VANDERBILT UNIVERSITY
MEDICAL CENTER

Are receptive vocabulary and articulation skills associated with speech recognition in children with hearing loss?

Rebecca Schoon, Tonia N. Davis, Stephen Camarata, Benjamin Hornsby, Fred H. Bess
Department of Hearing and Speech Sciences, Vanderbilt University, Nashville, TN

INTRODUCTION

A number of factors affect speech recognition in noise. Many of these factors, including degree of hearing loss, talker sex, and phonemic factors (ie., voicing), have been well documented (Boothroyd, 1984). Underlying language skills, however, especially vocabulary and overall speech intelligibility, may also affect speech recognition performance (Lewis et al., 2010; Nittrouer et al., 2013).

The purpose of this study was to examine the relationship between children's speech recognition performance, receptive vocabulary, and articulation accuracy. The current study asks:

(a) to what extent is receptive vocabulary associated with performance on speech-in-noise tasks? and
(b) to what extent is speech accuracy associated with performance on speech-in-noise tasks?

In addition, degree of hearing loss was considered.

PARTICIPANTS

28 children with hearing loss were included in this data set. Children qualified for the study if they had no diagnosis of autism spectrum disorder or cognitive impairment as reported by the parents. All children spent at least two hours per day in a general education classroom.

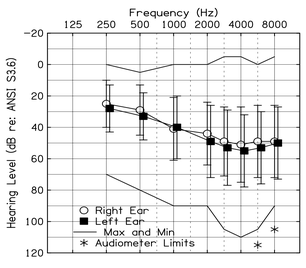

Figure 1. Composite audiogram.

	CHL (n=28)
Demographic Factors	
Age	10;0
Maternal Education	"College degree"
Audiologic Factors	
Degree HL Descriptive	71.00% "moderate"
Better Ear PTA	40.58dB HL (15.56)
Reported Age ID	5;0
Reported Age Fit	5;8
HA Use Descriptive	70.27% "consistent users"
Speech Recognition - Words Correct	46.11%
Speech Recognition - Phonemes Correct	77.07%
Language and Academic Factors	
Nonverbal Intelligence (TONI)	101.82 (12.07)
Articulation (AAPS)	93.94 (5.51)
Language (CELF)	90.59 (21.78)
Receptive Vocabulary (PPVT)	92.74 (16.02)
Phonological Awareness (CTOPP)	89.44 (16.74)
Reading Factors	
Decoding (WRMT)	95.80 (18.17)
Comprehension (WRMT)	97.89 (16.86)

Table 1. Child demographic , audiologic, and language factors.

METHODS

This study is part of a larger, study examining listening effort and fatigue in school-age CHL. As part of this larger study, children were administered a speech-and-language test battery that included measures of receptive vocabulary (Peabody Picture Vocabulary Test – 4th edition) and speech accuracy (Arizona Articulation Proficiency Scales – 3rd edition).

For the speech recognition tasks, children were seated in a reverberant room (RT60 = 0.6 seconds) and asked to repeat words presented from a loudspeaker located directly in front of them (approximately 1 meter). Verbal responses were recorded using a head-worn microphone. Speech recognition was measured using AB Isophonemic word lists (Boothroyd, 1968a,b). A 20-talker speech babble noise was presented continuously throughout the task at a fixed overall level of 56 dBA from loudspeakers situated at 45, 135, 225 and 315 degrees. Speech levels were adjusted to create three, individualized, signal-to-noise ratios (SNRs) ranging in difficulty (-4 to +12 dB range; 30 words/condition). For this study, only data from the most favorable aided SNR condition were used. Verbal responses on the speech tasks were independently scored by two-trained research assistants (Tables 2 & 3). Discrepancies were resolved by a third research assistant.

Target	Response	Phoneme Score (3)	Word Score (1)
fib			
thatch			
sum			
heel			
wide			
rake			
goes			
shop			
vet			
June			

Table 2. Blank example of 10 words from the verbal response scoring, including transcription, phoneme score, and word score.

