

LEXICAL SEMANTIC ORGANIZATION OF CHILDREN
WITH COCHLEAR IMPLANTS

by

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Abstract

The purpose of this study was to compare the vocabulary categorization performance of children with cochlear implants to children with normal hearing. Thirty children participated in this study: ten children with cochlear implants (mean age = 89 months), ten children with normal hearing matched for age, and ten children matched for vocabulary size. Each participant completed three tasks to measure (a) nonlinguistic categorization, (b) category label generation, and (c) category member listing performance. Analysis of variance demonstrated that children in the cochlear implant group sorted pictures with accuracy consistent with the age-matched group and more accurately than the vocabulary group ($F(1,28) = 5.821, p = .023$). ANOVA indicated that children with cochlear implants demonstrate delayed knowledge of superordinate relations as compared to the age-matched group, similar to the vocabulary group ($F(1,28) = 8.432, p = .00712$). Finally, ANOVA also indicated that none of the groups varied in ability to generate lists from various categories ($F(1,28) = 1.496, p = .231$). Thus, children with cochlear implants demonstrate a delay specifically in superordinate category relationship knowledge, which can affect academic performance.

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Introduction

Children with cochlear implants tend to have smaller vocabulary sizes than children with normal hearing, even when children receive cochlear implants at a relatively young age (Lund, Werfel, & Schuele, 2015; Nott, Brown, Cowan & Wigglesworth, 2009). Emerging evidence also indicates that children with cochlear implants develop weaker semantic and phonological representations of vocabulary words than children with normal hearing (i.e., children with cochlear implants lag behind children with normal hearing in quantity and quality of vocabulary knowledge; Ground, Lund, Werfel, & Schuele, 2014; Weschler-Kashi, Schwartz, & Cleary, 2014). In particular, children with cochlear implants appear to organize words in their mental lexicons differently than children with normal hearing. The purpose of this study is to compare the taxonomic vocabulary categorization performance of children with cochlear implants to children with normal hearing matched for age and children matched for vocabulary size. This study will help determine whether children with cochlear implants have a delay in word organization processes or if they are organizing words a different way (and so have a deficit in organization) compared to children with normal hearing. Knowledge of differences in word categorization will provide information about how to develop effective interventions for children with cochlear implants.

Vocabulary knowledge of children with cochlear implants

Cochlear implants, over the last three decades, have improved the speech-perception abilities of individuals with hearing loss through electric stimulation of the cochlea (Waltzman, Cohen, Green, & Rowland, 2002). As a

result, the oral language outcomes of children with severe to profound hearing loss have also improved (Waltzman et al., 2002). Despite technological advances, however, the receptive and expressive vocabularies of children with cochlear implants continue to lag behind those of age-matched peers with normal hearing (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006). In addition to having fewer total words in their lexicons, children with cochlear implants develop vocabularies at a slower rate than their peers (Conner, Hieber, Arts, & Zwolan, 2000; Tomblin, Barker, Spencer, Zhang & Gantz, 2005). As a result, investigators must ask whether these delayed vocabulary skills could be attributed to deficits in processes associated with word learning in children with cochlear implants.

Word learning for children with normal hearing

Disruptions at various levels of word learning could contribute to the impoverished vocabularies of children with cochlear implants. To encode and store a word into the mental lexicon for later retrieval, a child must: (a) perceive a word, (b) map the word to a specific referent, (c) note and store additional properties associated with that referent, and (d) integrate the word into the existing lexical network (Alt, Plante, & Creusere, 2004; Capone-Singleton, 2012; McGregor, Freidman, Reilly, & Newman, 2002). Therefore, a poor vocabulary may be the result of (a) perceiving fewer total words than children with normal hearing, (b) difficulty mapping those words to referents, (c) difficulty storing properties of words and referents, or (d) poor lexical-semantic organization. The extant literature indicates that children with cochlear implants do perceive fewer total words than children with normal hearing, and those words are of poorer

acoustic quality (Geers, 2006; Tomblin, et al., 2005). Children with cochlear implants also make fewer initial word-referent mappings than children with normal hearing (Tombin, Barker, & Hubbs, 2007; Houston, Carter, Pisoni, Kirk, & Ying, 2005; Willstedt-Svensson, Lofqvist, Almqvist, & Sahlen, 2004). The lexical-semantic storage and organization of children with cochlear implants has been less documented than that of children with normal hearing.

