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A brief history of a young discipline : developmental psycho linguistics

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A Brief History of a Young Discipline: Developmental Psycho linguistics

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With University Honors

Department of Communicative Disorders

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ABSTRACT:

This paper explores the theoretical history of developmental psycholinguistics from the publication ofN oam Chomsky's *Aspects of the Theory of Syntax,* in 1965 to the present work of Steven Pinker with special attention paid to Roger Brown, Dan Slobin, Michelle Bowerman, Richard Cromer, and the research team, David Rummelhart and James McClelland. It begins with the psychological theories of language development of Jean Piaget and B.F. Skinner concluding with the Words and Rules Theory of Steven Pinker.

The Dark Ages

The modern study of Language Development began as a reaction to the publication of No am Chomsky's *Aspects of the Theory of Syntax* (1965). In this book,, Chomsky outlined the debate that still captivates psychologists and psycholinguists today. The question posed was, "Is language an innate ability or is it a learned ability?" The battle had begun. This battle has created several landmark studies, numerous brilliant and innovative researchers, and most importantly, it gave birth to the field of developmental psycholinguistics.

When Chomsky first published his revolutionary book in 1965, many of the scholars concerned with language development were focusing on the work of psychologist Jean Piaget. Piaget contended that language acquisition was a product of the sensorimotor stage of cognitive development. His theory stated "Language is a part of a more general cognitive organization with its roots in action and in sensorimotor mechanisms deeper than the linguistic phenomenon" (Rieber, 1983, p. 110). Piaget goes on to state, "what we consider as innate ... is the general ability to synthesize the successive levels reached by the increasingly complex cognitive organization" (Rieber, 1983, p. 110). In other words, Piaget was proposing what is known as a constructivist framework for language acquisition. The structures involved with acquiring knowledge are more general mechanisms that can analyze anything (Chomsky, 1965, p. 48). Once experiences have been analyzed, they can be applied to situations, and knowledge is acquired through the application of these experiences. This theory assumes that there is no a priori knowledge, and all knowledge that is acquired is gathered strictly through expenence.

Most of the other scholars studying language development were concentrating on the work ofB.F. Skinner, a behavioral psychologist. . In his book, *Verbal Behavior,* Skinner outlined his approach to language development. . His theory states "language, like any other behavior, is learned through operant conditioning" (Berk, 2001, p. 167). This theory relies on the belief that a child acquires language through reinforcement provided by parents or other people that the child interacts with (Berk, 2001, p. 167). In other words, a child learns language by using a word or sentence and forming knowledge based on the positive or negative reinforcement of the people the child is communicating with. This theory is similar to the Piagetian theory in that there is no a priori knowledge of the structure of the language thus all knowledge must be acquired through experience analysis. However, the behavioralist approach does not consider the child's cognitive development to be a contributing factor to acquiring language. This theory is known as an empiricist framework for language development. .

Revolution: The Chomsky Era

Aspects of the Theory of Syntax presented a radically different approach to language development. In it, Chomsky proposed a rationalist framework... His structures for acquiring language use innate ideas and principles that are highly organized, restricted, and ultimately determine the form of knowledge (Chomsky, 1965, p. 48). A stimulus or word in this case, is presented and is processed. It is through this processing that knowledge is acquired. These structures are not limited to experience analysis. They are actually preset ways of organizing data. Chomsky called the structure for learning

language, the Language Acquisition Device. This Language Acquisition device is "one component of the total system of intellectual structures applied to problem solving and concept formation" (Chomsky, 1965, p. 56).

To understand more about Chomsky, his theory, and his influence on the field, one needs only to look at his background. Noam Chomsky was born on December 7, 1928. He attended the University of Pennsylvania taking his Ph.D. in Linguistics in 1955. Although he had written several books and articles on linguistics, philosophy, intellectual history, and contemporary issues (Rieber, 1983, p. 30) he had a special interest in grammar and syntax. This interest in syntax helped him to form his primary question, "What do we know?" This question rose out the observation in 1836 that no one teaches a child language (Chomsky, 1965, p. 51) one only presents the stimulus and lets it develop in the child's mind in its own way (Chomsky, 1965, p.51).

