Getting phonetic structure from an aphonetic signal

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BACKGROUND

•Why study working memory?

The ability to retrieve and use phonetic structure aids linguistic working memory. Nittrouer & Miller (1999) found that adults are better at using phonetic structure to store words in working memory than children (Figure 1). Adults and children performed similarly with rhyming words, but adults show an advantage with non-rhyming words where ready access to phonetic structure serves the strongest function.

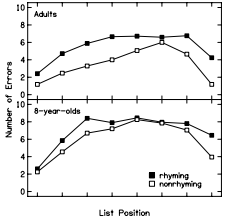

Figure 1. Adapted from Nittrouer & Miller (1999).

•Can listeners get phonetic structure from an aphonetic signal?

Recent work (Nittrouer, Lowenstein, & Packer, in press) has shown that adults and children can understand sine wave sentences (Figure 2), but do they get phonetic structure from the signal? It seems unlikely, because sine waves do not preserve the spectrotemporal detail long thought to support phonetic perception.

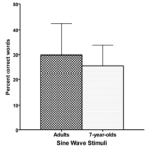

Figure 2. Adapted from Nittrouer, Lowenstein, & Packer (in press).

•Theoretical background

Baddeley's phonological loop, which consists of a phonological store and an articulatory rehearsal mechanism (2007), suggests that the perception of fine-grained articulatory movements leads to phonetic distinctions in working memory. So, the notion of a phonological loop is dependent on listeners retrieving and using precisely the spectrotemporal detail that is missing in sine wave speech.

STIMULI

Condition 1: Three sets of stimuli were used, all unprocessed: non-rhyming words, rhyming words, and environmental sounds.

Non-Rhyme: teen, ball, coat, pack, dog, ham, rake, seed

Rhyme: mat, bat, gnat, cat, hat, rat, vat, Pat

Environmental: bird, drill, piano, knock, whistle, breaking glass, sneeze, helicopter

Condition 2: Three word lists

List 1: bun, doll, morn, dad, log, gal, dug, bag

List 2: bum, lad, dud, gang, dawn, dab, long, bog

List 3: ball, rug, dog, mud, lab, door, gong, bomb

These word lists differed from the ones used in previous work because of concern that the non-rhyming words could be distinguished by vowel nuclei alone; therefore words were chosen with similar nuclei ("near-rhymes") from the low and central region of the vowel space.

Each list could be presented in three conditions: Unprocessed, Noise (0 dB SNR), or Sine (sine wave speech). Conditions and lists were crossed such that they were randomized for each participant (36 possible orders).

For both experiments, cards with pictures represented each word.

METHOD

Participants

Condition 1: Adults (50), 8-year-olds (38), 6-year-olds (40).

Condition 2: Adults (36), 8-year-olds (34).

Task

Participants listened to the 8-word list and had to arrange picture cards to match the order they heard. Ten trials were run for each list.

Criterion for inclusion

Participants had to label correctly each card when presented individually in each condition, both pre-test and post-test.

Data analysis

Because participants all showed the same overall pattern of response, total number of errors (out of 80) was chosen as the dependent variable.

RESULTS

	Condition 1			Condition 2		
	Non-Rhyme	Rhyme	Environmental	NR Unprocessed	NR Noise	NR Sine Wave
Adults	24.5 (9.0)	32.2 (7.9)	34.2 (10.1)	31.3 (9.4)	32.1 (10.0)	33.2 (7.6)
8-year-olds	45.7 (9.1)	53.1 (6.5)	51.7 (7.0)	53.1 (6.8)	54.9 (7.8)	53.6 (7.7)
6-year-olds	55.2 (7.5)	62.7 (5.8)	59.6 (7.1)			

Table 1. Mean total errors (out of 80) for each condition for the serial recall tasks. Standard deviations are in parentheses.

Condition 1

(Table 1, left)

•All participants showed an advantage for the non-rhyming stimuli.

•All participants performed the same on rhyming and environmental sound stimuli.

Condition 2

(Table 1, right)

•All participants did as well with sine waves as with unprocessed stimuli.

•However, they did worse with unprocessed near-rhyming stimuli than expected.

Participants who could not hear sine waves as speech

	Unprocessed	Noise
Adults	31.3 (9.4)	32.1 (10.0)
Adults who failed sine	36.6 (5.9)	39.8 (7.9)
8-year-olds	53.1 (6.8)	54.9 (7.8)
8-year-olds who failed sine	50.2 (7.5)	56.7 (5.0)

Table 2. Mean total errors (out of 80) for each condition. Standard deviations are in parentheses.

•Adults who could not correctly label all the cards for the sine wave stimuli had poorer overall recall scores on the unprocessed and noise conditions (Table 2)

•This was not true for 8-year-olds: they performed the same as 8-year-olds who could correctly label the sine wave stimuli. Both groups performed more poorly than adults.

CONCLUSIONS

•The kind of global spectral structure provided by sine waves supports language processing, even for adults.

•Unprocessed stimuli that were non-rhyming but had similar nuclei led to results similar to rhyming stimuli. This suggests that the perception of fine-grained articulatory movements (e.g., the margins of words) is less important for working memory than global spectral structure (e.g., the vowel nuclei).

•The phonological loop seems to rely most heavily on vowel segments.

REFERENCES

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