Lexical-Semantic Organization

The concept of a lexical-semantic storage network is derived from Quillian's (1969) spreading-activation theory of semantic processing. This theory hypothesizes that lexical concept items are linked in a mental storage network whereby related words or concepts are connected. There are many types of organization systems a person could access related to a central known word (e.g., *dog*), such as phonological associations (e.g., *dig*). One primary organization system used by children to classify words is taxonomic organization. Taxonomic associates of dog might include, for example, superordinate (e.g., *animal*), basic (e.g., *dog*), or subordinate (e.g., *Golden Retriever*; Waxman & Hatch, 1992; see Figure 1). The type and strength of those connections may vary, and connections within the network may overlap (e.g., "pet" may also be activated by "dog"; Collins & Loftus, 1975). The ability of children to understand the relations between words is important for academic learning. Children will be able to recall words that they have stored more easily if they have taxonomic organization understanding.

Lexical-Semantic Organization in Children with Normal Hearing

The lexical-semantic network organization of typically developing children with normal hearing changes with age, especially with respect to understanding of taxonomic relationships (Nelson & Nelson, 1990). Children are able to recognize superordinate taxonomic relationships (e.g., grouping animals together) as early as age three (Waxman & Gelman, 1986). However, young children seem to store and recall lexical entries based on experiences (e.g., animals living in the child's house) rather than based on superordinate category knowledge (Nelson, 1988). Over time, children's reliance on superordinate taxonomic organization strengthens and they are able to use superordinate taxonomic categories (e.g., animals, food, clothing) to quickly retrieve associated lexical items (Nelson & Nelson, 1990). Preschool children tend to recall more items in event-related categories than superordinate taxonomic categories, whereas children older than eight recall equal numbers of items in both conditions (Nelson & Nelson, 1990). Shifts in lexical-semantic organization may be associated with gains in oral and reading comprehension (Cronin, 1999). Thus, a superordinate taxonomic lexical-semantic organization system, as compared to event-related organization, may reflect mature lexical-semantic development.

Children with normal hearing who have word-finding deficits have underdeveloped lexical-semantic storage and organization systems compared to typically developing peers (McGregor & Windsor, 1996; McGregor & Waxman, 1998). McGregor and Waxman (1998) found that children with word-finding

deficits between the ages of three and seven had less knowledge of superordinate, basic and subordinate taxonomic relationships between lexical items than their peers without word-finding deficits. During simple naming tasks, McGregor & Windsor (1996) also found children with word-finding deficits benefited less from superordinate and category-member primes than their typically developing peers. Vocabulary deficits within this population appear associated with impaired taxonomic knowledge and lexical-semantic organization.

Lexical-Semantic Organization in Children with Cochlear Implants

There is limited research evidence that describes broad lexical-semantic organization in persons with hearing loss. Marschark and colleagues (2004) found adults with hearing loss, some of whom used cochlear implants, did not access lexical-semantic organization strategies when completing analogy tasks, whereas adults with normal hearing did access lexical-semantic organization strategies (Marschark, Convertino, McEvoy, & Masteller, 2004). More recently, Wechsler-Kashi and colleagues (2014) evaluated the lexical-semantic organization with a verbal fluency task for children with and without cochlear implants between the ages seven to ten. Children with cochlear implants did not name as many items given a phonological prompt (e.g., *Tell me words that start with /b/*) or given a semantic prompt (e.g., *Tell me all of the animals you can think of*) as compared to children with normal hearing. The authors concluded that children with cochlear implants, who have limited auditory and early linguistic experiences, may organize lexical entries differently than children with normal hearing (Wechsler-Kashi, Schwarts, & Cleary, 2014). Research to date has not

explored taxonomic systems of organization for children with cochlear implants.

Knowledge of children's abilities to organize new words into a taxonomic organization system will inform intervention targeting the maturation of lexical-semantic development. If children with cochlear implants only display deficits in perception and initial mapping of new words to referents, addressing those issues may improve their rate of vocabulary growth. However, if children with cochlear implants also have immature lexical-semantic organization systems, intervention must work to address that problem as well. This study sought to compare children with cochlear implants' knowledge and use of taxonomic organization to that of typically developing children with normal hearing to address this gap in the literature.

The purpose of this study was to compare the taxonomic vocabulary categorization performance of children with cochlear implants to children with normal hearing matched for age and children matched for vocabulary size using three experimental tasks. This study will help determine whether children with cochlear implants have a delay in word organization processes (e.g., if they perform the same as vocabulary matched children) or if they are organizing words a different way than children with normal hearing. Knowledge of differences in word categorization will provide information about how to develop useful interventions for children with cochlear implants. We addressed the following three research questions:

1. Do children with cochlear implants use non-linguistic, receptive taxonomic knowledge to group familiar pictures as accurately as children with normal hearing?
2. Do children with cochlear implants access and express knowledge of taxonomic relationships at the superordinate, basic, and subordinate levels with the same accuracy as children with normal hearing?
3. Do children with cochlear implants recall a different proportion of lexical items that are superordinate versus event-related for taxonomic categories than children with normal hearing?

