

Verbal fluency naming in children with CIs: What can we learn from children with CIs on sensitive periods for language?

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This study examined lexical retrieval processes as a possible underlying language mechanism responsible for language deficits in some children with cochlear implants (CIs). Lexical retrieval processing was examined using phonological and semantic verbal fluency (VF) naming tasks. In the VF tasks, children were given one minute to generate as many words as they can that begin with a given sound (/t/, /l/, /f/) or that belong to a certain semantic category (animals, food). Twenty children with CIs and twenty age- and IQ-matched normal-hearing (NH) children aged 7-10 participated in this study. Children with CIs generated fewer words on the VF tasks. In addition, qualitative differences were found in the performance of the two groups on these tasks. Children with CI seem to process words at a slower rate compared to NH children. Children with CIs showed significance differences compared to NH children in the phonological VF task on measures of the number of switches and the number of words produced in the first 15 seconds of the task. Age at implantation was significantly correlated with performance on the semantic part of the VF task. Younger implanted children performed better (named more words) on the semantic VF task. These correlations might suggest that early implantation is advantageous for certain aspects of lexical performance. Taken together the data support recent work suggesting that the development of certain aspects of language may have an earlier sensitive period than other linguistic skills.

INTRODUCTION

Research findings show a great enhancement rate of language development in young hearing-impaired children who have been implanted with a CI (Svirsky *et al.*, 2000; Blamey *et al.*, 2001; Le Normand *et al.*, 2003). However, there is a need to examine more specific aspects of language in order to learn more about the language processing abilities of children with CIs.

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The present study used phonological and semantic verbal fluency (VF) naming tasks. These tasks have been used extensively with typically developing children and also with children with language and reading impairments (Frith *et al.*, 1995; Nation *et al.*, 2001; Weckerly *et al.*, 2001; Koren *et al.*, 2005). However, these tasks have never been applied to hearing-impaired children who use CIs. In addition, this study is designed to look at more specific parameters related to optimal performance on VF tasks. Analyzing responses on phonological and semantic VF naming can aid in identifying differences in word retrieval processes that elucidate the organization of words in the mental lexicons of children with CIs, and point to specific areas in language processing where children with CIs may differ from NH children.

METHODS

Participants

Twenty children with CIs and twenty age- and IQ- matched NH children aged 7;10 to 10;2 participated in this study. All NH children passed an audiological screening test. In the CI group, inclusion criteria was a hearing impairment diagnosed before the age of 3;0 and a minimum of eight months experience with the CI device. All participants had TONI nonverbal IQ scores above 80. See Wechsler-Kashi (2011) and Wechsler-Kashi *et al.* (2013) for a complete description.

Stimuli and scoring procedure

In the VF task, children were given one minute to generate as many words as possible beginning with a particular speech sound (phonological VF) or from a specific semantic category (semantic VF).

Additional detailed clustering and switching analyses of the subjects' responses in the VF tasks were conducted. The rules for defining and scoring clusters were based on Troyer (2000), Troyer *et al.*, (1997), and Koren *et al.*, (2005). The analysis included both semantic and phonological clusters. Semantic clusters consist of words with related meanings that belong to the same subcategory (e.g., sea animals '...seal, dolphin, whale, fish...' or jungle animals '...lion, giraffe, monkey...') according to lists of common subcategories of *animals* and *food* listed in Troyer (2000), Troyer *et al.*, (1997), and Koren *et al.*, (2005). Phonological clusters consist of words that share similar phonemes (e.g., words that begin with /fr/ '...fright, fraud, free, fry...' or phonological neighbors; words with the same initial and final phonemes '...fat, feet, foot, fit...').

The analyses also included the number of switches within each subject's response. Switches were defined as transitions from one word, or a group of words (cluster) to the next word (or cluster). Additional analyses included measurements of reaction times to first-retrieved-words in each subtask. Reaction time was measured using Sound Forge 4.5 (1998) from the starting point of the task (press of the stopwatch) to the initiation of the verbal response. The score for the number of words produced during the first 15 seconds of the task was also obtained. This was measured by

counting the number of words generated in the initial 15 seconds time frame of the response (setting this point using Sound Forge 4.5, 1998). The score for the proportion of words produced during the first 15 seconds of the child’s response was attained by calculating the percentage of words produced during the first 15 seconds with respect to the total number of words in this subtask. The mean cluster size (MCS) measure was calculated by averaging the cluster size scores across each task. For each of the measures, a separate score was calculated for the phonological task and a separate score was calculated for the semantic task. See Wechsler-Kashi (2011) and Wechsler-Kashi *et al.* (2013) for a complete description.

