Nelson, Deborah G. Kemler, Kathy Hirsh-Pasek, Peter W. Jusczyk, and Kimberly Wright Cassidy. 1989. How the prosodic cues in motherese might assist language learning. *Journal of Child Language* 16:55–68.

Sakakibara, Yasubumi. 1992. Efficient learning of context-free grammars from positive structural examples. *Information and Computation* 97:23–60.

Shieber, Stuart M. 2006. Unifying synchronous tree-adjoining grammars and tree transducers via bimorphisms. In *Proceedings of the 11th Conference of the European Chapter of the Association for Computational Linguistics (EACL-2006)*, 377–384. Trento.

Siskind, Jeffrey Mark. 1996. A computational study of cross-situational techniques for learning word-to-meaning mappings. *Cognition* 61:39–91.

Wagner, Michael. 2005. Prosody and recursion. Doctoral Dissertation, Massachusetts Institute of Technology.

Yokomori, Takashi. 2003. Polynomial-time identification of very simple grammars from positive data. *Theoretical Computer Science* 298:179–206.

Yoshinaka, Ryo. 2011. Efficient learning of multiple context-free languages with multidimensional substitutability from positive data. *Theoretical Computer Science* 412:1821–1831.

Zettlemoyer, Luke S., and Michael Collins. 2005. Learning to map sentences to logical form: Structured classification with probabilistic categorial grammars. In *UAI*, 658–666. AUAI Press.

Affiliations

John Case
Department of Computer and Information Sciences
University of Delaware
case@cis.udel.edu

Jeffrey Heinz
Department of Linguistics
University of Delaware
heinz@udel.edu

Gregory M. Kobele
Computation Institute and Department of Linguistics
University of Chicago
kobele@uchicago.edu

Connectedness: Papers by and for Sarah VanWagenen
UCLA Working Papers in Linguistics 18: 115–146
Carson T. Schütze & Linnaea Stockall (eds.), 2014

The case of Chelsea: The effects of late age at exposure to language on language performance and evidence for the modularity of language and mind*

Susan Curtiss

The bulk of this paper is devoted to describing and analyzing the language performance of a woman given the case name, "Chelsea," who began first language acquisition at the age of thirty-two years. I conclude, based on these data, that given that Chelsea has not developed a grammar, that her case strongly supports there being a Critical Period for first language acquisition of grammar. As an addendum, I have added a second, far smaller part to this paper that discusses Chelsea's number cognition—her knowledge of number concepts, her arithmetic abilities and more. Together with the first part, I then draw some conclusions regarding what this case can tell us about not only the Critical Period for first language acquisition but also specifically about the domain-specificity of grammar and number and about the issues of modularity of language and mind, more broadly.

1 Introduction

This paper has two objectives. The first, which sections 3–8 are devoted to, is to report on the linguistic knowledge and progress of a woman given the case name of Chelsea. Facing the task of first language acquisition at the age of 32, Chelsea represents, perhaps, the oldest individual whose development of a first language has been studied in detail. I present language data collected from Chelsea over a period of more than ten years, as the basis from which to describe and analyze what she has come to know about language. I focus in particular on her lexical development and her knowledge of core properties and units of grammar and what this indicates regarding there being a Critical Period (CP) for first language acquisition of grammar.[1] The second (and secondary) objective, presented in section 9, is to discuss Chelsea's number cognition—what she appears to know about and can do in the realm of number—as a window into what her case can tell us about the task-specificity of both grammar and number as cognitive domains. Given the linguistic profile she presents, her case will bring to bear evidence that speaks not only to the CP, but also to both modularity within language (Little Modularity) as well as to modularity as a characteristic of the mind itself (Big Modularity).

* This paper reports data from a case that I have described only briefly in previous work (e.g., Curtiss, 1989, 1995). I have never published a paper on this case alone or in great detail. Yet It speaks to two issues I have worked on for years; namely, a critical period for first language acquisition and modularity of mind. As such it represents topics I have discussed with delight with Sarah on many occasions. I offer it as a tribute to the rich and stimulating discussions I always have with Sarah.

[1] I will be discussing the data herein from a generative linguistic-theoretic perspective (e.g., Chomsky, 1981, 1986a, 1986b, 1995).

1.1 The basic issue regarding a Critical Period for first language acquisition

Over the last several decades, after Lenneberg's seminal work on the biological basis of language and language development in which he proposed his now famous 'Critical Period for Language' hypothesis (Lenneberg, 1967), numerous studies have confirmed that first language acquisition[1] is highly maturationally constrained, such that attempts to develop a first language after middle-to-late childhood result in something less than native grammatical competence (e.g., Bickerton, 1990; Coppieters, 1987; Curtiss, 1977, 1995; Mayberry, 1993a,b, 1994; Mayberry and Eichen, 1991; Newport, 1984, 1990, 1991; Scovel, 1989). At the same time, work in developmental linguistics has made it clear that with sufficient exposure to language, all typically developing children develop a first language within a relatively short span of time, attaining near-native competence by approximately age 6, and arriving at the target grammar before adolescence. Research also suggests that within the first year to year and a half of life, typically developing children demonstrate considerable passive knowledge of phonology and syntax (e.g., Gleitman, 1990; Hirsh-Pasek and Golinkoff, 1997; Hirsh-Pasek, Kemler-Nelson, Jusczyk, Wright, and Druss, 1987; Naigles, Gleitman and Gleitman, 1993; Lidz, Waxman and Freedman, 2003; many others), and that children's early productions under-represent their grammatical knowledge.

Given the complexity of human grammars and the numerous constraints on the inductive powers and mental processing capacities of young children, the demonstration of a surprising degree of grammatical knowledge in infancy, the rapid and readily achieved feat of language acquisition, the narrow range of attested errors cross-linguistically and the increasing evidence that even early grammars embody the principles and structures of adult grammars strongly suggest that children are biologically preprogrammed in a way as to make them ideal language learners. (See also Berwick et al., 2013 for a recent discussion of Poverty of the Stimulus arguments and the inadequacy of attempts to discount them by other notions of "learning" from the input signal.)

1.2 Some important relevant background evidence re: the CP

Evidence proliferates that one characteristic of this biological programming for language development is that there are strong age or "CP" effects on ultimate competence achieved in first language development. In a series of elegant studies, Newport (1984, 1988, 1990) has demonstrated that it is only age at first exposure to ASL that predicts performance on comprehension and production tasks involving various structures of ASL[2]. Using tests tapping knowledge of SVO word order and the complex morphology of verbs of motion, and comparing native signers, early signers whose first exposure to ASL was between four and six years of age, and late signers whose first exposure was after age 12, Newport found a consistent pattern of results. Those whose exposure to ASL began before age six showed consistent mastery of both basic word order and verbal morphology, whereas those whose exposure to ASL as a first language came at age 12 or later performed poorly and inconsistently.[3] The number and types of errors also differentiated the groups.

[2] The reader is referred to the cited references throughout this section for details of the subjects, procedures, and results.

[3] It is worth noting, however, that, though those whose first exposure was between 4–6 years far outperformed the late learners, they performed significantly more poorly than the native learners on comprehension and production of both morphology and syntax. Thus there appear to be age effects even this early in life.

Native and early signers made few errors, while late signers made numerous errors and errors of a type suggesting that they had learned morphologically complex words as unanalyzed, frozen forms. "In short, increasing age of acquisition of the language from birth through late puberty results in steadily decreasing control over all but *the simplest aspects of the grammar*" (emphasis mine) (Newport, 1991: 121).

A number of other studies of the effects of age at exposure on ASL competence and processing report findings consistent with Newport's. Woodward (1973) presented data demonstrating greater mastery of the morphological rules of negative incorporation and reduplication in ASL in those individuals who had learned ASL before the age of six than in those after the age of six. Tartter and Fischer (1982) examined perception of signs under conditions of "visual noise" and found that native signers showed more efficient early stage processing of signs. Mayberry, Fischer and Hatfield (1983) demonstrated experimentally that those individuals who had acquired sign in the teenage years performed worse on sentence repetition than those who had acquired sign in childhood. Moreover, the later sign was learned, the worse the performance. Mayberry (1994) also showed that the signers who had learned sign later (from 8 on) made different types of errors. Early signers made largely semantically related substitutions; late signers made mostly phonological (formational) errors. Fischer and Mayberry (1982), studying short-term memory for ASL sentences and shadowing, also found that the significant performance differences between early and late learners translated into a difference both in competence level and error types. Mayberry and Eichen (1991) and Mayberry (1993a, b) again report significant effects of age at first exposure to ASL on sentence processing, lexical identification, memory for sentence meaning, and grammatical acceptability judgments, while age at first exposure to sign did not effect performance on digit recall, rate of sign production, or skills related to fine motor production.

The studies of sign language acquisition suggest that the point in development at which acquisition of a sign language may be adversely affected by lack of linguistic experience may be considerably earlier than Lenneberg proposed, perhaps as early as six years of age or even younger. Parallel data for spoken language do not exist, however, most probably because there are far fewer studies of CP effects on the first language acquisition of spoken language.

There have been only a few studies of late acquisition of spoken language and only one case which has been documented in much linguistic detail: Genie, who started learning a first language at the age of 13-and-a-half (Curtiss, Fromkin, Krashen, Rigler, and Rigler, 1974; Curtiss, 1977). Perhaps the most striking linguistic finding from that case was that not all aspects of language development appeared to be affected equally by her late language learning age. Most aspects of lexical knowledge (including both semantic and syntactic lexical knowledge) and argument structure appeared relatively unaffected. In contrast, Genie's knowledge of the principles and constraints governing combinations of (lexical or functional) phrasal units was very limited, and in fact, very little grammatical development took place in a period over two decades long. (See Curtiss, 1977, 1988 for detailed descriptions of Genie's linguistic performance.)

The data from Genie's case have been taken to support the notion of a CP for first language development, but importantly, suggest that different components of the linguistic system may be differentially vulnerable to age at acquisition, such that there is not a single, uniform CP effect for all aspects of language.

