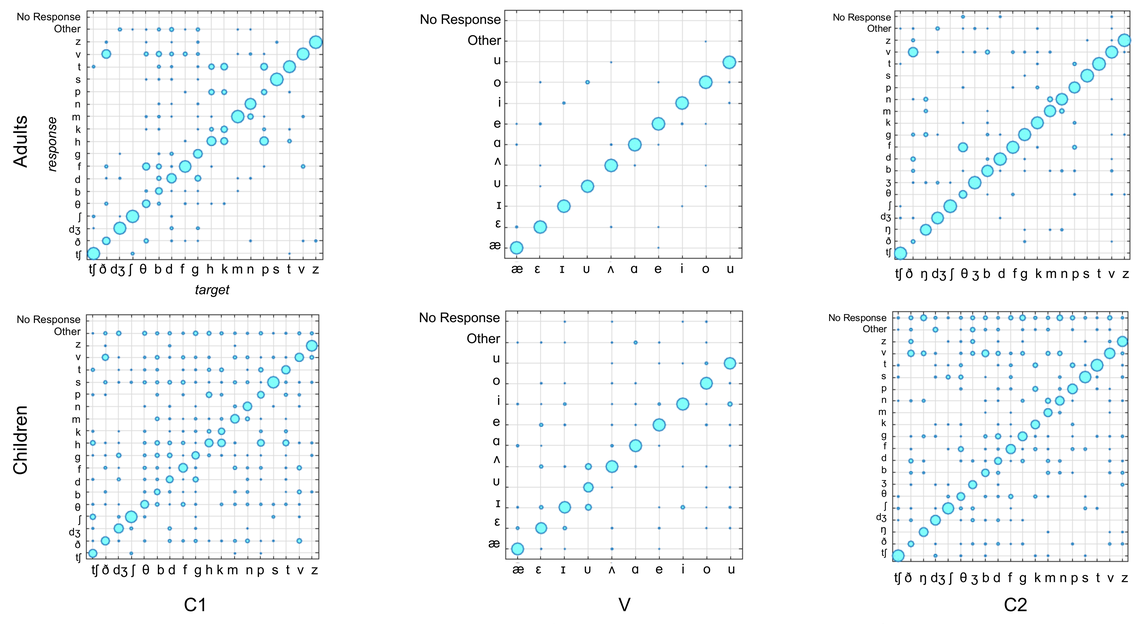


Figure 3. Error patterns for adults and children at -30 dB SNR for the 1st consonant (forward masking), vowel, and 2nd consonant (backward masking)

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SUMMARY

Comparisons at a presentation level of -30 dB SNR showed that all participants exhibited more forward than backward masking. In addition, adults performed better than children overall.

There are greater differences between children and adults for backward masking than forward masking. The child-adult difference is 11.3 dB for forward masking and 15.8 dB for backward masking.

Analysis of error patterns showed adults and children made similar errors. Very few errors occurred in the vowel position. Children frequently had "no response" in the backward condition, whereas adults tended to respond more often.

DISCUSSION

The present experiment is novel in quantifying the amount of backward masking children experienced for a speech signal. As documented previously for tones in noise, this study found greater non-simultaneous masking in children than adults, particularly for backward masking.

This suggests different mechanisms underlie forward and backward masking, which may be subject to different maturational trajectories.

These results may help explain why children struggle in noisy situations and support the use of classroom or personal assistive listening devices that improve the signal to noise ratio, such as FM systems.

FUTURE DIRECTIONS

Future studies could determine if the results generalize to real speech materials, though this would introduce linguistic confounds and make it difficult to measure perceptual processing ability alone.

Further research could also assess older children to better understand how the developmental trajectory of temporal processing continues.

Finally, spatial separation of the target signal and masker would more closely simulate real world listening and provide insight into the benefit this cue may provide for non-simultaneous masking.

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