For Chomsky, this meant that the structure for grammar, or format for the rules of language, is given, or innate. In order to begin the process of forming language one only needs experience with language (1965, p. 48). Chomsky further develops this theory by stating that language is "not taught by conditioning or behavioralism or data processing (Chomsky, 1965, p. 51). However, one should note that this theory only assumes that the mechanisms for *acquiring* knowledge are innate, that knowledge itself must be gathered through experience and then processed by these innate structures. He stated that evidence for this idea was located in the fact that children can instantly understand sentences that they had never used (Chomsky, 1965, p. 57). This would negate the step by step inductive operations of the sensorimotor stage proposed by Piaget. According to Piagetian theory, since the child had never used the sentence before, they would not have

had the opportunity to use previous experiences to gather the knowledge needed to make the statement..

Naturally, Chomsky's theory had cognitive psychologists, such as Piaget, in an uproar. They contended that language was learned through applications of thoughts that were gathered through experience analysis. Chomsky proposed instead that children learned language by processing stimuli into a set of innate rules for language that they were born with. These rules could not be taught to the child. However, the controversy surrounding this theory did not end there.

When Chomsky proposed that all children were born with an innate propensity for grammar, he did not specify which grammar, or set of language rules, the child was born with. Each human language has a unique form of grammar and syntax. Syntax is "a system of rules for building phrases out of words (that belong to particular grammatical categories, such as noun and verb) and for building sentences out of these constituent phrases" (Hoff-Ginsberg, 1997, p. 445.) Chomsky (1965, p. 16) theorized that syntax was made of two elements, a surface structure and a deep structure. The deep structure of syntax was the mechanism that allows an individual to interpret the meaning of a sentence while the surface structure, or what one would directly hear, is the phonetic structure, or sounds, that make up a sentence (Chomsky, 1965, p. 16). Since a child cannot predict exactly what language it will be using later in life, all children must be born with the same innate resources for learning language, or a Universal Grammar, as defined by Chomsky.

In an interview with Beckwith and Rispoli (1986), Chomsky explained his theory of Universal Grammar as follows:

Universal Grammar, the theory of the initial state, the genetically
determined system, would not be a format for rule systems with a method
of hypothesis testing to choose among them, but rather something quite
different.. To select a different metaphor, it would be something like a
system which has an intricate and complex wiring but with some of the
connections not established and with, say, a box of switches that can be in
one of several (perhaps just two) positions, thus putting the system in full
working order. Now, the switches are what are called 'parameters'. They
have to be set by experience-experience has to tell you how to set each
of these switches. Once you set them in one of the permissible ways, you
have acquired a particular language (p. 188).

He went on to explain that each of the parameters had to be able to be determined by the
limited amount of data that children have about language (Beckwith and Rispoli, 1986, p.
189). To sum up this theory of Universal Grammar, Chomsky believed that each child
was born with an innate structure for learning language that allowed them to formulate
the specific rules for the individual grammar that they would be using. These structures
would help the child establish parameters through the experiences of listening to the
language being spoken around them. Once all of the parameters for that particular
language have been set, the child has acquired the grammar of the language.

Renaissance: The Contribution of Roger Brown

As Chomsky was working on his theories of language development, he was
teaching linguistics at MIT. In 1957, a social psychologist named Roger Brown joined

the MIT faculty (Kagan, 1998). Brown (Kagan, 1998) had earned his doctoral degree from the University of Michigan in 1952 initially began teaching at Harvard before joining the faculty of MIT.. At both colleges, he taught undergraduate courses on social psychology and language. During the brief period at MIT, he published a book entitled *Words and Things,* a synthesis of relations between language and the mind (Kagan, 1998). In 1962, Brown returned to Harvard's faculty as a professor of social psychology. He also received a grant to conduct a study of the language acquisition of three children he called Adam, Eve, and Sarah (Kagan, 1998). The result. of this landmark study was the book,, *A First Language: The Early Stages,* published in 1973.