Methods

Participants

Thirty children between the ages of 27 and 125 months participated in this study. Children were part of one of three groups: a group of children with cochlear implants (age range: 78-125 months), a group of children with normal hearing matched to children with cochlear implants for chronological age (age range: 74-122 months), and a group of children matched to children with cochlear implants for vocabulary size (age range: 27-81 months). Children were recruited via advertisement with area audiologists and in the community. Participants were recruited based on the following criteria. For the cochlear implant group, children had to have at least one cochlear implant device of any brand, use spoken language as a primary communication mode, and speak English as a home language. All participants in the cochlear implant group had two parents with normal hearing. Children in any group were excluded from

participation in this study if they had an additional diagnosis that affected language or cognitive development (e.g., Autism Spectrum Disorder). Thirty children consented and thirty participated in the study. For individual child information, see Tables 1 and 2.

Procedures

Participants completed three experimental tasks and the Expressive One Word Picture Vocabulary Test in a well-lit, quiet room across one testing session. A single examiner administered all assessments and experimental tasks.

Taxonomic Grouping Task. The first experimental task was based on the task used by Waxman & Gelman (1986), which determined that children are able to recognize superordinate taxonomic relationships as early as age three.

Children were asked to sort familiar pictures by superordinate category membership. To introduce the task, the examiner said, “I want you to help me create some groups of pictures. Only pictures that are of the same kind can go together in one group. I will give you an example of the kinds of pictures I am looking for, and you can help me find the rest.” Prior to administering the experimental items, the examiner guided the children through an example response.

For each superordinate category tested, the examiner laid 20 picture cards face-up on the table. The examiner then selected three pictures from a given superordinate category and said, “I am looking for other pictures that belong in this group. Will you give them to me?” For example, in the introductory category “animals,” the examiner may have chosen the cat, the bear, and the

bird pictures. Children were encouraged to select seven additional category members. During the example trial, the examiner confirmed correct responses (e.g., “Yes! The dog belongs in this group; he is another animal”) and incorrect responses (e.g., “No, I don’t think the pizza belongs in this group”). Following the example trial, the examiner did not provide feedback about the correctness of children’s responses. The examiner recorded the children’s responses to three experimental trials for the superordinate categories furniture, plants, and transportation.

Taxonomic Feature Task. The second experimental task was based on the task used by McGregor and Waxman (1998), which determined that children with word finding deficits between the ages of three and seven had less knowledge of superordinate, basic and subordinate taxonomic relationships than their peers without word finding deficits. Children were given the following instructions: “We’re going to play a guessing game! I am going to give you a picture, and I want you to answer my questions about that picture.” The examiner presented an example to the child prior to beginning the test items. The sample item, consistent with McGregor and Waxman (1998), will be a photo of a truck. The examiner said, “See, here is a garbage truck. If I asked you ‘Is it an animal?’ you could say ‘No, it is transportation!’ If I asked you ‘Is it an airplane?’ you could say ‘No, it is a truck!’ If I asked you ‘Is it a dump truck?’ you could say ‘No, it is a garbage truck!’”

Children then answered questions about the other twelve objects pictured on a card (see Table 3). The clinician asked the child to name the picture, and

then asked a series of questions about the pictured object to elicit subordinate, basic, and superordinate taxonomic labels. For example, for the picture “eagle,” children were asked, “Is it a plant?” (Superordinate to elicit “animal”), “Is it a dog?” (Basic to elicit “bird”) and “Is it an owl?” (Subordinate to elicit “eagle”). The child’s labeling responses were recorded by the clinician during the session and audio-recorded for reliability purposes.

Category Member Task. The third experimental task was based on a task used by Nelson (1988) that assessed young children’s strategies for recalling lexical entries in verbal fluency tasks. Children were asked to generate members of categories related to (a) events (e.g., foods you eat for breakfast) or (b) superordinate taxonomic category labels (e.g., food). Children were only asked to generate members of a category related to one type of label (event or superordinate taxonomic) during a single testing session. The order of experimental tasks were counter-balanced across participants.

During the Category Member Task, children were given the following instructions: “We’re going to do an activity where I tell you a name. I want you to tell me all of the words you can think of that go with that name.” An initial practice category, “toys,” was presented to children, and the examiner listed three examples of toys. The child was prompted to add other familiar examples. If the child verbally indicated he or she understood the task, the examiner continued administration of the test items. If the child indicated he or she did not understand, the examiner offered two additional examples and then administered the test items. The same example was used across both testing sessions.