Other cases, although not described in linguistic detail, appear to show the same general patterns displayed by Genie. Young (1981) and McKinney (1983) report on first language acquisition in a few hearing-impaired adults who knew only esoteric gestures and, maximally, a few spoken words before language training in adulthood was begun. These cases appear to show the same relative vulnerability of grammatical development as opposed to vocabulary learning, the expression of at least simple propositions through the

combination of nouns, verbs, adjectives, and adverbs, and the development of a good deal of communicative competence through the use of what language they had come to know.

In summary, research on the effects of age at exposure to language on first language development, whether spoken or signed, provides strong evidence that children are biologically preprogrammed in a way that makes them ideal language learners, but only while they are children.[4]

1.3 A theoretical linguistic account of these effects

On a linguistic-theoretic view, the relevant biological preprogramming for grammatical development is task-specific and comprises a set of highly specified universal grammatical principles that characterize all natural languages (e.g. Chomsky, 1981; Lightfoot, 1982) coupled with a constrained set of possible instantiations of these principles, as articulated in Principles and Parameter theory (e.g., Atkinson, 1992; Chomsky, 1986a,b, 1995; Friedin, 1991; Pollock, 1989). On this view, these same principles and possible variations (parameters) hold for child grammars. In addition, the biological endowment involves programmed principles and procedures for activating and/or constraining the child's movement from stage to stage to arrive at the target grammar (e.g., Baker and McCarthy, 1981; Borer and Wexler, 1987; Crain, 1991; Gleitman and Landau, 2013 and references therein; Hyams, 1986; Hyams and Wexler, 1993; Lightfoot, 1989; Meisel, 1990, 1992; Pierce, 1992; Pinker, 1984, 1989; Valian, 1990; Wexler and Culicover, 1980).

This theoretical perspective requires that the grammatical principles defining human grammars not only be task-specific, but be specified in detail (and deterministic in character). The alternative, that language development is *not* the result of domain-specific principles is entirely inconsistent with this view and the predictions and explanations pursuant to it. It would be surprising, however, if grammar were not pre-specified in detail, given its complexity. Gould (1982), Jackendoff (1992, 1994) and others have pointed out that across species, the more complex a behavior or cognitive system is, the greater the likelihood that the underlying principles are specified in detail. Thus, views that assert that grammar is the product of non-specific, general principles of cognition are hard-pressed to account for the complex and detailed knowledge all natural language grammars embody, as well as the kinds and complexity of the mental representations that must be manipulated and computed in linguistic processing (see Berwick et al., 2013 for a recent discussion of the inadequacies of other accounts).

It appears that children know Gould, Jackendoff, Berwick et al, Chomsky, etc. are right. (Again, see Berwick et al., 2013 for a recent discussion of the relevant arguments.) Very early in life, even in infancy, children exhibit a surprising amount of passive linguistic knowledge in phonetics, phonology, morphology, syntax and semantics. Moreover, analyses of child grammars indicate that children appear not to invoke rules based on non-grammatical constructs as the basis for their analysis of syntactic structures, even when such rules might be argued to be developmentally or cognitively simpler.

To summarize, the relevant theoretical perspective is that first language acquisition is the unfolding of the task-specific biological endowment referred to as UG, coupled with the determination by the child, via grammatical and learnability principles, as to how UG is instantiated in her/his target grammar. To account for CP effects on first language development, this account must hypothesize that UG and/or relevant learnability principles become unavailable as adolescence approaches or in later years. In contrast to other accounts, this view holds that the mechanisms underlying CP effects lie within the domain

[4] Reports on creolization of both signed and spoken languages conform to what is reported for language development from non-pidgin models (e.g., Senghas, 1995; Coppola, & Senghas, 2010; Kegl, 2004.)

of grammar. Moreover, just as it is the activation and instantiation of the highly specified principles of grammar that account for normal language development, it is their increasing unavailability that accounts for the increasing inability to develop grammar (of a first language) beyond the CP. Additionally, the perspective adopted here allows for a dissociation between grammatical development and development in other cognitive domains, a consequent that is relevant to the case at hand. Thus, CP effects for language may be quite unrelated to cognitive maturity in areas outside of grammar.

2 Chelsea

2.1 Case History

Chelsea was born and raised in a rural community, the second of seven children in a warm, supportive family.[5] All of the other members of her family are of normal intelligence and have no history of developmental disabilities. Three weeks prior to delivery, Chelsea's mother was hospitalized for a hemorrhagic bladder infection, possibly the result of cytomegalovirus, a common cause of congenital deafness. The pregnancy and delivery were otherwise normal. Chelsea's developmental milestones were normal, but within the first few months of Chelsea's life, her mother suspected that Chelsea was deaf, a suspicion confirmed throughout Chelsea's childhood by her consistent failure to respond to any but the loudest auditory stimuli. Because of the lack of rehabilitative, diagnostic, and educational resources in Chelsea's home community, her parents took her to the California School for the Deaf. There, the now obsolete audiometric testing procedures of the time unfortunately led to "equivocal" results, and Chelsea was neither diagnosed as deaf, nor accepted to the school. As a result, Chelsea received no formal instruction or training of any kind.

Chelsea was "discovered" at the age of 32, when audiologic and neurological examinations were requested by local social services. The audiometric exam established that Chelsea had a profound hearing loss; the neurologic exam found that Chelsea had only a few subtle neurological signs; namely, those compatible with a longstanding, stable, *mild* congenital problem. Both a CAT scan and MRI of the head and brain were within normal limits. Standard EEG was also normal.

At the age of 32, in 1980, Chelsea was fitted with hearing aids, and a program of language and cognitive instruction and periodic evaluation was begun. Language training in both SEE (Signing Exact English) and spoken (Standard American) English has been carried out continuously for a period of almost 30 years. Numerous written and videotape records of language training sessions have been made, and additional records of linguistic testing and spontaneous speech have also been made. On standardized (nonverbal) psychological and neuropsychological tests Chelsea consistently demonstrates a performance IQ of between 77 and 89 and a M.A. (mental age) of somewhere between 9 and 10 years. A series of aided audiograms over the last 25 years show near normal hearing levels with her aids.

[5] This and other facts relating to the case history were learned from Dr. Peter Glusker (personal communication and Glusker et al., 1990), the neurologist to whom she was referred by social services and director of the intensive habilitative program carried out with Chelsea for well over two decades. The information concerning Chelsea's IQ and MA comes from Dr. Nina Dronkers (personal communication and Dronkers, 1987).

2.2 *The Data*

The data reported on in this paper are of three kinds: 1) utterances spoken or written by Chelsea during language training sessions; 2) spontaneous spoken utterances collected by the author during visits with Chelsea or shared with the author by members of the rehabilitative team either via videotape, written records or personal communication, and 3) test performance on a variety of linguistic tests. In evaluating Chelsea's linguistic status all three kinds of data have been examined where possible. In some instances, however, less import has been given to test performance, as task factors unrelated to linguistic knowledge have often been shown to negatively affect performance, thereby underrepresenting an individual's actual knowledge or ability (e.g. Crain and Fodor, 1993; Curtiss, Kempler, and Yamada, 1981; Hamburger and Crain, 1984).[6]

In addition, although the database includes well over 2,000 utterances, only a number of representative examples will be presented to illustrate each point. In each instance, the examples presented have been carefully selected so as to reflect the patterns embodied in the vast majority of relevant utterances.[7]

When Chelsea was first evaluated in mid 1980, her communication consisted primarily of gestures and one- and two-word utterances that labeled concrete and familiar objects and actions. Several of us expected that Chelsea and her family had created a repertoire of gestures used within the family for communicating with Chelsea ("home sign"). However, the family maintains that they did not have a "home sign" system and communicated with Chelsea largely through points, mimicking actions, and overt demonstrations. Attempts have been made to determine whether there was a system of home sign in Chelsea's family in a number of ways, including videotaping the family alone with Chelsea. Despite these attempts, there is no evidence of any home sign system, and if true, this is surprising, given the necessity for communication within the family structure and the frequency with which home sign systems are created in similar circumstances, which is understood to be frequent, if not the rule. (Approximately 90% of hearing impaired children are born to hearing families with no other hearing impaired family members.)

Taking her small repertoire of words and gestures as a starting point, this paper presents Chelsea's linguistic performance over a 12-year period with respect to her knowledge of lexicon, constituent structure, and syntactic categories. In each instance, I am looking for and counting as evidence, systematic and principled use and control of the relevant grammatical phenomena being referenced.

3 Lexicon

To assess Chelsea's lexical knowledge—what kinds of words she knows and how her mental lexicon is organized—a number of tests have been administered. The tests and her performance on them are presented in Table 1.

In many ways Chelsea's performance in this area is quite good Her comprehension scores steadily improved, consistent with the informal impression that she learns new vocabulary readily and continually. It is estimated that in mid-1980, at first examination by the neurologist and speech pathologist, Chelsea's spoken vocabulary numbered approximately only 50 words or less, but she has shown a steady increase in the number of written words she can both recognize and produce (Glusker, Curtiss, Dronkers, Howard, Mollanen, Nevile, Reisman, Ervin-Tripp and Yancey, 1990). A 1986 estimate placed her written vocabulary at approximately 300 words, including nouns, verbs, adjectives, and miscellaneous particles (Walters, personal communication). A 1992 estimate placed her written vocabulary at close to 500 words and her spoken vocabulary too large to reliably estimate (Glusker, personal communication).

As will be seen, knowledge of word meanings and use of vocabulary is Chelsea's major linguistic strength and the area most fully developed. Her extensive knowledge of the meanings of words and the cohesiveness of the internal semantic organizational structure of her lexicon are exemplified in a number of ways.

First, her mental lexicon includes words for objects, actions, events, people, locations, emotions, etc.; i.e., a lexicon capable of expressing and communicating an extensive range of meanings. Second, she uses words appropriately with respect to meaning and context, as illustrated throughout her utterances. Third, she can search her mental lexicon to generate a series of words all of which are members of specific semantic categories, as evidenced by her performance on the *Producing Word Associations* subtest of the CELF (see Table 1), and in certain respects, she has matured in her ability to do so, as evidenced by the word lists themselves (presented in Appendix A).