This study was the first attempt to make Chomsky's epistemic theory an empirical hypothesis. Brown made this possible by separating psychology from grammar. He and his graduate students diligently studied language samples provided by the three children from ages18 to 27 months up to five years afterwards (Brown, 1973, p.53). The analysis of these language samples not only gave empirical evidence for Chomsky's work but also provided the basis for the field of developmental psycho linguistics. The driving question behind this research was "how does one know what a child knows about language?"

Perhaps the most logical place to start is in the actual analysis of the language samples. Because children acquire language at different rates, Adam, Eve and Sarah were selected to participate in the study based on the average length of their utterances and not chronological age (Brown, 1973, p. 53). This average length of utterance or mean length of utterance (MLU) was not only used to establish a basis for this study, but it also functioned as a progress measure. Brown justified this by stating "The mean length utterance (MLU) is an excellent sample index of grammatical development

because almost every new kind of knowledge increases length" (Brown, 1973, p. 53). In other words, as the child achieves a greater understanding of grammar, their utterances will become more grammatically complex and ultimately longer..

To calculate MLU, Brown and his students established a set of rules based on the number of morphemes a child used in one utterance. A morpheme is defined by Hoff-Ginsberg as "the smallest element in a language that carries meaning" (1997, p. 438). In addition to words such as cat and baby, Brown defined 14 additional grammatical morphemes that are acquired later in child language development.. To get the actual MLU number, all of the morphemes of a language sample taken in one session with the child were added together and divided by the total number of utterances for the sample (Brown, 1973, p. 54). To measure progress over time, the MLUs of several language samples were plotted against chronological age for each child at the age of the sample (Brown, 1973, p. 55). The results were astounding. It was now possible to graph the rate at which children learned English grammar.. The MLU soon became a standard assessment tool for linguists and speech pathologists alike and remains so in the fields today.

The 14 grammatical morphemes that Brown identified in the course of the study are as follows:

1. present progressive (+ *ing)*

2-3. *in, on*

4. plural irregular (for example, *men,* regular **+** *s)*

5. past irregular (for example *came, went)*

6. possessive (+ *'s)*

7. uncontractible copula *(am, is, are, was, were)*

8. articles *(a, the)*

9. past regular (+ *d)*

10. third person regular (+ s; for example *she talks)*

11. third person irregular (for example, *does, has)*

12. uncontractible auxiliary *(am, is, are, has, have)*

13. contractible copula *('m, 's, 're)*

14. contractible auxiliary *('m, 's, 're,* when combined with *+ ing; 've, 's* when combined with a past participle such as, *has been)* (Hoff-Ginsberg,   1997, p. 144).

Each of these fourteen morphemes are attached to a stem, and add not only more meaning to the child's utterance, but more complexity as well. Brown considered each of these morphemes acquired on the first of three consecutive language samples when the child supplied them in 90% of the contexts in which they were required for grammatical correctness, or obligatory (1973, p. 255). As the child developed a greater understanding of grammar, they used the morphemes as they were needed to follow the rules of the language. It should be noted that these morphemes were not acquired spontaneously nor simultaneously, but rather over a period of time. Brown (1973) states "a considerable period of time elapses between the first appearances of a morpheme and the point where it is almost always supplied where required" (p. 257).

By using the acquisition of the grammatical morphemes to measure the acquisition of grammatical knowledge, Brown made the data he collected objective.

