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STRUCTURE OF MENTAL LEXICONS OF CHILDREN WHO USE COCHLEAR IMPLANTS: PRELIMINARY FINDINGS

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INTRODUCTION

Logan¹ has proposed that children older than 2 years with normal hearing organize and retrieve words from their mental lexicons using a phoneme-based strategy similar to that of adults. It is not clear whether the mental lexicons of children with profound deafness who use cochlear implants (CIs) are similarly organized, but the structures of such lexicons may indicate how these children acquire the ability to recognize and produce spoken words. To examine this, errors produced by such children on the Lexical Neighborhood Test (LNT),² an open-set, monosyllabic word recognition test, were analyzed within the framework of the Neighborhood Activation Model (NAM).^{3,4} This model proposes that spoken word recognition occurs in the context of phonologically similar words, such that recognition of a spoken word is dependent on 1) the frequency of occurrence of the word and 2) words in the lexicon that are phonologically similar (by single-phoneme substitution, addition, or deletion) to the target word (“neighbors”), including both the number of neighbors (“neighborhood density”) and the neighbors’ mean frequency of occurrence in the language (“neighborhood frequency”).

METHODS

Participants

Fifteen children with prelingual (<3 years) profound hearing loss who received the Nucleus 22 cochlear implant (5 implementing a multipeak [MPEAK] strategy and 10 a spectral peak [SPEAK] strategy) participated. The mean age at onset of profound loss was 0.2 ± 0.5 years, the mean age at implantation was 5.2 ± 1.9 years, and the mean age at time of testing was 7.3 ± 1.9 years. Seven used oral communication (OC), and 8 used simultaneous communication (SC). Children were selected on the basis of their ability to complete the LNT.

Materials and Testing Protocol

At the 2-year postimplant interval, each child was administered the LNT. This open-set test was chosen over a closed-set one because the multiple-choice format of the latter provides only minimal information about the structure of the lexicon and its contribution to word recognition. The LNT includes target words that are “easy” and words that are “hard” to recognize. “Easy” words occur frequently in the language and reside in neighborhoods that are sparse and of low mean frequency. “Hard” words are of low frequency and reside in dense neighborhoods with high mean frequencies. The test was administered by live-voice presentation without visual cues at approximately 70 dB sound pressure level. Participants were instructed to repeat the words they heard; to avoid confounds with pure production

errors, participants were also asked to sign, spell, or write their responses or to demonstrate comprehension of the meanings of their responses.

Analysis

The responses were scored on the basis of percentages of phonemes and words correct and then analyzed according to parameters proposed in the NAM (see above). Two computerized lexical databases represented the mental lexicon: 1) to represent an adult lexicon, a 20,000-word on-line pocket lexicon,⁵ and 2) to represent a child lexicon, a 600-word lexicon for 5-year-old children.⁶ Separate calculations were performed for users of OC and SC, and for easy and hard words.

RESULTS

Percent Correct Words and Phonemes

For OC users, the percentage of words correct was 63.7% for easy and 52.1% for hard words. For SC users, the scores were 36.5% for easy and 23.5% for hard words. For OC users, the percentage of correct phonemes was 77.1% for easy and 71.6% for hard words. For SC users, the percentage of correct phonemes was 58.1% for easy and 46.8% for hard words.

Within-Neighborhood Responses

With the use of the adult lexicon, it was determined whether responses resided in the neighborhoods of the relevant target words. Table 1 shows the percent responses residing in the target's neighborhood, also broken down by correct (target) and incorrect (but in the neighborhood of the target) responses.

Frequency and Neighborhood Structures of Responses (Adult Lexicon)

The frequency of occurrence and neighborhood characteristics (neighborhood density and frequency) were determined for all responses. Separate calculations were performed with the adult lexicon⁵ and the child lexicon.⁶ The frequencies and neighborhood characteristics of target words and responses were then compared to determine whether responses were "easier" or "harder" than targets. Table 2 shows the percentage of responses with characteristics of being "harder" than the target (lower frequency, from denser neighborhoods with higher mean frequencies).

Frequency and Neighborhood Structures of Responses (Child Lexicon)

Using the word list for 5-year-olds,⁶ we determined the frequency and neighborhood characteristics of responses to both easy and hard words. Table 3 shows the percentage of responses that were "harder" than the target (lower frequency, from denser neighborhoods with higher mean frequencies).

