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Some Aspects of Language Development in Normal-Hearing Children and Children With Cochlear Implants

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Objective: This article presents some important processes of normal child language acquisition and applies them to language acquisition data of children with cochlear implants.
Data Sources: Modern studies of language acquisition, covering various languages, have demonstrated a close link between linguistic and cognitive development. Sensorimotor intelligence provides a construction of reality on which the first grammatical structures are built, encoding a number of relations which hold between objects, persons, events, and localizations. When acquiring the more complex morphological and syntactic aspects of their mother-tongue, children use a number of characteristic information processing strategies which make some formal markings easier to learn than others. There is considerable variability across children with respect to rate of acquisition, the use of imitation, and analytic versus holistic processing strategies. Caregivers' language input can facilitate language acquisition, notably the use of expansions and reformulations, and a generally accepting style.
Empirical Study of Children with Cochlear Implants: Language acquisition data from two children with cochlear implants show great differences with respect to rate of acquisition, construction of the German case system, and syntax. Whereas one child discovers the regularities of the case inflectional system quickly, the other child appears to prefer holistic and rote learning processes and uses a sequential strategy for combining words. It is suggested that variability between children with cochlear implants may be due to different frequencies of actually processed linguistic items.
Conclusions: Future research should compare language development in children with cochlear implants and those with normal hearing making use of psycholinguistic methods of research design and analysis. **Key Words:** Cochlear implant—Language—Language acquisition.
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From the point of view of cognitive developmental psychology, language development and cognitive development are closely related. There are several aspects to this relationship. Firstly, cognitive development is considered to be a prerequisite for the development of grammar in that it provides both a construction of reality that is then encoded linguistically and information-processing strategies that allow the child to decode language and store linguistic items in memory. Secondly, children approach language with different cognitive styles. Thirdly, as in cognitive development, the quality of the environment can be more or less favorable to language development. Each of these points will be discussed in order.

COGNITIVE PREREQUISITES OF GRAMMAR

Sometime during the second year of life, children begin to realize that objects exist separately from the self and the self's actions on them, and that they continue to exist when they are removed in space and time (1). When children produce their first two-word combinations, at ≈18–24 months of age, the meanings of these utterances express exactly this construction of reality. Children use operations of reference to comment on the existence, disappearance, or recurrence of objects or persons, and the semantic relationships of two-word utterances encode agent–object, agent–action, action–object, or locative relations (2–5). In this way, grammar is considered to be based on the terminal achievements of sensorimotor intelligence (2–5).

Children then proceed to master the morphologic and more complex syntactic aspects of their mother-tongue. For German, this involves case and gender morphology, with case markings occurring on articles, adjectives, pronouns, and, occasionally, nouns. It further involves learning a rather complex system of plural markers and acquiring verb morphology marking for person, numerosity, and tense. Acquiring syntactic structures involves learning rules for word order, negation, interrogation, coordination, and subordination of clauses.

On the basis of cross-linguistic research, certain information-processing strategies are inferred that children are believed to apply (6). Because of these processing biases, some formal markings are acquired more quickly than others. One strategy is to pay attention to the ends of

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content words (nouns, verbs, adjectives). This is why suffixes are learned fast. Formal markings, which are perceptually salient, are also learned quickly. These two principles explain why German verb inflections are acquired early and why and case markings are acquired late. Inflections such as *-t* or *-st (er sing-t [he sings], du sing-st [you sing])* are perceptually salient. Prenominal case markers, however, are not. They are unstressed and sometimes not easily distinguishable, even if they were stressed, e.g., the masculine accusative and dative definitive articles *den* and *dem*. Children also tend to preserve the order of words and morphemes. Thus, English children produce *has been reading*, but not *been has reading*. Another strategy that children apply is to avoid exceptions to linguistic rules. This is why they sometimes regularize irregular verbs (*catched* for *caught*).

STYLES OF LANGUAGE ACQUISITION

While these processing strategies are used by all children, individual children also take different approaches to learning language (7). Children vary on two dimensions, both of which are believed to reflect analytic and holistic mechanisms of processing information (7,8). Researchers speak of a "style" of language acquisition because the same mechanism seems to underlie a number of different linguistic behaviors in the areas of vocabulary, grammar, and phonology, and persists over time (7,8). Thus, a child with a highly analytic style discovers morphologic regularity quickly and is, therefore, liable to make more overgeneralization mistakes, i.e., using the rules when they are not applicable. Such a child also learns words quickly because she/he analyzes the world of objects and actions into single units, which are named, and combines these content words when constructing two-word utterances. An analytic child imitates rarely and segments words clearly in his/her speech. A child with a highly holistic style, on the other hand, often uses unanalyzed formula expressions and is intonation-oriented in his/her pronunciation; this results in low intelligibility. Such a child imitates more than she/he understands and combines nonspecific function words, e.g., *there, here*, with content words in his/her two-word utterances. Some correct formal markings are acquired, but generalization of underlying rules is much slower, resulting in fewer overgeneralizations. However, it is important to stress that the two language styles are not exclusive and that both information processing mechanisms are necessary to acquire language. It is best to think of the differences between children as a continuum. Most children are somewhere in between the highly analytic and highly holistic types. The analytic style is the quicker way into language at the beginning, but the more holistic children catch up later on.