Table 1: Chelsea's performance on tests of lexicon

Name of test	Year given	Performance level
Comprehension		
Peabody Picture Vocabulary Test[a]	1980	2;3[b]
	1981	4;3
	1982	5;11
	1983	5;8
CYCLE-R[c] Lexicon subtests	1984	Passed all subtests
	1985	Passed all subtests
Production		
Boston Naming Test[d]	1986	24/60 correct; approx. age score 5;6
	1992	23/60 correct; approx. age score 5;6
CELF-Producing Word Associations subtest[e]	1984	35: above 10th–12th grade level
	1986	28: 7th grade level
	1989	33: 9th–10th grade level
	1992	32: 9th grade level

a. An array of four pictures is presented. The subject is asked to point to the picture corresponding to the word given. (Dunn and Dunn, 1981)
b. Read: years;months.
c. Arrays of two to four pictures are presented and include semantic and phonological foils. (Curtiss and Yamada, 1987)
d. A series of pictures whose labels decrease in word frequency is presented, and the subject is asked to name the picture. (Kaplan, Goodglass and Weintraub, 1983)
e. Subjects are given one minute to name as many animals as they can, then one minute to list as many foods as they can. (Semel and Wiig, 1980)

In 1986 Chelsea produced word lists at a level equivalent to those of 7th graders. Note, however, that although the words listed are appropriate to the semantic category,

[6] The data I examine are all spoken language data. Although Chelsea signs and does so actively, in the data examined, she frequently spoke without signing or signed only a portion of the words spoken. The production data I present and examine consist entirely of spoken or written utterances.

[7] All of the data prior to 1984 were supplied to me by one or more members of her rehabilitative team. My own data collection began in 1984, but I gratefully continue to receive data from others.

there is not a consistent within-category scanning by subcategory, especially in the case of animals, where she moves from one subcategory type to another with each item listed. Scanning by subcategory such that related word pairs, triplets and even longer series are produced before moving on to a new sub-domain already appears in similarly generated word lists of five-year-olds, as revealed in testing of preschool and young school-aged children (performed by myself), and thus suggests that in 1986 Chelsea's lexicon had a less tightly structured internal semantic organization than do children five years or older. The repetition or "intrusion" of items is minimal, however, and quite comparable to normally developing children and adults (see the CELF manual, 1980).

In 1989, Chelsea produced more words on this task, and the total number of words generated was equivalent to a level between 9th and 10th grade. Her performance improved not only in number of words generated, however; it also reflected a more normally structured word list in which she scanned her lexicon by subcategory within the superordinate level category given. Her food list reflects an extensive search within what is arguably a single subdomain, and her animal list includes a number of related pairs (e.g., *chipmunk–squirrel; calf–bull; goose–duck),* although she still moved rapidly from one subdomain to another in a manner characteristic of young children 5 or younger. Moreover, on the positive side her word lists included several "exotic" or less common items, such as *yellow squash, green squash, heron, possum* and *lovebird,* another indication of an expanding, well-developed lexicon.

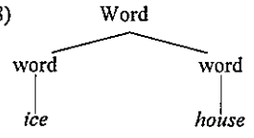
In 1992, her performance showed essentially the same characteristics and level of development as her 1989 performance. Her list of foods was a longer, tightly structured list of fruits and vegetables, and her animal list again contained a number of "exotic" items *(quail, jaybird, gopher),* yet she did not search any readily labelable subcategory of foods or animals for any notable period.

In addition to the lexical abilities mentioned above, Chelsea's knowledge about encoding concepts into words (i.e., the lexicalization of meaning) extends to the ability to create words for items she does not already have a label for, as illustrated by (1)–(7) below, produced during administration of the *Boston Naming* test (Kaplan et al., 1983) in 1992.

	Test item shown	**Chelsea's word**
(1)	hanger	hang
(2)	bench	outside chair
(3)	volcano	elevator fire
(4)	igloo	ice house
(5)	stethoscope	doctor tie
(6)	muzzle	dog bit
(7)	tongs	tongs

With the exception of the first item, these word creations suggest some knowledge of how to form new words by means of compounding. This knowledge, however, consists principally of the knowledge that words may be combined to form another word; e.g., (8):

(8)



However, there are not enough examples of this sort in the data, nor relevant data of other sorts (e.g., knowledge of syntactic categories) to indicate any other knowledge pertinent to compound formation, such as what the category of the head of the compound (and therefore the compound itself) is, or what its placement must be relative to other morphemes in the compound.

Nevertheless, her ability to create words which transparently and appropriately reflect the sense, reference, and/or function for items she knows experientially but has no label for evidences some word-building knowledge and is consistent with her having constructed a word-based lexicon, whose entries contain defining semantic specifications. Moreover, her lexicon appears to embody connections between entries which share semantic properties; namely, semantic category relations, such that they form "neighborhoods" which can be scanned for appropriate word use in spontaneous speech or word search purposes in production and comprehension.

These lexical strengths, notwithstanding, it is of note that Chelsea is not able (as far as I know) to demonstrate the extent of her lexical knowledge consistently on vocabulary tests (as shown by Table 1). Rather, Chelsea's performance on formal tests has shown a far poorer performance on tasks where she must match a name to a picture (either produce the name, herself, or select the match from an array of 4 pictures) on the one hand, what we might consider more traditional vocabulary tests, than she demonstrates on lexical access tasks and appropriate use of words in real-life contexts. On naming and word-to-picture matching tasks she has performed poorly, as we have seen, while in contrast, on tasks where she is asked to retrieve appropriate words from her own mental lexicon, tasks without pictures to consider or other extra-linguistic requirements or "obstacles", she evidences a far more extensive, normal lexicon, much as described above. This discrepancy between task and real life performance may be related to her cognitive limitations outside of language. As my colleagues and I as well as others have seen and reported (e.g. Crain and Fodor 1993; Curtiss 1988; Curtiss and Yamada, 1981; Hamburger and Grain, 1984; Yamada, 1990; Rondal, 1993, 1995), performance on formal tasks reflects attentional capacity, short term or working memory, other cognitive capacities, and at times, world knowledge and social maturity as well as the knowledge the task seeks to assess. Her poor performance on picture-matching and naming tasks, therefore, most probably belies and significantly under-represents the extent of her real lexical knowledge.

4 Morphology and Syntax

4.1 Argument structure/Theta structure

In contrast to her robust knowledge of the semantics of words, Chelsea's knowledge of argument structure of even simple propositions is impaired. Such semantic structural requirements constitute *theta*-structure encoded in the lexicon of verbs. The fundamental linguistic principle governing theta structure is the *Theta-Criterion*—a well-formedness condition that requires 1) that each theta role that a verb obligatorily assigns be assigned, and 2) that each argument of a verb bear only one theta role.

Chelsea has persistently demonstrated little knowledge of the *theta* structure of the verbs she knows and uses. There are few apparent constraints governing the presence, absence, or repetition of arguments, and these theta-structure violations in her speech result in a preponderance of semantically ill-formed utterances.

One frequent error in this area has been the repetition of predicates or arguments—clear violations of the Theta Criterion, as examples (9)–(24) below illustrate. (Glosses or

contexts are given in brackets wherever a reasonable approximation of the meaning intended can be discerned or a context is clear.)

Picture descriptions/comments produced during language training/testing sessions

(9)	Story skunk story	
(10)	Plate table the woman girl plate	
(11)	Riding ride bike ride boy	['The boy is riding the bike']
(12)	Boy rope broken rope on	
(13)	Change mirror mirror	
(14)	The boy is kick kicking can the can	['The boy is kicking the can']
(15)	Woman girl pushing woman	['The woman is pushing the girl']
(16)	Sleep nap sleep	

Spontaneous utterances

(17)	The man is walking [unintell.] truck car truck walking	
(18)	Two. Two cake two	[She had been asked: "How many cakes?"]
(19)	That Tom love you hug you hug you	[re: Tom's affection for her]
(20)	Sunday brought here Sunday	[re: Chinese food delivered for dinner on a Sunday]
(21)	Open eye open	['Open your eyes']
(22)	Missy girl same both girl	['Missy and Goofy are both girls']
(23)	Cat chasing cat	[She was asked: "What is the cat chasing?" answer, a dog]
(24)	Fort B. Fort B. LA. your	[a comment about where we were each from]

In the last few years of data collection the repetition of arguments decreased substantially in Chelsea's spontaneous speech and now occurs only infrequently. However, in utterances containing verbs, Chelsea continues to omit required *theta* roles and/or include too many arguments and often omits the core of predicate argument structure itself; namely, verbs. She also makes selectional restriction *(S-selection)* violations, choosing arguments which have the wrong semantic features, such as *inanimate* instead of *animate,* or *edible* instead of *inedible.* Such errors continue to make many of Chelsea's utterances not only semantically ill-formed, but without considerable knowledge of context, uninterruptable as well. A sampling of these different error types, all clear violations of predicate argument structure and the Theta-Criterion, is presented in (25)–(45) below.

On the assumption that these utterances mean something like what a speaker of English might expect them to mean, the errors are underlined. (In some cases guesses as to where the verb would, should, or could have appeared have been made.[8])

[8] It may be that in a few of these cases Chelsea's error was producing the wrong verb.

