

## BACKGROUND

- The effects of broadened auditory filters on adult perception are minimal when static spectra such as steady-state vowels are presented (Turner & Van Tasell, 1984), but when sentence-length materials are used, effects are greater and increase with the extent of spectral smearing (Baer & Moore, 1993). This suggests abnormally broad auditory filters have the greatest impact where listeners need to track dynamic formant patterns.
- Where children are concerned, it could be predicted that broadened auditory filters would have even more of a deleterious effect because they are especially dependent on dynamic formant patterns.
- Spectral smearing of formants (model of broadened filters) should therefore disproportionately affect children.
- The question follows of whether making formants more prominent would result in improved recognition.

## HYPOTHESES

1. Adults and children alike would show diminished recognition scores with smeared spectra compared to unprocessed materials in noise.
2. This effect would be greater in magnitude for children than for adults.
3. For adults, the effect would increase with a decrease in signal-to-noise ratio (SNR).
4. Enhancing signal spectra (i.e., making formants more prominent) would lead to improved recognition in noise.

## METHOD

### PARTICIPANTS

Adults (40) and children ages 5 and 7 (20 of each age). All participants passed a hearing screening and had typical language development, and were also screened for expressive vocabulary, reading (adults) and articulation (children).

### PROCEDURES

Listeners heard sentences in three processing conditions (smeared, enhanced, unprocessed). Children and half the adults listened at 0 dB SNR. The other half of adults listened at -3 dB SNR. Two dependent measures were reported: (1) percent correct words in sentences, and (2) the proportional effect of smearing [calculated using (Unprocessed – Smeared)/Unprocessed.]

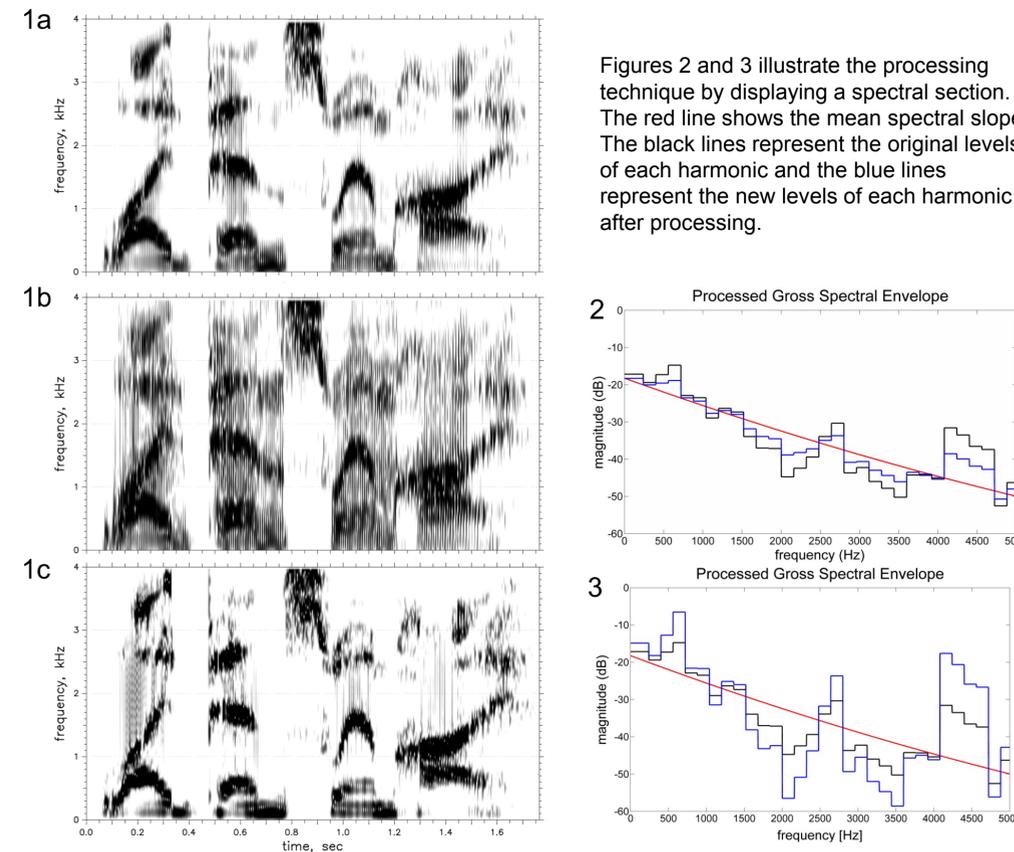


Figure 1. "Wide pens swim high", unprocessed (1a), smeared (1b), and enhanced (1c).