DISCUSSION

As expected, *phonemes correct* scores were higher than *words correct* scores for both easy and hard words and for both OC and SC users. The mean length of words on the LNT is 3 phonemes — evidence that children receive at least partial information regarding phonemes in words through the CI. Also as expected, both phonemes- and words-correct scores were higher for users of OC than for users of SC; this may indicate greater attention to acoustic information for the OC users than for the SC users. Further evidence that CIs transmit information regarding the phoneme structure of words lies in the fact that between 45.0% and 71.7% (depending on communication mode and the easy-versus-hard distinction) of

responses were in the neighborhood of the target. For users of OC especially, this indicates a structure of the lexicon much like that of adults, that is, a phoneme-based strategy of organization and extraction of words.

When analyzed within the adult lexicon, and depending on the neighborhood structure of targets and the communication mode, between 53.7% and 76.9% of responses were lower in frequency than targets, between 38.1% and 78.6% of responses came from neighborhoods more dense than those of targets, and between 44.9% and 64.3% of responses came from neighborhoods with higher mean frequencies than those of targets. We therefore concluded that a large number of responses were “harder” than their targets when assessed within the adult lexicon. Similar results were found when responses were analyzed within a children’s lexicon. Although “harder” responses may be counterintuitive, the open-set response format of the LNT makes it effectively both a perception *and* a production task, and little research has been conducted on frequency and neighborhood effects in production tasks.

A related question addresses the proper context in which to analyze the frequency and neighborhood structure of responses on the LNT. Frequency and neighborhood structure have traditionally been assessed in the context of adult vocabularies.³ As has been shown elsewhere,⁷ however, the large differences between children’s and adults’ lexicons give rise to similarly large differences in the neighborhood structures of words in those lexicons. Test items for the LNT were selected from analyses of the vocabularies of 1- to 5-year-olds,¹ somewhat younger than the children in the present study. The present study analyzed children’s lexicons in the context of a spoken word list⁶ investigated in previous studies of children’s lexicons⁷; moreover, this list was likely more appropriate than Logan’s¹ for the age of the children under study here, given delays in language development. However, of the 100 items on the LNT, 45 do not appear in the child lexicon used, so that almost half of the target items had to be assigned zero frequencies when analyzed within the children’s lexicon. A similar strategy was necessary for many of the responses. Further questions arise regarding elicitation procedures (eg, spontaneous¹ versus elicited⁶) and the status of grammatically inflected forms.

Therefore, although neighborhood structure analyses of children’s responses may have more face validity in the context of a putative children’s lexicon, it is also true that determining the appropriate children’s lexicon is a matter of debate. For longitudinal studies, adult lexicons may still be the best context for neighborhood structure analyses.

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TABLE 1**PERCENT WITHIN-NEIGHBORHOOD RESPONSES (ADULT LEXICON)**

	<u>Oral Communication</u>		<u>Simultaneous Communication</u>	
	Easy	Hard	Easy	Hard
Correct	63.7%	52.1%	36.5%	23.5%
Incorrect but neighbor of target	8.0%	18.4%	11.6%	22.0%
Total (target or neighbor of target)	71.7%	70.5%	48.1%	45.0%

TABLE 2

PERCENT RESPONSES "HARDER" THAN TARGETS (ADULT LEXICON)

	<u>Oral Communication</u>		<u>Simultaneous Communication</u>	
	Easy	Hard	Easy	Hard
Lower in frequency of occurrence than targets	76.9%	53.7%	66.9%	60.3%
Form denser neighborhoods	78.6%	56.1%	61.6%	38.1%
From neighborhoods with higher frequencies	64.3%	48.8%	61.6%	44.9%

TABLE 3

PERCENT RESPONSES "HARDER" THAN TARGETS (CHILD LEXICON)

	<u>Oral Communication</u>		<u>Simultaneous Communication</u>	
	Easy	Hard	Easy	Hard
Lower in frequency of occurrence than targets	69.0%	44.9%	58.3%	49.5%
From denser neighborhoods	72.8%	44.4%	68.9%	42.0%
From neighborhoods with higher frequencies	65.2%	46.0%	63.6%	42.7%