Picture descriptions/comments produced during language training/testing sessions

(25)	Cow drinking baby	[selectional restriction violation]
(26)	Penny dollar __ man girl	[no verb]
(27)	The dog is swimming the ball	[selectional restriction violation]
(28)	The they are is hugging the dinner	[selectional restriction violation]
(29)	Robert push hair	[selectional restriction violation]
(30)	Give boy friend	['The woman is giving her boyfriend a valentine'; *give* requires three theta roles; C produced only one, her utterance includes only a V and Indirect object.]
(31)	This boy __ ice cream	['This boy has ice cream'; no verb]

Spontaneous utterances

(32)	The girl is with the girl get wins	[difficult to analyze without knowing the exact gloss, but clear violations of argument structure (and constituent structure as well)]
(33)	The man is walking the put food	[violation of argument and constituent structure]
(34)	Work pictures Fionna Daddy wood Tuesday Vickie	[too many arguments without accompanying verbs]
(35)	Missy don't __ milk	['Missy doesn't like milk'; no verb]
(36)	Morning up ___ outside ___ the mushroom	['In the morning when I got up I went outside and found a mushroom'; no verbs]
(37)	Cindy baby stomach ___ hospital	['Cindy went to the hospital to have the baby that was in her stomach'; no verb]
(38)	Ride tree bush splash	[difficult to analyze without knowing the exact gloss, but clear violations of argument structure and no subject]
(39)	Giinny no Nancy Frank	[no verb, too many arguments]
(40)	I ___ mistake	[no verb]
(41)	Peter __ banana	[no verb]
(42)	Study working spell	['I'm studying; working on spelling'; missing subject; *-ing* affixed to wrong stem]
(43)	Miss Frank	[missing subject]
(44)	I work nothing Jan D.	[Difficult to analyze without knowing the exact gloss, but clear violations of argument structure]
(45)	Butter sorry?	[On best reading, no verb; no subject]
(46)	Airplane fly headache	['When the airplane was flying, I got a headache'; second subject and verb missing]

These pervasive and persistent violations provide clear evidence that the verbs in Chelsea's lexicon do not contain information regarding *theta* structure in their representations, and, further, that whatever principles govern words and word strings in Chelsea's language, they do not include the Theta-Criterion.

It is not the case that Chelsea never produces utterances that are coherent and clear propositionally, although still often ungrammatical, as illustrated in (47)–(57).

(47) Boy ___ over tree
(48) Bear ___ outside
(49) The man is stop the car
(50) They are swimming the fast

(51) Green stuff ___ ocean
(52) Missy scratch ____ , Goofy too
(53) What are you doin, bird?[9]
(54) Goofy like milk
(55) Want do by myself
(56) Me ___ too wet
(57) Your house you move

In fact over time there may have been/be a growing tendency for Chelsea to produce semantically coherent (non-taught) novel utterances, and, what is more, there appears to have been some growth in assigning verbs the appropriate number of arguments in her spontaneous utterances. However, Chelsea has never consistently produced novel, semantically well-formed utterances, and as it is the case that grammatical principles are obligatory, there do not appear to be any semantic well-formedness constraints operating obligatorily over her word combinations.

Additional evidence for this assertion comes from her performance on a semantic judgment task she was given on several occasions (the *Semantic Judgment Test,* Jackson, 1985). The task involved determining if the sentence presented was "silly" or not. On each occasion, the instructions and a number of examples were presented. Every item was read slowly, loudly, and repeated. This task has been used successfully with normally developing preschool children and young elementary school-aged children with focal lesions. Table 2 below presents Chelsea's performance on this task together with sample items.

Table 2: Semantic Judgment Task

Date of test	Chelsea's score	Pattern of performance
1986	17/26 correct	Apparent random guessing
1987	12/26 correct	Apparent random guessing
1989	13/26 correct	Apparent random guessing
1992	13/26 correct	Some systematicity for a few items (see below)

Sample test items

1. The door ate dinner
2. Ann cut for the scissors
3. Sally ran to school
4. The ball is happy
5. The cup chased the girl
6. The children were mad
7. Amy made a pie for Jane
8. Keep the book with the bag
9. The dog bit the cat
10. The girl ate the sandwich

[9] A number of years ago, to enhance her communicative effectiveness, professional staff working with Chelsea began to teach her common phrases and expressions she could learn as a frozen, single entity and then use in specific, frequently occurring situations. This strategy has proved extremely beneficial and has helped Chelsea to be communicatively clear and effective in many situations, even with total strangers. Some of the "best" example sentences presented in the text are likely part of this repertoire, such as items (53) and (55) above, and all others with modals, cliticized auxiliaries, subject-aux inversion, tags, and others.

As can be seen, her performance was at chance level each time she was given the task. In the first three administrations, her judgments were essentially random and also inconsistent from year to year; that is, she would get different items correct at each testing. A closer look at her performance at the latest testing however, suggests that she was becoming increasingly able to extend her knowledge of the semantics of words in her lexicon (and the concepts they encode) to make semantic acceptability judgments on word combinations where attributive relations were concerned. She labeled all items like (58–60), for example, as "silly", reflecting her knowledge about doors, balls, houses, etc. and their attributes.

(58) The door ate dinner
(59) The ball is happy
(60) The house is sad

Thus, while overall she showed little ability to make judgments of semantic well-formedness over word combinations, even when comprised of words in her own productive vocabulary, she appeared to be developing some ability to do so when the relation between words is attributive. Apart from this, however, we find little evidence that Chelsea has developed systematic knowledge of any semantic well-formedness constraints that operate over propositions. In sum, once we move beyond the comprehension and use of single words, we find that Chelsea exhibits clear and persistent deficits.[10]

4.2 More on Syntactic structure

As can be gleaned from examples already presented, Chelsea does not appear to possess a set of rules or principles constraining grammatical form. To wit, let us examine her syntactic knowledge in three specific areas in particular in more detail: 1) lexical and phrasal syntactic categories, 2) constituency and constituent structure and 3) functional categories—three of the most fundamental aspects of grammar, in essence—the essential building blocks of syntactic structure.

4.2.1 Categories

Perhaps the most basic units of syntax are syntactic *categories*; the lexical categories, Noun (N), Verb (V), Adjective (A), Adverb (Adv), Preposition (P). (Phrasal and functional and phrasal categories will be discussed in sections 4.2.4 and 4.2.5.) In addition to its meaning and pronunciation, every word in the lexicon is a member of a syntactic category, and its category membership is part of its lexical entry; i.e., part of its lexical representation. Therefore, part of knowing a word is knowing its syntactic category.

Does Chelsea's language contain syntactic category knowledge? It appears that it does not. Relatedly, do her lexical entries contain category membership information? The answer appears to be *no.* Distributional and morphological errors abound in her speech (and writing). It is difficult to determine the exact violations in some cases because of the inconsistencies in constituent order and the difficulties of determining the intended meanings of many of Chelsea's utterances. Plausibly, (61)–(70) are examples where morphological or distributional properties of nouns and verbs are violated. (It is obvious that these examples involve a variety of other syntactic violations as well.)

(61) Fiving the boy looking five ['The boy looks five years old']
(62) The woman is bus the going ['The woman is riding on the bus']

[10] Testing for more complex semantic abilities like inference and presupposition has been impossible because of Chelsea's poor comprehension generally. Attempts have been made but abandoned.

(63) The man is walking the put food [(33) repeated here]
(64) The man is truck the ice cream
(65) They the they are swimming and the lake [In addition to other violations, this utterance violates the constraint that only constituents of the same syntactic category can be coordinated.]
(66) The small a the hat to the bring
(67) Banana the eat
(68) I Wendy be drive come
(69) The bee is honey the hive
(70) Nancy the marry?[11]

In (61) a verbal affix is attached to a Noun; in (62), (63), (66), (67) and (70) determiners occur before verbs (or noun–determiner order is unfixed); (68) contains a string of verbs without any obligatory intervening syntactic units; and in (64) and (69) a noun appears in a verb "slot". Just as plausibly, however, these examples involve violations of higher order "categories"; i.e., *phrasal* categories (XPs), violations involving *functional* categories (projections of non-lexical syntactic categories or features), or violations of constituent structure.

4.2.2 Constituents and Constituent structure

Knowing which NPs may occur without determiners, which VPs must contain direct object complements, etc. is information specified in the lexicon and therefore is part of the lexical entry of each noun and verb a person knows (referred to as subcategorization information or a word's *C-selection* properties). Related to a word's C-selection properties is another fundamental principle of grammar: the *Projection principle,* a constraint which requires that a word's C-selection properties be adhered to at every level of grammar. The acquisition of all aspects of constituent structure is remarkably rapid and error-free in the normal case (c.f. Crain, 1991; Hirsh-Pasek et al., 1987; Pinker, 1984, 1989 and many others). What knowledge of constituent structure does Chelsea's language embody? Does Chelsea's language appear to include or be constrained by the *Projection principle*? Does her language contain any information governing the order of heads and their complements? Does her language reflect knowledge that the basic word order of English clauses is S V O?

Most of the evidence regarding Chelsea's knowledge of the properties of constituent structure comes from her own productions, which we examine below. However, there were two formal tests administered to Chelsea to assess her knowledge of specific aspects of constituent structure, and we will first examine her performance on these.

One test, the *Active Voice Word Order* subtest of the CYCLE-R (Curtiss and Yamada, 1987) assessed Chelsea's knowledge of S V O order in English sentences. Table 3 presents her performance on this test over a nine-year period. A second test, the *Sentence Judgment Test* (Curtiss and Cline, 1983) was given to Chelsea three times (1987, 1989 and 1992) to evaluate Chelsea's sensitivity to head–complement order in English with respect to head Noun–relative clause order (in addition to her knowledge of many other aspects of grammar). Tables 3a–3d present her performance on the relevant items of these tests.

[11] Remarkably, despite being hearing impaired, Chelsea signals questions via correct prosody.