INPUT LANGUAGE AND CHILD PROCESSING

Speech directed to young children does not only differ from speech directed to adults, but also may facilitate language acquisition (9). For instance, in English, questions in maternal input relate positively to auxiliary and copula growth in child speech. This can be explained by the perceptually salient sentence-initial position of the auxiliary or copula in questions (9). A discourse feature with a generally facilitative effect is the continuation of the child's topic, because it leads to more language production by the child and, thus, to more opportunity for learning (10,11). Adult expansions and reformulations of child utterances have been shown to facilitate language growth (10). Expansions echo part of a child's utterance formally correctly and add new information, in this way keeping the conversation going, whereas reformulations just correct form (e.g., *the ball is rolling* after *ball roll*). Both formulations are believed to facilitate learning, because they present a contrast between the formally correct and incorrect expressions when the child is attentive and when the semantic content is known, so that less processing capacity is required for content and can be used for processing form. However, reformulations of child utterances may work only for those forms that the child is currently acquiring (10).

Adults, too, have different styles when they talk to children (12,13). Mothers differ to the extent that they make reference to objects, describe the immediate environment, refer to persons and the child's behavior, and give directives. Children of ≈2 years of age are linguistically more advanced in terms of mean length of utterance (MLU) and vocabulary when their mothers make frequent object reference, request information, and provide repetitions (12,13), whereas linguistic progress is slower when mothers use many directives and comment on the child's behavior (12,13). Perhaps most importantly, it appears that analytic children profit more from adult object reference and descriptions of the immediate context, whereas there is no effect for holistic children (13). Thus, children make different use of input language depending on the information-processing style they prefer.

CHILDREN WITH COCHLEAR IMPLANTS

If one wants to compare language acquisition in children with cochlear implants with that of children with normal hearing, it is best to look at children who were implanted at a young age, since, in older children, the process of language acquisition is likely to be influenced by suppressing previously learned systems of communication and differences in cognitive development. Furthermore, language learning becomes increasingly more difficult as a function of age (14). The focus here will be on spontaneous speech data acquired from two German children who were implanted at ages 2 years 4 months and 3 years 2 months, with first tune ups at 2 years 6 months and 3 years 4 months, respectively (15, unpublished observations). Figure 1 shows the MLU for these children at the available data points, and, for comparative purposes, for two normally hearing children (14, unpublished data). MLU is counted in morphemes and, thus, captures morphologic and syntactic progress (2). Figure 1 shows that variability in rate of language development

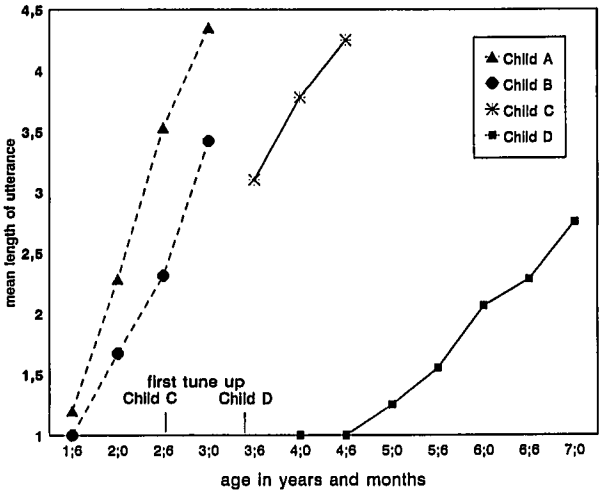

FIG. 1. Mean length of utterance for two normal-hearing children (**A** and **B**) and two children with cochlear implants (**C** and **D**).

is much more pronounced in the two children with cochlear implants. Child C's progress is as rapid as that of a fast language learner with normal hearing (child A), whereas the other child (D) is very much slower and does not get anywhere near the level of child C.