The Category Member task included labels developed by Nelson and Nelson (1990). Superordinate taxonomic category labels included: animals, clothing, and food. Event-specific labels included: animals found on a farm, animals found at a zoo, clothing you wear inside the house, clothing you wear to play outside, food you eat for breakfast and food you eat for lunch. Order of individual item administration was randomized across participants, but only one type of label was presented during a given testing session. Responses were recorded on an answer sheet and audio-recorded for reliability purposes.

Reliability

An undergraduate research assistant in the department of Communication Sciences and Disorders collected reliability data from each task from one-third of the videos across all sessions. Reliability was calculated by using a point-by-point agreement.

Results

The overall purpose of this study was to compare the taxonomic vocabulary organization performance of children with cochlear implants to children with normal hearing matched for age and children matched for vocabulary size. Each participant completed three experimental tasks meant to evaluate differing levels of lexical semantic knowledge and organization.

The first research question addressed whether children with cochlear implants used nonlinguistic receptive taxonomic knowledge to group familiar pictures as accurately as children with normal hearing matched for age and children matched for vocabulary size. Children were given the opportunity to sort

pictures into the taxonomic groups “transportation,” “plants,” and “furniture.” For each category, an analysis of variance (ANOVA) was calculated with the number of correct pictures sorted as the dependent variable and group membership (cochlear implant, age-matched, or vocabulary-matched) as the independent variable. The ANOVA for the “plants” category indicated no main effect of group ($F(1,28) = 1.966, p = .172$), whereas the ANOVA for the “furniture” and “transportation” categories did indicate a main effect of group ($F(1,28) = 9.918, p = .004; F(1,28) = 5.821, p = .023$, respectively). Follow-up, pre-planned linear contrasts indicated that children with cochlear implants did not differ statistically in responses from the age-matched group of children with normal hearing in the “furniture” ($M_{CIgroup} = 8.4, SD_{CIgroup} = .843, M_{AMgroup} = 8.9, SD_{AMgroup} = .316; F(1,13) = 1.93, p = .075, d = .626$) or “transportation” categories ($M_{CIgroup} = 8.2, SD_{CIgroup} = 1.549, M_{AMgroup} = 8.9, SD_{AMgroup} = .316; F(1,13) = 1.31, p = .217, d = .785$). This finding indicates that the main effect of group in these categories is heavily influenced by the lower performance of children in the vocabulary-matched group. Figure 2 displays findings for all groups.

The second research question addressed whether children with cochlear implants access and express knowledge of taxonomic relationships at the superordinate, basic, and subordinate level with the same accuracy as children with normal hearing. Children were asked to label a series of pictures at the superordinate, basic, and subordinate level. For each category, an ANOVA was calculated with the number of correct labels of each category as the dependent variable and group membership (cochlear implant, age-matched, or vocabulary-

matched) as the independent variable. The ANOVA for the “superordinate” category indicated a main effect of group ($F(1,28) = 8.432, p = .00712$), whereas the ANOVA of the “basic” and “subordinate” groups did not indicate a main effect of group ($F(1,28) = .159, p = .693; F(1,28) = 4.015, p = .0549$, respectively). Follow-up, pre-planned linear contrasts indicated that children with cochlear implants did differ statistically in responses from the age-matched group of children with normal hearing in the “superordinate” category ($M_{CI\ group} = 3.3, SD_{CIgroup} = 4.715, M_{AMgroup} = 9.8, SD_{AMgroup} = 2.486; F(1,13) = 3.856, p = .0018, d = 1.725$). However, these children did not differ statistically from the vocabulary-matched group with normal hearing ($M_{CI\ group} = 3.3, SD_{CIgroup} = 4.715, M_{VMgroup} = 4.1, SD_{VMgroup} = 4.654; F(1,13) = .382, p = .707, d = .1708$). This finding indicates that the main effect of group in these categories is heavily influenced by the lower performance of children in the vocabulary-matched group and the cochlear implant group. Figure 3 displays findings for all groups.

The third research question addressed whether children with cochlear implants recall a different proportion of lexical items that are superordinate versus event-related for taxonomic categories than children with normal hearing. Children were asked to generate categories related to (a) events (e.g., foods you eat for breakfast) or (b) superordinate taxonomic category labels (e.g., food). An ANOVA was calculated with the number of category members generated as the dependent variable and the group membership (cochlear implant, age-matched, or vocabulary-matched) as the independent variable. The ANOVA for the “broad” and “narrow” categories did not indicate a main effect of group ($F(1,28) = 1.496,$

$p = .231$; $F(1,28) = 2.603$, $p = .118$, respectively). Follow-up, pre-planned linear contrasts were not reported because there was no significant main effect. A lack of effect was likely the result of high variability within each of the groups.