Table 3a: Active Voice Word Order subtest
Sample item: *The boy is chasing the girl.* Pictured: 1) boy chasing girl, 2) girl chasing boy, 3) girl and boy chasing clown, 4) boy chasing dog

Year	Performance	Number correct
1984	Failed, no pattern to errors	2/5
1985	Failed, no pattern to errors	1/5
1986	Failed, no pattern to errors	2/5
1987	Passed	5/5
1989	Failed, no pattern to errors	1/5
1992	Failed, no pattern to errors	1/5

Table 3b: Wh-Subject questions
Sample item: *Who is pushing the girl?*
Pictured: woman pushing a girl pushing a boy down a slide

Year	Performance	Number correct
1984	Failed, no pattern in responses	1/5
1985	Failed, no pattern in responses	1/5
1986	Failed, no pattern in responses	2/5
1987	Failed, pointed to left-most figure pictured	0/5
1989	Failed, pointed to center figure pictured	0/5
1992	Failed, no pattern in responses	1/5

Table 3c: Wh-Object questions
Sample item: *Who is the girl pushing?*
Pictures: same as in 3b

Year	Performance	Number correct
1984	Failed, no pattern in responses	1/5
1985	Failed, errors = pointing to N named in each test S	1/5
1986	Failed, errors = pointing to N named in each test S	2/5
1987	Failed, errors = pointing to N named in each test S	0/5
1989	Failed, pointed to center figure pictured	0/5
1992	Failed, no pattern in responses	1/5

Table 3d: Performance on Sentence Judgment Test items relating to head–complement order in relative clauses
Sample item: **The who came here girl is crying* (vs. *The girl who came here is crying*)

Year	Number correct	False positives[a]	False negatives[b]
1986	1/4	1	2
1989	1/4	1	2
1992	1/4	1	2[12]

a. A false positive is judging a string to be well-formed when it is ungrammatical.
b. A false negative is judging a string to be ill-formed when it is grammatical.

[12] Errors were made on a different set of items on all of these tests in different years.

Her performance on the Active Voice Word Order test over the years indicates that she does not have a consistent mapping of grammatical role onto SVO order in English. Neither her spontaneous utterances nor her test performance over many years demonstrate the emergence of any consistent or systematic mapping of SVO order onto words strung together. Her error-filled productions and her performance on the relevant items of the Sentence Judgment test also suggest that she does not yet possess the knowledge that heads and complements must be systematically ordered with respect to each other. Representative examples from her spontaneous productions illustrate this lack of knowledge (see (71)–(86) below).

	Utterance	**Approximate Gloss**	**S V O order**[13,14]
(71)	Breakfast eating girl	'The girl is eating breakfast'	OVS
(72)	Combing hair the boy	'The boy is combing his hair'	VOS
(73)	Riding ride bike ride boy	'The boy is riding the bike'	VOS
(74)	The woman is bus the going	'The woman is riding on the bus'	SOV
(75)	Banana the eat	'He is eating the banana'	OV
(76)	C., cut hair off you?	'C., did you cut your hair off?'	SVOS[15]
(77)	You got big picture	'You have large photographs'	SVO
(78)	Peter sandwich bread turkey	'Peter had a turkey sandwich with bread'	SO (interrupted object of P)
(79)	Teeth brush	'She's brushing her teeth'	OV
(80)	Jessica watch	'I am watching Jessica'	OV
(81)	Girl present open.	'The girl will open the present'	SOV
(82)	Shit the bird table	'The bird shit on the table.'	VS(P)P
(83)	Stand boy	'The boy is standing'	VS
(84)	Kick the boy girl	'The boy is kicking the girl'	VSO
(85)	He her little puppy have	'He has her little puppy'	SOV
(86)	Goofy like milk	'Goofy likes milk'	SVO

To ascertain how representative these utterances were in the ordering of constituents serving as subjects, objects, and verbs, 500 utterances were selected randomly (50 from each year for which I have data (1980, 1981, 1982, 1983, 1984, 1985, 1986, 1987, 1989, 1992), and the frequency of occurrence for each ordering occurring in the data for that year was calculated. Two important findings emerged. First, every possible order of SVO was attested in the data for each data point, although VSO was far rarer than any other orders. Second, no consistent ordering of S, V, or O with respect to each other and no changes in ordering patterns over the years were revealed, as illustrated in Table 4.

4.2.3 C-selection (subcategorizaion)

Chelsea's utterances also indicate no consistent adherence to the C-selection properties of the nouns, verbs, or adjectives she uses, as illustrated by (87)–(94). (A description of the errors is given, at least in part, after each example.)

[13] Any of these may be null in Chelsea's productions.

[14] Many of these seem to be Topic-Comment utterances, but while that may be the case, it remains true that she has not developed a consistent mapping of word order onto S V and O.

[15] The initial subject NP is an appositive, and was spoken with normal American English prosody for such structures.

Table 4: Order of S V and O in Chelsea's utterances

Order of constituents	Average frequency of occurrence across years	Frequencies of orderings in 1992 alone
S before VP	45%	43%
V O	46%	45%
O V	54%	65%
V first[a]	59%	57%
VSO (S occurring within the VP)	18%[b]	19%[b]

a. When all sentences with S V O were counted.
b. Although a smaller percentage than the other orders, this still represents almost 1/5 of utterances containing an S V and O.

(87)	The dog is swimming the ball	[(27) repeated here; *swim* doesn't take a DP complement][16]
(88)	They are swimming the fast	[Adjectives may not take determiners on their own; and the adjective occurs here without a head noun.]
(89)	The they are is hugging the dinner	[Pronouns are DPs and so may not be preceded by determiners; Auxiliaries must agree in number with the subject and with each other]
(90)	Cows the in outside walking the barn	[*walk* may not take an NP complement.]
(91)	The small a the hat to the bring	[Adjectives may not precede determiners.]
(92)	Nancy the marry?	[Proper nouns may not take determiners in English, or verbs may not follow determiners.]
(93)	She coming people	[*come* may not take a DP complement.]
(94)	See sit chair	[*sit* may not take a DP complement]

4.2.4 Phrasal categories

The absence of constituent structure in Chelsea's language could be described in part as the absence of phrasal categories in her language. Below are further illustrations of phrasal category violations involving missing heads or other obligatory but missing constituent-internal or XP-internal units, inconsistent and impermissible order of units within constituents/XPs (other than those already discussed earlier) and constituents whose internal structure is interrupted by elements from other constituents. (The assumed target structure is provided in brackets for these errors.) Other syntactic violations are also present in some of these examples, so the relevant constituent structure/phrase structure errors are underlined.

Picture descriptions

(95)	The boat sits <u>water on</u>	
(96)	The <u>small a</u> the hat <u>to the bring</u>	[gloss cannot be determined]
(97)	Banana the eat	

Spontaneous utterances

(98)	<u>Orange</u> Tom <u>car in</u>	['Tom is in the orange car']
(99)	The girl is cone the ice cream	['The girl is shopping, buying an ice cream

[16] Except in sentences like *She swam 10 laps*; *He swam the distance in 3 hours.*

	shopping buying the man	cone from the man']
(100)	Boy the ___ a the truck	[*N-Det order; VP contains no V, only its complement]
(101)	Hot pepper __ Sarah Daddy	[The VP contains no V, only its complement]
(102)	Robert eat peppers hot	[*N-Adj order]
(103)	Cows the in outside walking the barn	['The cows are walking in the barn outside'; *Det-N order, PP interrupted by intruding material.]
(104)	The is the ball wagon	['The ball is in the wagon'. The *be* intervenes between the determiner and its complement, the subject noun; the PP is missing its head.]
(105)	Flower orange	[*N-Adj]
(106)	You banana with	['You are with a (have a) banana'; *NP-Prep]

In sum, Chelsea fails to exhibit knowledge of any of the properties of phrase structure or constituent structure examined, and her utterances do not appear to embody any of the relevant fundamental grammatical properties or constraints.

4.2.5 Functional categories

Two questions are central here: 1) does Chelsea's language include any C-, I- or D-system functional category structures, and more important, 2) is her use and comprehension of functional category structures (or features) motivated by or a reflection of knowledge of relevant grammatical principles?

The answers to both of these questions are probably evident to the reader from the example utterances already included in the text. The answer to 1) is *yes*. Chelsea's utterances include many functional category elements. However, they include no C-system elements at all (and no movement of units up to a C position). We can conclude, therefore, that Chelsea's language has no C-system at all. The answer to 2) is, *no*; there do not appear to be any constraints governing when and where C-, I- or D-system functional elements should, should not, may, or may not occur. The closest Chelsea comes to controlling a functional category structure is with the plural morpheme, which she has come to use often. Plural markers remain optional for her, however, and they are not optional elements in English. Moreover, she appears to mark lexical items for plural where English disallows them, as is the case with Determiners. Examples (107)–(117) provide more evidence in support of these conclusions. (Some of the example utterances have appeared in previous sections of the text.)

Utterances containing I-system structures

(Relevant structure(s) underlined and labeled in [square brackets] with errors described.)

(107)	They the they are swimming and the lake	[subject-aux agreement]
(108)	Linda is make 23 wreath yesterday	[aux *be,* but without its *-ing* component or appropriate past tense inflection; note also missing plural on *wreath.*]
(109)	Goofy is run__ in outside jump window	[subject-aux agreement; *be* without *-ing*]
(110)	The cats is on room the big.	[*S-aux agreement]
(111)	I Vickie at going Chelsea	[no case assigning element; no *be* part of *be* + *-ing*]
(112)	Chelsea and Catherine lunch to walks eggs and apple	[infinitival *to,* but ungrammatical *finite* verb in the infinitive clause]

(113)	Be sorry Peter	[no tense]
(114)	Jessica watch	[no tense]
(115)	Woman girl pushing woman	[no *be*]
(116)	That Tom love_ you hug_ you hug_ you	[no tense]
(117)	Surprise Nancy	['I will surprise Nancy'; no modal]

In sum, many I-system structures are present in the data, but are used inconsistently and ungrammatically. Some do not occur at all; namely, auxiliaries *have* or *do;* modals, even those often the earliest to appear (sometimes referred to as "catenatives"), such as *gonna, hafta, oughtta,* etc.; regular *past tense,* and past participles. Her use of INFL elements appears completely unconstrained.

