

## Why we study linguistic processing of vocoded signals?

- We are interested in how signal structure other than that affiliated with specific phonetic segments is used in language processing by adults and children. Vocoded signals largely eliminate temporal and spectral fine structure, but preserve temporal envelopes. Listeners can recognize sentences with temporal envelopes. We ask how well they facilitate other linguistic processes.
- The sort of acoustic structure preserved by vocoding is similar to that available through cochlear implants. Word recognition is a common clinical measure used with implant patients. We ask if word recognition is sufficient to evaluate the linguistic processing abilities of individuals with implants.

## Exp. 1: Serial Order Recall of Words

In this paradigm, listeners hear strings of nouns made known beforehand. They are asked to recall the order of presentation. Listeners show different response patterns for speech and non-speech signals. We wanted to see if vocoded signals would be processed like speech or non-speech.



## METHOD

- Participants:** 48 adults and 24 8-year-olds. All typical.
- Stimuli:** 8 CVC nouns, presented in each of 3 ways.
- natural, unprocessed
  - 8-channel noise vocoded
  - natural words in noise: 0 dB SNR for all children; ½ of adults heard 0 dB SNR and ½ heard -3 dB SNR.
- Fourth condition consisted of 8 common environmental sounds.
- Procedures:**
- Adults heard 8-item lists; children heard 6-item lists.
- Practice trials and pre-test to make sure listeners understood task and items were recognized perfectly.
  - Words presented without pictures; pictures appeared after presentation; listener pointed to pictures in order of recall; 10 lists in each condition.
  - Post-test to make sure items were still recognized perfectly.

## RESULTS

Adults scored the same at 0 and -3 dB SNR: 59 vs. 57 percent correct, SD = 16 percent

Therefore, data were combined across the two adult groups.

Adults performed similarly for unprocessed and signals in noise; worse for vocoded; worse still for environmental sounds.

Adults did show speech-related recency effect for vocoded signals.

Children performed similarly for vocoded and noise; better for unprocessed; worse for environmental sounds.

Figure 1: Correct recognition by position.

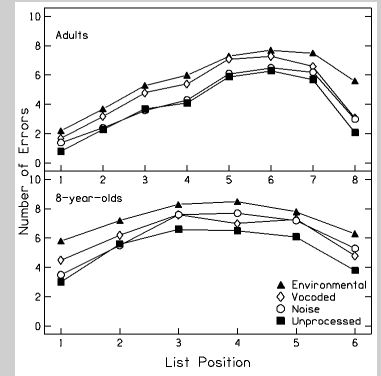


Table 1: Mean percent correct recognition (and SD), across positions.

	Adults	8-yr-olds
Unprocessed	61 (12)	47 (17)
Noise	58 (16)	39 (15)
Vocoded	51 (12)	38 (13)
Environmental	43 (14)	27 (9)

Table 2: Mean corrected response times (seconds). Adults = 8 Items; 8-yr-olds = 6 Items.

	Adults	8-yr-olds
Unprocessed	4.2 (1.5)	2.8 (1.0)
Noise	4.2 (1.6)	3.1 (1.2)
Vocoded	4.7 (1.9)	3.1 (1.0)
Environmental	5.2 (1.9)	3.8 (1.1)

## Exp. 2: Phonetic Awareness (Final Consonant Choice)

In this paradigm, listeners hear a target word and must select the one (out of three) that ends in the same sound.

This task requires that listeners be able to recover phonetic segments.

We wanted to see if listeners could recover those segments as readily with vocoded signals, which they recognize, as with unprocessed signals.

## METHOD

- Participants:** 40 adults and 40 8-year-olds. All typical. Children showed age-appropriate PA on a phoneme deletion task.
- Stimuli:** 48 trials consisting of target word and 3 match choices. All CVCs. Unprocessed, 8-channel vocoded, & embedded in noise at 0 dB (children) and -3 dB (adults).
- Procedures:**
- Practice trials to learn procedures.
  - Pre-test to make sure all words were recognized perfectly.
  - Half of listeners heard unprocessed and noise; half heard unprocessed and vocoded.
  - Trials randomly varied between unprocessed and processed stimuli.

## RESULTS

Adults and children performed similarly on unprocessed words, regardless of which group they were in.

Therefore, data were combined for the unprocessed condition.

Listeners in both age groups showed similar accuracy for unprocessed and vocoded signals; poorer for speech in noise.

Table 3: Mean percent correct decisions on PA.

	Adults	8-yr-olds
Unprocessed	92 (6)	74 (13)
Noise	85 (9)	63 (16)
Vocoded	91 (6)	70 (12)

Table 4: Mean corrected response times (seconds). NOTE: Adults and children had similar baselines.

	Adults	8-yr-olds
Unprocessed	0.7 (0.5)	4.2 (1.7)
Noise	1.2 (0.7)	4.4 (1.5)
Vocoded	1.0 (0.7)	4.1 (2.1)

Table 5: FOR CORRECT ANSWERS ONLY, mean response times.

	Adults	8-yr-olds
Unprocessed	0.5 (0.4)	3.1 (1.4)
Noise	0.8 (0.5)	3.9 (2.0)
Vocoded	0.9 (0.6)	3.3 (1.8)

## CONCLUSIONS

- Vocoded signals are not processed as is natural speech, even when word recognition is similar for both.
- Vocoded signals introduce additional processing demands that are not captured by word recognition measures.
- Phonetic structure might be recovered independently of lexical access in linguistic processing.
- Vocoding of speech signals can not be modeled as simple degradation.
- Adults and children process vocoded signals differently; in fact, they likely process all signals differently.

## ACKNOWLEDGEMENT

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