### STIMULI

- 75 4-word syntactically correct, semantically anomalous sentences spoken by a male talker (Figure 1a).
- Sentences were processed in two ways:
  - Spectra of the voiced portions were smeared to be half as sharp as the spectral envelopes of the original stimuli (Figure 1b and Figure 2).
  - Spectra of the voiced portions were enhanced to be twice as sharp as the spectral envelopes of the original stimuli (Figure 1c and Figure 3).
- Resulting stimuli were embedded in speech-shaped noise based on the average long-term spectra across all the stimuli. Two SNRs were used: 0 dB and -3 dB.

Figures 2 and 3 illustrate the processing technique by displaying a spectral section. The red line shows the mean spectral slope. The black lines represent the original levels of each harmonic and the blue lines represent the new levels of each harmonic after processing.

## RESULTS

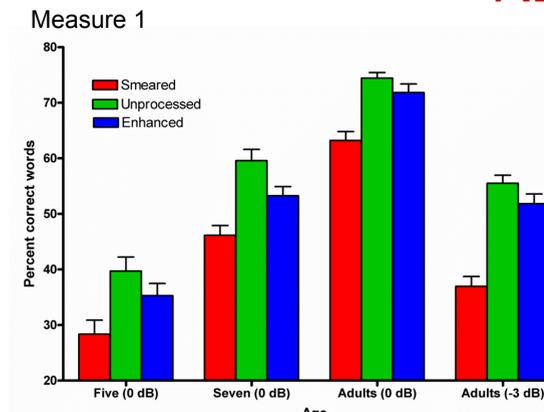


Figure 4. Mean word recognition scores for the three processing conditions, by age. Error bars are standard errors of the mean.

Results from a repeated-measures ANOVA with processing condition as the repeated measure and age as the between-subjects measure, for listeners tested at 0 dB SNR.

	df	F	p	Partial $\eta^2$
Processing	2, 114	69.86	<.001	.55
Age	2, 57	117.21	<.001	.80
Age x Processing	4, 114	.63	NS	

Results from a repeated-measures ANOVA with processing condition as the repeated measure and SNR as the between-subjects measure, for adults:

	df	F	p	Partial $\eta^2$
Processing	2, 76	85.05	<.001	.69
SNR	1, 38	165.56	<.001	.81
SNR x Processing	2, 76	5.36	.007	.12

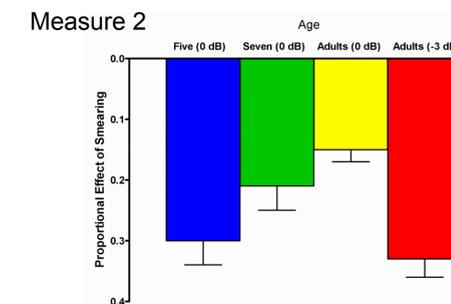


Figure 5. Mean proportions of the effect of smearing, by age. Error bars are standard errors of the mean.

At 0 dB SNR:

- Word recognition improved with increasing age across all conditions.
- Word recognition was poorer for both smeared and enhanced conditions.
- The decrement in performance was greater for smeared than for enhanced materials.
- Children showed a larger proportional effect of smearing than adults, and the age effect was significant:  $F(2,59) = 4.45, p = .016$ .

At -3 dB SNR:

- Adults at -3 dB SNR performed more poorly than adults at 0 dB SNR.
- Adults showed a larger effect of spectral smearing at the poorer SNR.

## CONCLUSIONS

1. Outcomes supported the first three hypotheses.
2. Failure to support the fourth hypothesis may be due to the following: Enhancement of subglottal or nasal resonances, which do not provide meaningful information, could have interfered with speech recognition. Future efforts might involve extracting and enhancing vocal-tract resonances only.
3. Results suggest broadening of auditory filters might explain some of the variability in language outcomes found for children with hearing loss.
4. Children might benefit more than adults from appropriate spectral enhancement.

### REFERENCES

- Baer, T. & Moore, B. C. J. (1993). Effects of spectral smearing on the intelligibility of sentences in noise. *J. Acoust. Soc. Am.*, 94, 1229-1241.  
Turner, C. W. & Van Tasell, D. J. (1984). Sensorineural hearing loss and the discrimination of vowel-like stimuli. *J. Acoust. Soc. Am.*, 75, 562-565.

### ACKNOWLEDGEMENT

Work supported by NIDCD Grant No. DC-000633