Utterances containing D-system structures

(118)	Fours cats	[plural marked ungrammatically on the quantifier as well as on the noun]
(119)	The girl_ skates	['The girl's skates'; plural marker present but possessive marker is null.]
(120)	This sheep jump	['These sheep are jumping' or 'These sheep jump'; no plural marking on the demonstrative determiner.]
(121)	How many apples? How manys apple_? (Spoken in succession)	[correct use of plural followed by *placement of the plural on the quantifier, with the plural marker missing on the noun.]
(122)	Sue to home the today	[*use of determiner with adverb]
(123)	Chelsea and Catherine lunch to walks eggs and apple_	[plural on *egg* but not on *apple*]
(124)	They the they are swimming and the lake	[determiner used erroneously with a pronoun]
(125)	The small a the hat to the bring	[too many determiners and inconsistent specificity and definiteness on the determiners used; determiner used with a verb]

To summarize, Chelsea's utterances exhibit clear *unprincipled* use of determiners in many of these examples, including the ungrammatical occurrence of determiners with pronouns and proper nouns, the occurrence of more than one determiner with the same noun, including determiners of opposing semantic specificity, and what appears to be the occurrence of determiners with verbs and adverbs. Possessive markers do not occur at all in the data. Plurals, which occur with frequency, are nonetheless optional for Chelsea ((108) and (123) are good examples of this), whereas they are obligatory in the grammar of English for all count nouns in plural contexts. What is more, she used plural markers where it is ungrammatical to do so.

It is interesting to note that while the examples from her spontaneous speech are clearly ungrammatical, the use of grammatical markers is one area in which Chelsea's spontaneous speech often differs from her spoken and written utterances elicited in language training or other didactic settings. Whereas the utterances produced in the latter contexts are consistently ungrammatical, in part *because* of the ungrammatical use of functional category structures. Over the years, despite many counterexamples, Chelsea's spontaneous speech more regularly appears to be largely agrammatic; i.e., strings of open class words without grammatical morphemes. Stated differently, in the former instance her utterances are filled with grammatical formatives; they abound in unprincipled exhi-

bitionism, whereas they make far rarer appearance in her spontaneous speech. This difference can be seen in numerous examples presented above.

As an aside, it is interesting to note that Genie, too, displayed a similar discrepancy between "trained" speech and spontaneous speech. The few times Genie's utterances were ungrammatical because of the unprincipled presence of grammatical morphemes (in striking contrast to her typical agrammatic speech where such formatives did not occur), was also in response to direct attempts to teach her to produce structures that did not appear in her own novel productions. Note (126)–(130) below, which were produced when an attempt was made to teach her to use the copula by her speech therapist. Contrast these utterances with (131)–(139), examples of Genie's spontaneous speech.

Utterances produced during "Language Training" (1973–1974)
(126) Mr. B. is flu
(127) Mixmaster is shake
(128) Picture is boy
(129) Spit is swallow
(130) Glass is break

Spontaneous utterances
(131) Applesauce buy store (1972)
(132) Man motorcycle have (1977)
(133) Tummy water drink (1977)
(134) Want go ride Miss F. car (1973)
(135) Genie full stomach (1976)
(136) Genie bad cold live father house (1973)
(137) Father hit Genie cry long time ago (1975)
(138) Genie have mother have baby grow up (1975)
(139) Mama have baby grow up (1975)

4.3 Summary

In summary, we have examined three of the most fundamental aspects of syntax (and morphology): 1) (lexical and phrasal) syntactic categories, 2) constituent structure, and 3) functional categories, and in each case have found that Chelsea's utterances do not embody any of the relevant principles governing syntactic units, their form, or their possible combination. In short, she does not possess even the fundamentals of a grammar. This fact also means, of course, that Chelsea's knowledge of language does not include any more complex grammatical structures or any syntactic operations, either, as more complex structures are built from the combination or recursion of more basic structures and via *Merge* and/or *Move*.

5 A word about discourse

Chelsea is difficult to understand and has sorely limited comprehension of language. Yet, she readily engages in social discourse via language and does so with considerable skill in certain respects. She not only knows when it is her turn to speak, she uses conversational operators, such as *Well*, and *You know/ya know as well as* conversational fillers, such as *um*, *uh*, and the like to indicate that a response is forthcoming or to signal that she is not finished with what she has to say. She also uses facial expressions and body language, such as shoulder shrugs or hands on hips—culturally determined communicative gestures. Her use of prosody for emphasis and to differentiate interrogatives, declaratives,

vocatives and commands is also remarkably spot on. In these respects Chelsea seems very much an *American* interlocutor, and as a result, one is often lured into thinking (perhaps automatically) that together you will be engaging in a typical American discourse exchange. However, that initial impression is immediately undone as Chelsea proceeds to speak in frequently incomprehensible, and almost always ungrammatical novel utterances, since these are the prevailing characteristics of her spontaneous speech. We find in Chelsea, therefore, a person with often quite normal discourse skills alongside little else other than words in the realm of language.

6 Overall summary of Chelsea's language to this point

The picture of Chelsea's language revealed from its examination is one in which we find an ever-increasing word-based lexicon, organized into semantic categories, as well as a well-developed sense of turn-taking and holding coupled with a gestural repertoire that marks her as an American speaker, but essentially no grammar. Her comprehension and production indicate that her language does not contain any systematic use or knowledge of even the basic semantic, morphological, or syntactic units or principles, properties, or constraints operating over and governing the internal or combinatorial structures of grammar. It is not sufficient that Chelsea sometimes produces utterances that conform to English grammar or on occasion passes items on formal tests on these aspects of grammar. She fails to show consistent knowledge of any of the aspects of grammar we have examined aside from lexicon and some discourse skills—areas that evidently are not subject to the effects of age at exposure to language that hold for grammar.

Her case therefore supports there being a critical period for first language acquisition of grammar. Thus, we find that perhaps the combination of her hearing impairment coupled with her more advanced age left Chelsea with the ability to grow a large and organized lexicon and to use it in conversational discourse. Nothing more. (Note in comparison, that while Genie's language was severely limited, she acquired not only a large lexicon, but also both lexical and phrasal categories as well as the C-selection facts of the verbs in her lexicon, selection restrictions which she never violated.)

Before turning to the issue of Chelsea's number cognition, let us turn to a brief description of Chelsea's ability to consciously manipulate some of the linguistic knowledge she does possess; i.e., her metalinguistic knowledge and performance.

7 Phonology and related metalinguistic ability

7.1 Discriminating phonemic distinctions

Because Chelsea is hearing impaired and even aided, does not possess normal hearing, her phonological development was not analyzed extensively and is not discussed here. However, her ability to discriminate between minimal pairs involving most of the "phonemic" distinctions in the vowel and consonant repertoire of spoken (Standard American) English (e.g. place, voice, and manner distinctions for consonants; height, backness, and tenseness distinctions for vowels) was examined.

To this end, Chelsea was given the CYCLE-P (Curtiss and Yamada, 1987), which presents two pictures, each representing a common word whose pronounced "name" differs from the other item on the page typically by one phonetic feature. The set of consonant distinctions covered includes, where possible, all of their possible syllable (or in the case of disyllabic words, word-internal) positions. A few examples are presented in (140)–(147):

(140) *face* vs. *vase*
(141) *pie* vs. *tie*
(142) *robe* vs. *road*
(143) *bell* vs. *bear*
(144) *cat* vs. *catch*
(145) *kitten* vs. *kitchen*
(146) *braid* vs. *bread*
(147) *pool* vs. *pull*

The CYCLE-P was administered in 1989 and 1992 (without accompanying signs). Chelsea performed quite well both times, given her hearing impairment. She made errors with all distinction types, but made few vowel or voicing errors. Thus, although her speech is often difficult to understand, it belies her sensitivity to most spoken English consonant and vowel distinctions. Chelsea scored 149/159 items given (omitting those depicting items she did not know the word for), a better than 88% correct performance.

7.2 Meta-phonological and metalinguistic ability

Chelsea's implicit knowledge of linguistically relevant dimensions regarding how words are pronounced and how well she is able to use this knowledge for particular metalinguistic purposes was also evaluated. To this end, we administered two tasks: a homophones task and a rhyming task.

7.2.1 Homophones

Her ability to judge whether two words were homophones or not was assessed, using a test designed and normed by Peters and Zaidel (1980). The test involves a four-picture array in which the pronunciation of two of the four items pictured is homophonous; a third item depicts a phonological foil, and the fourth, a semantic foil. The task is to point to the two items that are homophonous. There is a pretest where recognition and pronunciation of the words involved is established and practice items are given. In both 1989 and 1992, as a result of her performance on the pretest we had to exclude items from the test. (148) is an example item from the test.

(148) picture array: ***bat*** (animal) ***mitt***
hat ***bat*** (baseball bat)

Chelsea had some difficulty with this task in 1989. Nevertheless, it is of note that even in 1989 she never chose the semantic decoy, demonstrating that she was already able to systematically ignore (associative) semantic relations between words and focus on phonological structure alone. In 1992 she had no trouble with the task and clearly controlled the necessary manipulations. In every item given, she readily selected the homophonous pair, making no errors.

This performance is rather remarkable given that Chelsea is hearing impaired, and given that to determine if words are homophones, one must simultaneously and consciously consider and perform linguistic manipulations of both phonological and semantic structure.

7.2.2 Rhyming

A rhyming task was also administered to Chelsea, using a test I designed and normed (Curtiss, 1985), patterned after the homophones test. The rhyming task involves a four-picture array in which the pronunciation of two of the four items pictured constitutes a rhyme; a third item is a phonological foil, and the fourth, a semantic foil. The tester names the four items pictured, and the task is to point to the two items that rhyme. The pronunciations of the rhyming items differ from each other by only one distinctive feature. A pretest is given to ensure that the task is understood. (All of the words used on the test are common, imageable concrete nouns.)

Chelsea had no difficulty with the pretest, but did not know two of the test words, thereby eliminating two of the 20 items from the test. Sample items are presented below in (149) and (150).

(149) Here's *pie, cake, pea,* and *tie.* Which two rhyme?
(150) Here's *apple, pear, bear,* and *pour.* Which two rhyme?

Chelsea performed well on this task, displaying surprising ability once again, despite her hearing impairment, to manipulate the internal phonological/phonetic structure of words and ignore the other linguistic relations (even other phonological relations) between the words given.

In summary, her hearing impairment notwithstanding, Chelsea displays surprising knowledge of the sound structure of Standard American spoken English words and the ability to manipulate this knowledge metalinguistically. Her surprisingly good performance in this area adds validation to the investigation into her knowledge and performance of spoken English.