More detailed aspects of both children's grammatical development are summarized in Table 1. Although both children acquired verb inflections, modal verbs, plural markers, and adjective endings, they differed markedly in their use of case morphology. Initially, child C frequently marked case and gender incorrectly, but progressed quickly to the productive use of correct case markings with few remaining mistakes. Child D, on the other hand, used gender correctly in the nominative, sometimes in the accusative, learned some individual contracted dative forms, but did not go beyond that. The two children also differed substantially with respect to syntax. Child C quickly moved on to more complex syntax, whereas child D continued to use two-word utterances and did not progress beyond three constituents, producing many syntactic mistakes, such as wrong word order or simply linking content words by means of the conjunction *and*. Child D produced vocalizations that are not German words for quite some time, and had a clear preference for the use of all-purpose function words such as *da (there), hier (here).*

These two children not only differed markedly with respect to rate of acquisition, but also seemed to approach language in different ways. Child C's initial treatment of case marking suggests a highly analytic style in which an all-purpose form d_9 and the substitution of one case for another are applied consistently. These incorrect regularity are discarded when the correct ones are discovered. The frequency of mistakes suggests that the lack of perceptual salience of German case marking is more pronounced for a child with nonoptimal hearing.

There are several indications that child D used predominantly holistic and rote learning processes. Some individual correct case forms are learned. The fact that this occurs over a long time period is to be expected if generalization does not occur (16). The child's problems with syntax suggest the use of a sequential strategy for combining words and a lack of ability for hierarchical ordering of linguistic elements. Frequent use of all-purpose words requires little analysis and may be a compensatory strategy if one has problems memorizing words. The question is why do generalization processes seem to get off the ground in one child, while they do not in another. As a working hypothesis is the suggestion that the degree to which generalization processes will function depends on the frequency of actually processed linguistic items. If, for instance, auditory processing is not fast

TABLE 1. *Grammatical forms used by two children with cochlear implants*

Child C	Child D
Marking of case and gender	
On articles	
At 3;6: many mistakes, particularly accusative instead of dative, use of all-purpose form dative, use of all purpose FH form d_9	At 6;0: correct marking of nominative and sometimes accusative
From 4;0: correct marking of all cases with some mistakes left	From 6;0: some contracted dative forms (e.g., *zum/zur* [to the], *am* [at the], *im* [in the])
On adjectiveS	
From 4;0: correct marking	From 6;0: correct marking
Plurals	
At 3;6: two correct plural markers	At 5;6: one correct plural marker
From 4;0: three correct plural markers	From 6;0: three correct plural markers
Verb inflections	
At 3;6: third person singular	From 5;6: third person singular of copula and of some modal verbs
From 4;0: all singular markers and third person Plural of full verbs, copula, modal verbs	At 6;0: third person singular on full verbs At 7;0: all singular markers and third person plural of full verbs, copula, modal verbs
From 4;0: perfect tense	At 7;0: past participle
Syntax	
From 4;0: five constituents	From 5;6: three constituents, incorrect word order, simply linking word by conjunction "and"

TABLE 2. *Predicted dimensions of similarity and dissimilarity between normal-hearing children and children with cochlear implants*

No differences	Differences in dependence on frequency of processed input items
Meanings of two-word utterances	Onset of language
Functional categories	Persisting morphologic mistakes
	Persisting vocalizations
	Slower vocabulary growth
	Slower rate of acquisition
	Predominantly holistic and imitative
	Reduced inflectional system
	Reduced syntax

enough, much language input is lost and higher order cognitive processes do not have sufficient information on which to build (16). This interpretation is not irreconcilable with the influence of biologic factors, such as changes in cerebral organization as a result of auditory deprivation. The frequency hypothesis can be tested empirically and by means of connectionist computational modeling (17). For a particular linguistic structure, neural network simulations of learning can be run, with different input frequencies reflecting the hypothesized frequencies processed by the child, to see if outcomes match the child's productions (18).

The frequency hypothesis allows predictions about similarities and dissimilarities between normally hearing children and those with cochlear implants, attributing variability among children with cochlear implants largely to different frequencies of processed input items. The two groups will not differ with respect to meanings of two-word utterances and functional categories, because these are based on nonlinguistic knowledge. Children with cochlear implants will differ with respect to the use of unanalyzed inflectional forms, vocabulary growth, and extent to which they develop syntax (Table 2), because these structures are sensitive to input frequency (18,19).

CONCLUSIONS

Comparative, longitudinal studies on language development in children with cochlear implants and children with normal hearing, using larger samples, should be conducted. Such studies should use psycholinguistic methods of research design and analysis and include an analysis of parents' language. It is crucial to measure those variables that allow inferences about children's information processing strategies, because it is by knowing children's mechanisms of learning that we can hope to assist their learning process. Equally, parental language must be scrutinized for variables that have an effect on the child's development of language over time. Language intervention programs can be most effective if they adapt to the child's style of learning and take account of parental interactive style.

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