Target	Response	Phoneme Score (3)	Word Score (1)
have	/hæd/	2	0
wig	/bɪg/	2	0
buff	/bʌf/	3	1
mice	/mait/	2	0
teeth	/tiɵ/	3	1
jays	/jeiz/	3	1
poach	/potʃ/	3	1
rule	/ru/	2	0
den	/dæn/	2	0
shock	/rat/	1	0

Table 3. Example of verbal response scoring. Child errors can be noted in transcription, phoneme score, and word score.

RESULTS

- Receptive vocabulary was not associated with performance on speech recognition-in-noise task (Words Correct r=.24, n.s.; Phonemes Correct r=.34, p=.06).
- Articulation was associated with performance on the same task (Words Correct r=.46, p<.01; Phonemes Correct r= .42; p<.01).
- Better ear PTA was not associated with performance (r=.09 and r=.06, n.s.), likely due to audibility of the speech and noise signals provided by the hearing aids.

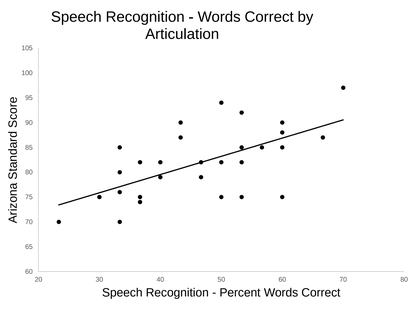

Figure 2. Relationship between speech recognition and articulation.

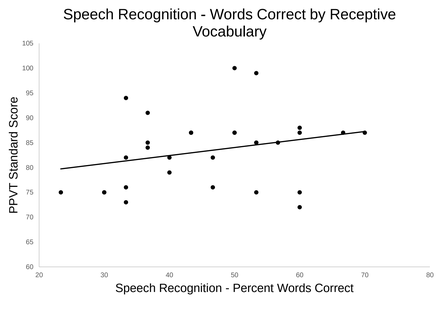

Figure 3. Relationship between speech recognition and receptive vocabulary.

DISCUSSION

- Although a few studies have found a relationship between receptive vocabulary and laboratory speech recognition skills, this was not found in the current study. However, the relationship approached significance (p=.06).
- Children were not told to expect real words in this study, so it is possible that vocabulary skills could affect speech recognition in real-world situations that are not captured in this study.
- Children with concomitant speech sound disorders in this study demonstrated decreased accuracy in speech recognition tasks. For example, deaffrication (e.g., producing "bad" for "badge") would result in a lowered words-correct and phonemes-correct score, although this is a normal substitution pattern for children with speech delays and disorders.
- These errors may confound the results of audiologic testing if the child is asked to produce what they hear. Service providers should identify speech sound errors prior to speech recognition testing and modify materials or procedures as needed. In addition, using closed sets of materials may be helpful for children with severe articulation errors.

KEY REFERENCES

Antia, S. D., Jones, P. B., Reed, S., & Kreimeyer, K. H. (2009). Academic status and progress of deaf and hard-of-hearing students in general education classrooms. *Journal of Deaf Studies and Deaf Education*.

Boothroyd, A. (1984). Auditory perception of speech contrasts by subjects with sensorineural hearing loss. *Journal of Speech, Language, and Hearing Research*, *27*(1), 134-144.

Cupples, L., Ching, T. Y., Crowe, K., Day, J., & Seeto, M. (2014). Predictors of early reading skill in 5-year-old children with hearing loss who use spoken language. *Reading Research Quarterly*, *49*(1), 85-104.

Lewis, D., Hoover, B., Choi, S., & Stelmachowicz, P. (2010). The relationship between speech perception in noise and phonological awareness skills for children with normal hearing. *Ear and hearing*, *31*(6), 761.

Moeller, M. P., Tomblin, J. B., Yoshinaga-Itano, C., Connor, C. M., & Jerger, S. (2007). Current state of knowledge: Language and literacy of children with hearing impairment. *Ear and Hearing*, *28*(6), 740-753.

Nittrouer, S., Caldwell-Tarr, A., Tarr, E., Lowenstein, J. H., Rice, C., & Moberly, A. C. (2013). Improving speech-in-noise recognition for children with hearing loss: Potential effects of language abilities, binaural summation, and head shadow. *International journal of audiology*, *52*(8), 513-525.

ACKNOWLEDGEMENTS

The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R324A110266 (Bess, PI) to Vanderbilt University.

Special thanks to our many research assistants and volunteers on this project.