8 Grand language summary

The bulk of this paper has been devoted to presenting and analyzing Chelsea's language over the course of more than a decade in which data were collected, with the objective of considering these data in relation to the notion of a critical period (CP) for first language development.

Her data provide strong support for a CP or a clear effect of age on the development of grammar. In contrast to a well-developed lexicon and discourse skills and even metaphonological abilities, Chelsea appears to have no grammar. While she has consistently been able to learn lexical items, grammar has eluded her. Her productions lack the elements, principles and constraints governing human grammars. Chelsea can be said to be truly *a*grammatic; i.e., without grammar. She is able to use what she knows to communicate and navigate her world (e.g., go shopping, go out to eat, ride public transportation, take care of children and animals, engage in rich, social intercourse, especially now that she uses rote-learned phrases to shop, order food, ask questions necessary to take public transport and shop, and the like). However, Chelsea is not generating novel utterances by means of a grammar that she knows or has developed, not the grammar of English or of any human language.

9 Chelsea's number cognition

In this last section, I want to briefly describe a remarkable aspect of this case, one which has been reported on elsewhere (Grinstead et al., 1997; Curtiss, 1995, 2013), that speaks to the not unrelated issue in cognitive science, that of the task-specificity of cognitive domains and modularity of mind. Despite having no grammar, even a rudimentary one, Chelsea has a well-developed number sense. She can count as high as she is asked to count; i.e., she clearly knows the recursive counting function and how to use it. She knows which are large and which, small numbers. She knows which is the larger of any

two numbers, presented either orally or on paper, and which, the largest, when given more than two different numbers, no matter how large. She knows that there is an infinite set of numbers (that one can always add to whatever number one has). Moreover, she can add, subtract, multiply and divide. She keeps and reconciles a checkbook. She can negotiate purchases, knows whether she has received the proper change for purchases made as well as predict how much change she should receive in a monetary exchange. She knows how to calculate the amount of tax that applies to any given amount (as well as how much to tip). Chelsea can also tell time, and frequently comments on times things will take place or have taken place. She wears a watch and uses it to negotiate her life throughout the day.

Like individuals without language described in Schaller (1995), cases of severely cognitively impaired children with intact grammars but with almost no number concepts or knowledge (Curtiss, 1988, 1995, 2013), and the population of Turner's Syndrome, who have marked visual and spatial deficits except In the realms of reading, writing and performing number operations on paper (e.g., Kempler and Curtiss, 1981; Curtiss, 1995) Chelsea's case provides strong evidence for the domain-specificity of number, a domain that can develop completely in the absence of grammar (and all language) as well as be selectively impaired both developmentally and in breakdown (Curtiss, 2013).

10 Final summary and conclusions

Given her well-developed number cognition alongside the language profile she displays, Chelsea's case supports a modular view of both language and the mind. Not all aspects of language have remained elusive to Chelsea. She has a large, perhaps continually growing vocabulary, she possesses aspects of discourse competence having to do with turn-taking and holding her conversational place and has learned the culture-dependent elements of conversational interactions that are markers of American English verbal interactions, specifically, including the use of American English conversational operatives like "well", "ya know", and other such expressions. Yet, her comprehension is poor, and her speech is very often incomprehensible, making it hard for her to contribute readily to the progress of a topic. From Chelsea's case alone, then, we see, that language is not "of a piece". It is clearly separable into distinct parts, including lexicon, the grammar, and distinct components of discourse. This separability of the language system into pieces comports with what is often referred to as "Little Modularity". And the absence of a grammar module alongside a remarkably well-developed (learned) number module provides evidence in support of a view of the human mind that is modular more broadly ("Big Modularity").

In conclusion, therefore, Chelsea's case provides persuasive and provocative evidence in support of both a Critical Period for first language development that most strongly impacts the computational component of language (the grammar and processor) and the modularity of the human mind, as well.

Appendix A: Word lists generated

Year	Foods		Animals	
1986	banana		dog	
	apple		tiger	
	grape		elephant	
	potato		raccoon	
	chicken		squirrel	
	fish		bird	
	shrimp		butterfly	
	clams		parrot	
	bread		bug	
	butter		rabbit	
	jam		horse	
	egg		cow	
	sugar		camel	
	coffee		elephant	
Total	**14**	**+**	**14**	**= 28 (7th grade equivalent)**

Year	Foods		Animals	
1989	potato		dog	
	onion		bird	
	garlic		parrot	
	squash		chipmunk	
	cabbage		squirrel	
	carrots		chicken	
	broccoli		goat	
	salad		calf	
	yellow squash		bull	
	green squash		lovebird	
	orange		cat	
	tomato		possum	
	lettuce		lion	
	tiger			
	giraffe			
	seal			
	elephant			
	goose			
	duck			
	heron (signed)			
Total	**13**	**+**	**20**	**= 33 (9th–10th grade equivalent)**

Year	Foods	Animals
1992	apple	horse
	banana	pig
	plum	dog
	watermelon	chicken
	orange	cat
	apple	bird
	grapes	parrot
	fruit	fish
	orange	goldfish
	salad	goat
	beet	cow
	corn	camel
	peach	sheep
	celery	quail
	carrots	jaybird
	pepper	gopher
	chipmunk	

Total 15 + 17 = 32 (9th grade equivalent)

Appendix B: Performance on the CELF-R Producing Formulated Sentences subtest

(Instructions: Use this word in a sentence.)

Year	Word given	Chelsea's response
1989	car	Van bus motorcycle. That car truck sentence.
	yellow	Buy yellow truck yellow car.
	children	The children is play. Toy.
	nothing	The nothing. Nothing. Me word nothing. Tree fall nothing truck.
	what	Forgot what.
	belongs	*no response*
	because	*no response*
	slowly	*no response*
	after	*no response*
	tell	Tell people shopping.
	herself	Herself car.
	if	1) If book wrong idea.
		2) That if. That you student, me, you, all us.
1992	car	The car is blue.
	yellow	The is yellow draw.
	children	My niece children.
	nothing	I work nothing. Jan D.
	what	What is make paper copy.
	belongs	I don't know.
	because	Because back [unintell.] word.
	slowly	Quiet slow.
	after	After working.
	tell	The word tell Vickie.
	herself	My hurt myself mold.
	if	1) *no response*
		2) Sentence if. White paper make it.

References

Atkinson, M. 1992. *Children's syntax: An introduction to Principles and Parameters Theory*. Oxford: Blackwell Publishers.

Baker, C., and J. McCarthy (eds.). 1981. *The logical problem of language acquisition*. Cambridge, MA: MIT Press.

Berwick, R., N. Chomsky, and M. Piatelli-Palmarini. 2013. Poverty of the stimulus stands: Why recent challenges fail. In M. Piatelli-Palmarini and R. Berwick (eds.), *Rich languages from poor inputs*, 19–42. Oxford: Oxford University Press.

Bickerton, D. 1990. *Language and Species*. Chicago: University of Chicago Press.

Borer, H., and K. Wexler 1987. The maturation of syntax. In T. Roeper and E. Williams (eds.), *Parameter setting*. Dordrecht: Reidel.

Chomsky, N. 1981. *Lectures on Government and Binding*. Dordrecht: Foris.

Chomsky, N. 1986a. *Knowledge of Language. Its nature, origin, and use*. New York: Prager.

Chomsky, N. 1986b. *Barriers*. Cambridge, MA: MIT Press.

Chomsky, N. 1995. *The minimalist program*. Cambridge, MA: MIT Press.

Coppieters, R. 1987. Competence differences between native and non-native speakers. *Language* 63:544–573.

Coppola, M., and A. Senghas. 2010. Deixis in an emerging sign language. In Diane Brentari (ed.), *Sign Languages: A Cambridge Language Survey*, 543–569. Cambridge, UK: Cambridge University Press.

Crain, S. 1991. Language acquisition in the absence of experience. *Behavioral and Brain Sciences* 14(4):597–612.

Crain, S., and J. D. Fodor. 1993. Competence and performance in child language. In E. Dromi (ed.), *Language and cognition: A developmental perspective*. Ablex.

Curtiss, S. 1977. *Genie: A Psycholinguistic Study of a Modern-Day "Wild Child"*. New York: Academic Press.

Curtiss, S. 1985. The Rhyming Test. Unpublished.

Curtiss, S. 1988. Abnormal language acquisition and the modularity of language. In F. Newmeyer (ed.), *Linguistics: The Cambridge Survey II: Linguistic theory; Extensions and implications*, 96–116. Cambridge: Cambridge University Press.

Curtiss, S. 1989. The independence and task-specificity of language. In M. Bornstein and J. Bruner (eds.), *Interaction in Human Development. Crosscurrents in Contemporary Psychology VII*. Lawrence Erlbaum Associates.

Curtiss, S. 1995. Language as a cognitive system: Its independence and selective vulnerability. In C. Otero (ed.), *Noam Chomsky: Critical Assessments: 4*, 217–255. Routledge.

Curtiss, S. 2013. Revisiting Modularity: Language as a window to the mind. In M. Piatelli-Palmarini and R. Berwick (eds.), *Rich languages from poor inputs*, 68–90. Oxford: Oxford University Press.

Curtiss, S., and D. Cline. 1983. The Sentence Judgment Test. Unpublished.

Curtiss, S., V. Fromkin, S. Krashen, D. Rigler, and M. Rigler. 1974. The linguistic development of Genie. *Language* 50:528–554.

Curtiss, S., D. Kempler, and J. Yamada. 1981. The relationship between language and cognition in development: Theoretical framework and research design. *UCLA Working Papers in Cognitive Linguistics* 3:1–60.

Curtiss, S., and J. Yamada. 1981. Selectively intact grammatical development in a retarded child. *UCLA Working Papers in Cognitive Linguistics* 3:61–92.

Curtiss, S., and J. Yamada. 1987. The CYCLE: The Curtiss-Yamada Comprehensive Language Evaluation-R: Receptive measures. Unpublished. [fore-runner to the CYCLE, 2008].