RESULTS

As reported in Wechsler-Kashi (2011) and Wechsler-Kashi *et al.* (2013), children with CIs named significantly less words on both phonological and semantic VF tasks. These findings are illustrated below in Fig. 1.

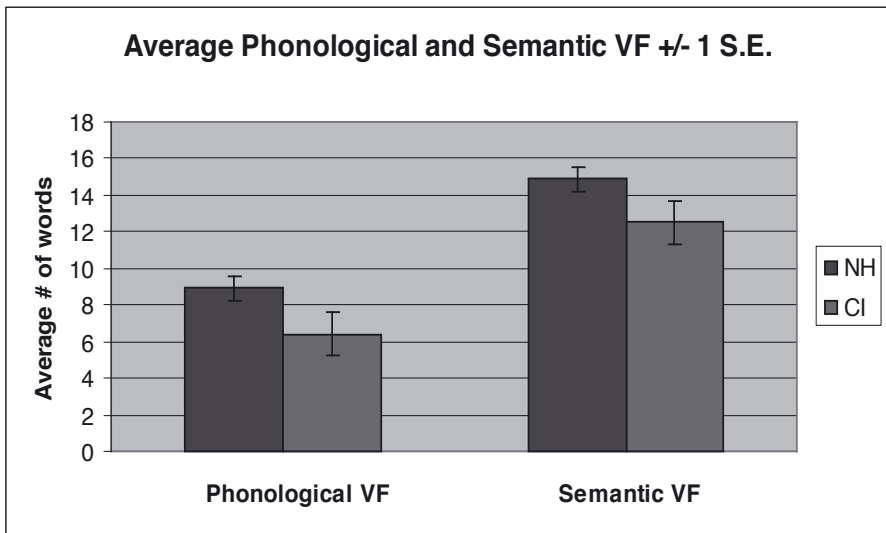


Fig. 1: Average number of words and standard errors (S.E.) on phonological and semantic VF naming tasks.

Pearson product-moment correlation coefficients were computed between results in the VF experiment and variables related to background factors in the CI group, age at implantation, and years of CI use. These correlations are summarized in Table 1. As can be seen in Table 1, age at implantation and years of CI use were significantly correlated with performance on the semantic part of the VF task. Younger implanted

children performed better on the semantic VF task (named more words on the semantic task). Similarly, more years of CI use was positively correlated with performance on the semantic VF task. Children who had used their implants for a longer duration of time performed better on the semantic VF task.

	Phonological VF task	Significance	Semantic VF task	Significance
Age at implantation	$r = 0.335$	$p > 0.05$	$r = -0.463$	$p < 0.05$
Years of CI use	$r = -0.109$	$p > 0.05$	$r = 0.514$	$p < 0.05$

Table 1: Pearson correlation coefficients between age at implantation and years of CI use and performance on VF experiment.

Results of the detailed analyses of the verbal fluency responses are summarized below in Table 2.

	Phonological			Semantic		
	CI	NH	Significance	CI	NH	Significance
Number of clusters	3.75 (0.50)	4.95 (0.54)	$p = 0.06$	8.55 (0.86)	8.4 (0.61)	$p > 0.05$
Number of switches	12.7 (1.49)	18.1 (1.39)	$p < 0.05$	12.6 (1.25)	14 (0.80)	$p > 0.05$
Number of words in first 15 s of task	3.06 (0.24)	4.58 (0.26)	$p < 0.05$	5.3 (0.44)	6.25 (0.37)	$p > 0.05$
Latency (RT) in ms to first word produced	1643 (246)	1037 (204)	$p > 0.05$	2009 (749)	1200 (147)	$p > 0.05$
Proportion of words in 15 s	40% (3.00)	42% (1.85)	$p > 0.05$	51% (2.74)	50% (1.37)	$p > 0.05$
Mean cluster size	2.04 (0.13)	2.21 (0.14)	$p > 0.05$	2.58 (0.09)	2.73 (0.07)	$p > 0.05$

Table 2: Cross group comparisons for the analyses of the VF responses. Standard errors are provided in parentheses. ANOVA significance levels are also presented.

DISCUSSION

Research findings show that children with CIs seem to access words less efficiently than NH peers. Moreover, the differences found between performance on

phonological and semantic VF tasks in children with CIs implies that their phonological memory is more susceptible to auditory limitations. Age at implantation was significantly correlated with performance on the semantic part of the VF task. Younger implanted children performed better (named more words) on the semantic VF task. The results support recent work suggesting that the development of certain aspects of language may have an earlier sensitive period than other linguistic skills. Further studies, examining performance of children with CIs on VF naming tasks at different ages can aid in better defining these time frames.

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