Across tasks and across groups, reliability remained above 98 percent. Given the high degree of reliability, the authors' original scoring was used for all analyses. See Table 4 for reliability calculations.

Discussion

The purpose of this study was to compare the taxonomic vocabulary categorization performance of children with cochlear implants to children with normal hearing matched for age and children matched for vocabulary size using three experimental tasks. The results of this study demonstrated that children with cochlear implants differ from children with normal hearing specifically in areas of superordinate taxonomic organization. Knowledge of differences in word categorization will provide information about how to develop useful interventions for children with cochlear implants.

Taxonomic Grouping Task

The first research question addressed if children with cochlear implants use non-linguistic, receptive taxonomic knowledge to group familiar pictures as accurately as children with normal hearing. Children with cochlear implants sorted pictures into categories using nonlinguistic knowledge with the same accuracy as children with normal hearing matched for age. Children matched for their vocabulary size completed the task less accurately but at a developmentally appropriate level. Some of the children matched for vocabulary were very young

(for example one child was 27 months old and another child was 40 months old). Thus, the average performance of children in the vocabulary-matched group was hypothesized to be lower than that of the other two older groups (Waxman & Gelman, 1986). Importantly, these findings are consistent with the findings that many children with cochlear implants have normal nonverbal cognitive skills (Knoors & Marschark, 2014). Our findings indicate that deficits in the taxonomic knowledge of children with cochlear implants are not the result of their inability to understand how to group items by category nonverbally.

Taxonomic Feature Task

The second research question addressed if children with cochlear implants access and express knowledge of taxonomic relation at the superordinate, basic, and subordinate level with the same accuracy as children with normal hearing. The Taxonomic Feature Task concluded that children with cochlear implants express taxonomic relations as accurately as age-matched children with normal hearing at the basic level of knowledge (e.g., children could identify items like *cat* and *flower*). However, when children with cochlear implants were asked to express relations at the superordinate level of knowledge (e.g., identify *animal* and *plant*), they performed less accurately than children matched for age, but similar to children matched for vocabulary size.

Children with normal hearing are able to recognize and identify superordinate taxonomic relations starting as early as age three (McGregor and Waxman, 1998). In this case, it appears that children with cochlear implants demonstrate a delay in understanding of superordinate relations. This is

particularly interesting in light of the finding that children with cochlear implants in this study correctly expressed the superordinate labels in the Taxonomic Feature Task (i.e., *animals*, *clothes*, *plants*) when these items were assessed by the Expressive One Word Picture Vocabulary Test (EOWPVT; Brownell, 2000). In other words, children with cochlear implants appear to know the word “*animal*,” for example, but could not label singular basic items (e.g., “dog”) within that superordinate category. This finding may indicate that children with cochlear implants only have a partial understanding of the role of superordinate category membership; they can label groups of category members with a superordinate label but don’t understand that those members also can be labeled with a category individually. Because this performance was similar to the performance of vocabulary-matched children with normal hearing, it appears that children with cochlear implants may demonstrate an overall delay in superordinate taxonomic relation understanding, as opposed to a disorder.

Knowledge of superordinate relations and classifications is critical for early academic success in school; many schools teach units thematically and expect children to pick up on superordinate relations between familiar items. This knowledge of relations builds a foundation for later learning that requires understanding of taxonomic relations (e.g., understanding *genus* and *species* in sciences classes). Children with cochlear implants may require more individualized instruction to catch up to their normal hearing peers in knowledge of superordinate taxonomic relations.

The performance of children expressing taxonomic relations at the subordinate level was statistically the same as children with normal hearing in both the age-matched and vocabulary-matched groups. However, children with cochlear implants had a numerically lower performance than children with normal hearing matched for age. Although the difference between children with cochlear implants and children with normal hearing was not statistically significant, it was clinically significant; there was an effect size difference of $d = .80$ (a large difference). This large difference could have been a result of the children with cochlear implants having a smaller vocabulary compared to children with normal hearing or the result of children with cochlear implants not understanding subordinate relations. However, unlike with the superordinate task, the Expressive One Word Picture Vocabulary Test did not indicate that children with cochlear implants had knowledge of the terms used in the subordinate task (e.g., children did not also demonstrate separate knowledge of words like “sandals.”)

Category Member Task

The third research question addressed if children with cochlear implants recall a different proportion of lexical items that are superordinate versus event-related for taxonomic categories than children with normal hearing. This task was designed to determine if children with cochlear implants demonstrated mature lexical organization, as evidenced by superordinate label generation, as compared to event-related label generation. There was no main effect of group for this task, likely the result of the large variability among the three groups of children. There were potential fatigue effects that had an impact on all groups,

particularly the vocabulary-matched group, because the Category Member Task was the last task administered. The order of the tasks was necessary because the first task did not allow for examiners to indicate to children that categories were being labeled (consistent with the original design of task; Nelson & Nelson, 1990). The second task provided the same level of prompting for each child to elicit the different categories. The last task required the children to generate category members individually without additional prompting. Therefore, the structure of task order may have influenced results, and the null finding should be interpreted with caution given the wide variability of performance.