Curtiss, S., and J. Yamada. 1987. The CYCLE-P: The Curtiss-Yamada Comprehensive Language Evaluation-P: Phoneme distinctions. Unpublished.

Dronkers, N. 1987. Chelsea's Cognitive and Neuropsychological Status. Paper presented at the Orton Dyslexia Society Annual Meeting. San Francisco.

Dunn, L., and Dunn, L. 1981. *Peabody Picture Vocabulary Test—Revised*. Circle Pines, MN: American Guidance Service.

Fischer, S., and R. Mayberry. 1982. Memory and Shadowing of ASL: qualitative measures. Paper presented at the Annual Meeting of the Linguistic Society of America, San Diego.

Friedin, R. (ed.) 1991. *Principles and Parameters in comparative grammar*. Cambridge, MA: MIT Press.

Gleitman, L. 1990. The structural sources of verb meanings. *Language Acquisition* 1:3–55.

Gleitman, L., and B. Landau. 2013. Every child an isolate: Nature's Experiments in Language learning. In M. Piatelli-Palmarini and R. Berwick (eds.), *Rich languages from poor inputs*, 91–104. Oxford: Oxford University Press.

Glusker, P., S. Curtiss, N. Dronkers, F. Howard, N. Moilanen, H. Neville, C. Reisman, S. Ervin-Tripp, and V. Yancey. 1990. Primary language acquisition in a deaf adult: The Chelsea Project. Paper presented at the 1990 Biennial Conference of the Orton Society.

Gould, J. 1982. *Ethology*. New York: Norton.

Grinstead, J., J. MacSwan, S. Curtiss, and R. Gelman. 1997. The Independence of Language and Number. *Proceedings of the 22nd annual Boston University Conference on Language Development*, 303–313. Cascadilla Press.

Hamburger, H., and S. Crain. 1984. Acquisition of cognitive compiling. *Cognition* 17:85–136.

Hirsh-Pasek, K., and R. Golinkoff. 1997. *The origins of grammar*. Cambridge, MA: MIT Press.

Hirsh-Pasek, K., D. Kemler-Nelson, P. Jusczyk, K. Wright, and B. Druss. 1987. Clauses are perceptual units for young children. *Cognition* 26:269–286.

Hyams, N. 1986. *Language Acquisition and the Theory of Parameters*. D. Reidel, Dordrecht.

Hyams, N. and Wexler, K. 1993. On the grammatical basis of null subjects in child language. *Linguistic Inquiry* 34:421–439.

Jackendoff, R. 1992. *Languages of the mind*. Cambridge, MA: MIT Press.

Jackendoff, R. 1994. *Patterns in the mind: Language and human nature*. Basic Books.

Jackson, C. 1985. The Semantic Judgment Test. Unpublished.

Kaplan, E., F. Goodglass, and S. Weintraub. 1983. *Boston Naming Test*. Philadelphia: Lea & Febiger.

Kegl, J. 2004. Language Emergence in a Language-Ready Brain: Acquisition Issues. In Lyle Jenkins (ed.), *Biolinguistics and the Evolution of Language*. John Benjamins.

Kempler, D., and S. Curtiss. 1981. A note on the cognitive profile associated with Turner's syndrome. *UCLA Working Papers in Cognitive Linguistics* 3:117–120.

Lenneberg, E. 1967. *Biological Foundations of Language*. New York: Wiley.

Lidz, J., S. Waxman, and J. Freedman. 2003. What infants know about syntax but couldn't have learned: Experimental evidence for syntactic structure at 18 months. *Cognition* 89:B65–B73.

Lightfoot, D. 1982. *The language lottery: Toward a biology of grammars*. Cambridge: MA: MIT Press.

Lightfoot, D. 1989. The child's trigger experience: 'Degree-0' learnability. *Behavioral and Brain Sciences* 12:321–334.

Mayberry, R. 1993a. First-language acquisition after childhood differs from second-language acquisition: The case of American Sign Language. *Journal of Speech and Hearing Research* 36:1258–1270.

Mayberry, R. 1993b. The first language timing hypothesis as demonstrated by American Sign Language. *Child Language Research Forum* 25:76–85.

Mayberry, R. 1994. The importance of childhood to language acquisition: Evidence from American Sign Language. In J. C. Goodman and H.C. Nusbaum (eds.), *The development of speech perception*. Cambridge: MIT Press.

Mayberry, R., E. Eichen. 1991. The long-lasting advantage of learning sign language in childhood: Another look at the critical period for language acquisition. *Journal of Memory and Language* 30:486–512.

Mayberry, R., S. Fischer, and N. Hatfield. 1983. Sentence repetition in ASL. In J.G. Kyle and B. Woll (eds.), *Language in Sign*, 206–214. London: Croom Helm.

McKinney, V. 1983. First language learning in deaf persons beyond the critical period. Unpublished Ph.D. dissertation, Claremont Graduate School.

Meisel, J. 1990. INFL-ection: Subjects and subject-verb agreement in early child language. In J. Meisel (ed.), *Two first languages: Early grammatical development in bilingual children*, 237–298. Dordrecht: Foris.

Meisel, J. 1992. *The acquisition of verb placement: Functional categories and V2 phenomena in language acquisition*. Dordrecht: Kluwer.

Naigles, L., L. Gleitman, and H. Gleitman. 1993. Children acquire word meaning components from syntactic evidence. In E. Dromi (ed.), *Language and cognition: A developmental perspective*, 104–140. Norwood, NJ: Ablex.

Newport, E. 1984. Constraints on learning: Studies in the acquisition of American Sign Language. *Papers and reports on child language development* 23:1–22.

Newport, E. 1988. Constraints on learning and their role in language acquisition: Studies in the acquisition of American Sign Language. *Language Sciences* 10:147–172.

Newport, E. 1990. Maturational constraints on language learning. *Cognitive Science* 14:11–28.

Newport, E. 1991. Contrasting conceptions of the critical period for language. In S. Carey and R. Gelman (eds.), *The epigenesis of mind: Essays on biology and cognition*, 111–130. Hillsdale, NJ: Lawrence Erlbaum Associates.

Peters, A., and E. Zaidel. 1980. The acquisition of homonymy. *Cognition* 8:187–207.

Pierce, A. 1992. *Language acquisition and syntactic theory: A comparative analysis of French and English Child Grammars*. Kluwer.

Pinker, S. 1984. *Language Learnability and Language Development*. Cambridge, MA: Harvard University Press.

Pinker, S. 1989. *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press.

Pollock, J.-Y. 1989. Verb movement, universal grammar, and the structure of IP. *Linguistic Inquiry* 20:365–424.

Rondal, J. 1993. Exceptional cases of language development in mental retardation: The relative autonomy of language as a cognitive system. In H. Tager-Flusberg (ed.), *Constraints on language acquisition: Studies of atypical children*. Hillsdale, NJ: Lawrence Erlbaum.

Rondal, J. 1995. *Exceptional language development in Down Syndrome*. New York: Cambridge University Press.

Schaller, S. 1995. *A man without words*. Berkeley: University of California Press.

Scovel, T. 1989. *A time to speak: A psycholinguistic inquiry into the critical period for human speech*. Cambridge: Newberry House.

Semel, E., and E. Wiig. 1980. *Clinical Evaluation of Language Functions*. Charles E. Merrill Publishing Co.

Senghas, A. 1995. Children's contributions to the birth of Nicaraguan Sign Language. Ph.D. Dissertation. MIT. Distributed by MIT Working Papers in Linguistics.

Tartter, V., and S. Fischer. 1982. Perceiving minimal distinctions in ASL under normal and point-light display conditions. *Perception & Psychophysics* 32:327–334.

Valian, V. 1990. Null subjects: A problem for parameter-setting models of language acquisition. *Cognition* 35:105–122.

Wexler, K., and P. Culicover. 1980. *Formal principles of language acquisition*. Cambridge, MA: MIT Press.

Woodward, J. 1973. Inter-rule implications in American Sign Language. *Sign Language Studies* 3:47–56.

Yamada, J. 1990. *Laura: A case for the modularity of language*. Cambridge, MA: MIT Press.

Young, R. 1981. Sign language acquisition in a deaf adult: A test of the critical period hypothesis. Unpublished Ph.D. dissertation, University of Georgia.

Affiliation

Susan Curtiss
Department of Linguistics
UCLA
scurtiss@ucla.edu

Connectedness: Papers by and for Sarah VanWagenen
UCLA Working Papers in Linguistics 18: 147–159
Carson T. Schütze & Linnaea Stockall (eds.), 2014

Learning Adjuncts*

Meaghan Fowlie

Human languages include adjuncts, which are grammatically optional elements. Some adjuncts can also be repeated indefinitely. I consider four learnable classes of languages and ask whether these classes include optional and repeated elements, and what input a learner requires in order to generalise from finite to indefinite repetition.

Keywords adjunct, adjective, optionality, repetition, learnability, PDFA, 0-reversible, n-gram, substitutable context free

1 Introduction

At the heart of linguistic study is the question of how such a complex system can be learned by people so young and unformed that they cannot even survive on their own. In describing existent human languages we often hope that the phenomena we encounter will provide some insight into this puzzle: perhaps we have found a universal feature, meaning it could be somehow "built in", sidestepping the necessity for children to learn it; or perhaps we have found a clearcut parameter on which human languages may differ, pointing out a specific fact that children might automatically watch for. Language acquisition studies children's language learning directly, while formal language theory can be used to discover what sorts of grammars are required to describe human language. Learnability theory is the study of mathematical models of language acquisition.

This paper will explore learning models applied to two specific phenomena: optionality and repetition. Adjuncts are by definition optional in that although a sentence will have a different meaning without the adjunct, it is still perfectly grammatical, and the meanings of the sentences differ systematically. For example, in (1) we see that the adjective *red* is optional, and (1-a) entails (1-b).

(1) a. My love is like a **red** rose.
b. My love is like a rose.

Many human languages allow optional repetition of adjuncts, as for example English:

(2) a. My love is like a **red red** rose.
b. She's **really really really really really** nice.

*This paper is dedicated to Sarah VanWagenen, who was one of the coolest people I have met.