Research Implications

This study included limitations that give us future research directions. First, children in the cochlear implant group had a wide range of vocabulary knowledge. It is possible that children with low vocabulary knowledge display different lexical-semantic organization than children with high vocabulary knowledge within that group. A future study should explore the ways in which individual levels of knowledge of children with cochlear implants affect outcomes of taxonomic lexical-semantic organization tasks. Second, each member of the cochlear implant group had no additional disabilities. Because children with cochlear implants are statistically more likely to have additional disabilities than children with normal hearing, it is likely that the sample in this study is not representative of the entire population of children with cochlear implants. Moreover, the children in this study were more likely to perform well because they did not have any additional disabilities. A future study could explore

strategies children use to recall lexical entries and the impact additional disabilities have on taxonomic lexical-semantic organization. Third, maternal education of the three groups could have contributed to our results. Maternal education levels differed between the children with cochlear implants and the age-matched and vocabulary-matched groups. On average, mothers of children with cochlear implants on average had 14.9 years of education, whereas mothers of children matched for age and vocabulary had 16.15 or 17.3 years of education. Further, maternal education was correlated in general with the sizes of children's vocabularies. Despite this, maternal education did not meet statistical criteria to be covariate (i.e., did not significantly correlate with the dependent variable). Thus, it is possible that maternal education differences between the age-matched and cochlear implant groups could have had an indirect influence on performance of children with cochlear implants. A future study should further explore direct and indirect influences of maternal education on lexical-semantic organization of children with cochlear implants.

Table 1. Participant Characteristics by Group

Group	Mean Age in Months	Mean EOWPVT Raw Score	Mean EOWPVT Standard Score	Mean Years of Maternal Education
Cochlear Implant <i>n</i> = 10	89 (14.90)	70.9 (27.21)	87.8 (17.63)	14.9 (2.08)
Age Matched <i>n</i> = 10	90.60 (17.09)	103.3 (18.32)	117.2 (18.52)	16.15 (2.47)
Vocabulary Matched <i>n</i> = 10	57 (16.51)	70.6 (23.97)	117.7 (12.68)	17.3 (1.95)

Table 2. Individual Characteristics of Cochlear Implant Group

Participant	Age of Identification in Months	Degree of Hearing Loss Left/Right Ear	Age of Implantation in Months	Devices Used Left/ Right Ear
1	0	Profound/Profound	21	CI/CI
2	15	Severe-to-Profound/Profound	22	CI/CI
3	44	Profound/ Severe	50	CI/CI
4	18	Profound/ Profound	36	CI/CI
5	6	Severe/ Severe	25	CI/CI
6	18	Profound/Profound	23	CI/CI
7	0	Severe-to-Profound/ Severe-to-Profound	24	CI/CI
8	42	Moderate-Severe/Severe-to-Profound	43	HA/CI
9	0	Profound/Profound	22	CI/CI
10	18	Severe-to-Profound/Severe-to-Profound	36	CI/CI

Table 3. Target List for Taxonomic Feature Task

Picture	Questions to elicit target label		
	Superordinate	Basic	Subordinate
rose	animal	tree	dandelion
sunflower	animal	tree	cornflower
palm tree	animal	flower	oak
apple tree	animal	flower	pear tree
eagle	plant	dog	owl
blackbird	plant	dog	bluebird
collie	plant	bird	dachshund
Dalmatian	plant	bird	bulldog
sandals	food	pants	tennis shoes
boots	food	pants	party shoes
jeans	food	shoes	shorts
sweat pants	food	shoes	dress pants

Note. Adapted from McGregor and Waxman (1998).

Table 4. Point-by-Point Reliability Agreement by Group and Task

	Task 1	Task 2	Task 3	Overall Agreement by Group
Age-Matched Group	98.76%	100.00%	96.83%	98.53%
Cochlear Implant Group	100.00%	100.00%	98.69%	99.56%
Vocabulary-Matched Group	100.00%	99.07%	100.00%	99.69%
Overall Agreement by Task	99.59%	99.69%	98.51%	99.26%

Figure 1. Lexical Semantic Organization

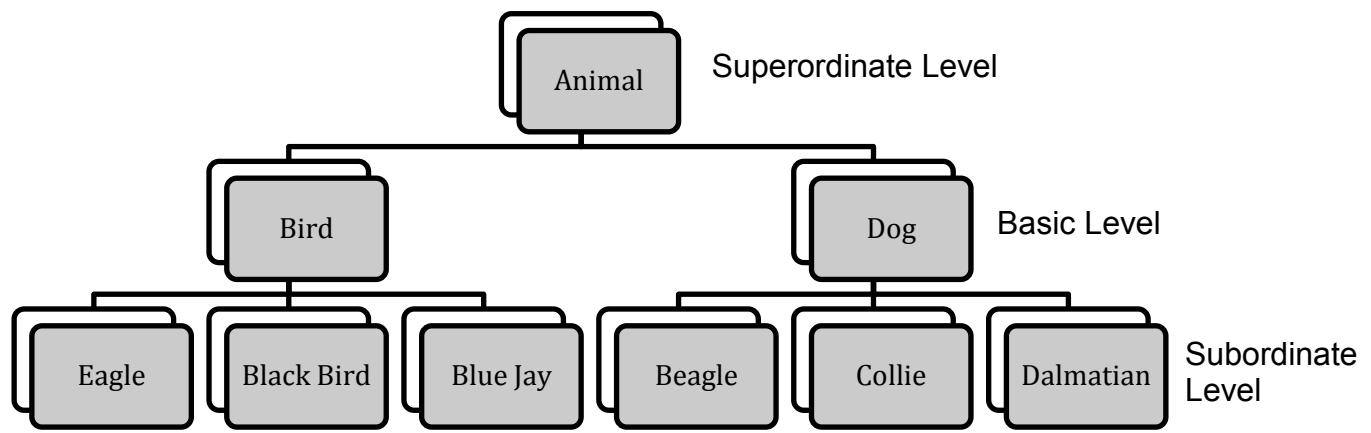


Figure 2. Taxonomic Grouping Task

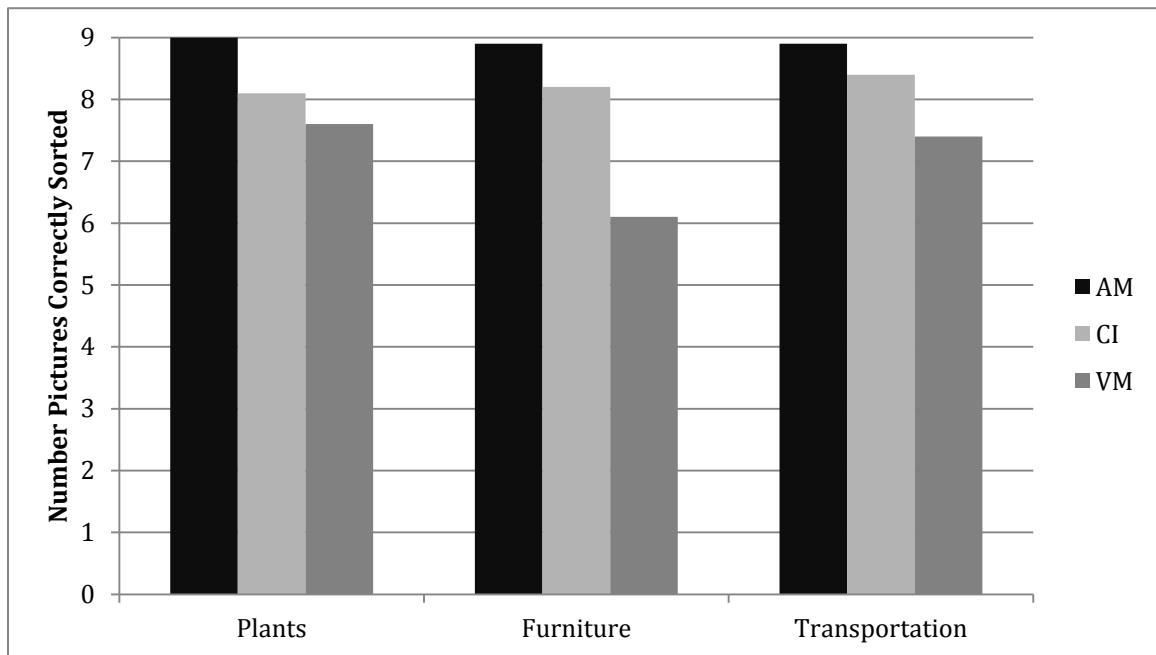


Figure 3. Taxonomic Feature Task

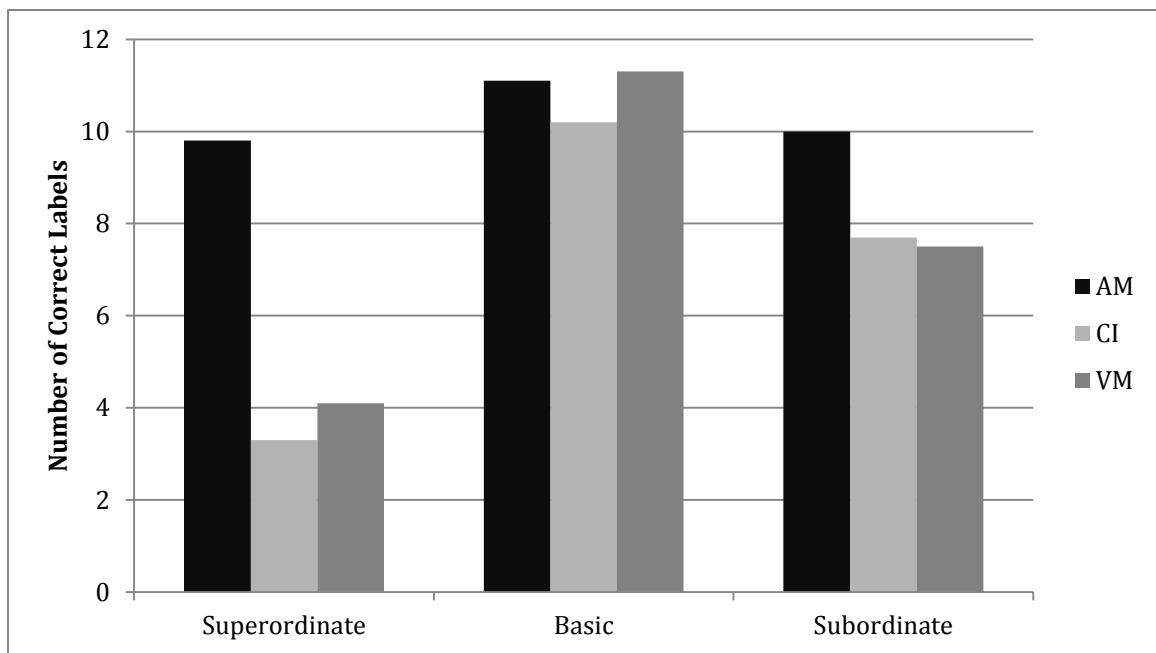
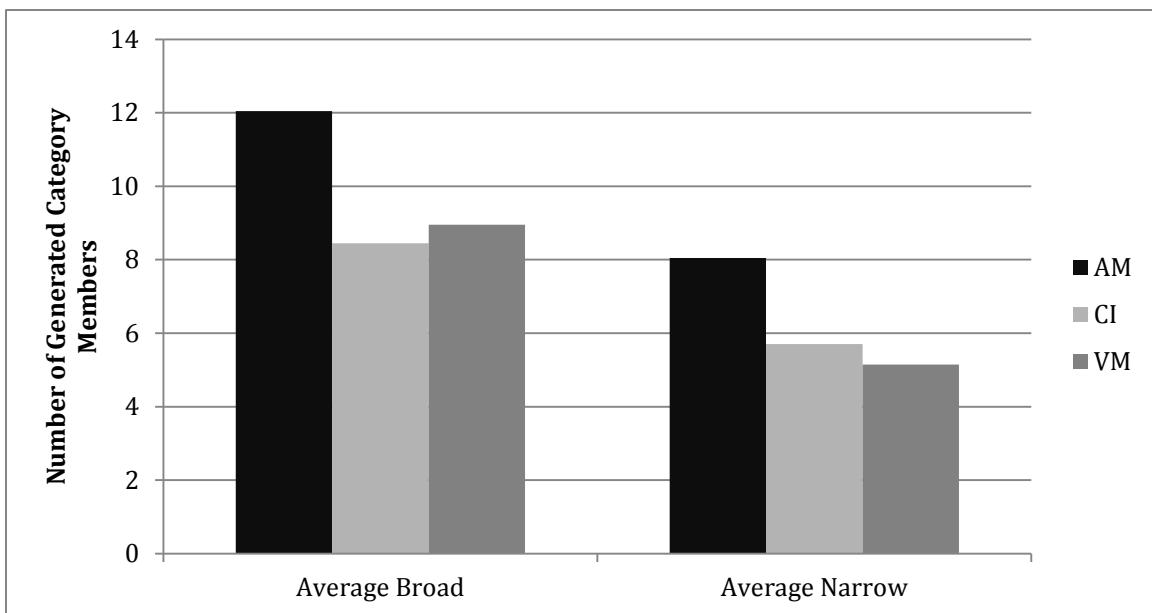


Figure 4. Category Member Task



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