Other measures he could have considered were locative questions such as those using the morpheme, *where.* He then would have had to look at "1. The frequency with which the child uses the construction compared with parental frequency ... 2. The representativeness of the child's usage degree to which he exploits all the possibilities of the ... construction; 3. The grammatical and semantic appropriateness of the child's answers to the *where* questions of others" (Brown, 1973, p. 255). This would have been virtually impossible to accomplish objectively for several reasons. First, there are no utterances from parents that test a child's comprehension of these questions. The parent does not have any way to know that the child completely understood the question posed. They can only assume that the question was or was not comprehended through the child's response. This response could be correct, however, the child may not have understood the all of the implications of that particular question, instead responding only to what they understood. In addition to this, the usage of the *where* construction for the second and third criteria would depend on the topic of conversation, making the measure more of what the child wants to say, not necessarily what he or she is capable of saying (Brown, 1973, p. 255). By using the fourteen grammatical morphemes, Brown was able to measure progress more objectively. It was a matter of the child either adhering to the structure of the language or not. More subjective criteria, such as topic of conversation, did not become an issue in this context.

As Brown was compiling the data from the acquisition of the fourteen morphemes for the three children, he made an astonishing discovery. All of the children had acquired the fourteen morphemes in a consistent order (Brown, 1973, p. 272). This was incredible, considering that Adam, Eve, and Sarah had never met each other, and the

language samples were taken at each child's home, not in a clinical environment (Brown, 1973, p. 272). While Brown was compiling the data for *A First Language,* Jill and Peter de Villiers, two of Brown's graduate students, conducted their own study of the acquisition of the fourteen morphemes (Brown, 1973, p. 273). Their data was based on speech samples provided by children between the ages of 16 to 40 months. They used the same scoring measures and coding rules as the original study (Brown, 1973, p. 273). Their results had a high correlation with Brown's, making it "clear that we have a developmental phenomenon of substantial generality" (Brown, 1973, p. 274). Several other studies have been completed since the time of Brown's original study, and they have all revealed similar results.

The second observation that Brown (1973) made while compiling the data from the fourteen morphemes was the rate at which each of the children acquired each of the morphemes was incredibly varied (p. 273). Again, the de Villiers' data was consistent with the original study (Brown, 1973, p. 274). This data proved that the acquisition of grammar is an individual process, and that chronological age, when considered alone, has little to do with predicting the language rules that the child can and will use.

The final observation that Brown made from the data collected from the fourteen morphemes was that the MLU of each of the children at the time of acquisition for each of the morphemes was not as varied as one might expect (Brown, 1973, p. 271). This proved that "MLU is a fairly good index of the level of development of grammatical morphemes" (Brown, 1973, p. 273). It was further observed that chronological age in conjunction with MLU scores, can be a very good predictor of grammatical development (Brown, 1973, p. 273). Brown (1973) further explains this by stating, "if two children at

the same stage or MLU value are also at the same age they are more alike in their control of our grammatical morphemes than if they are at the same stage and the ages are quite far apart" (p. 273). Once again, the de Villiers' data showed a high correlation with the original study (Brown, 1973, p. 274).

It was from this last observation that Brown was able to identify five major stages in child language development. . The stages were further divided into sub-stages and are as follows:

Stage	MLU	Age Range
Early I	1.01-1.49	16-26 months
Late I	1.50-1.99	18-31 months
II	2.00-2.49	21-35 months
III	2.50-2.99	24-41 months
Early IV	3.00-3.49	28-45 months
Late IV/Early V	3.50-3.99	31-50 months
Late V	4.00-4.49	37-52 months
Post V	4.50+	41-

(Hoff-Ginsberg, 1997, p. 151).

These stages represent major growths in syntactic structure and the development of grammar for the child. These growths in structure and development are actually a set of processes a child uses to construct more complex sentences. "They are a set of major

processes, existing in every language I have ever read about" (Brown, 1973, p. 3). In fact, every language has the same set of four basic sentence modalities or constructions. They are (in English): Yes-No Questions, *wh* questions, negatives, and imperatives (Brown, 1973, p. 16). The difference in each of the languages is syntax and semantics, or the structure of a sentence and the meaning that can be interpreted.

Brown's five stages can be perceived as evidence of Chomsky's Universal Grammar. All languages have the same four basic structures. Related languages, or languages that have evolved from the same classical language, have similar semantics (Brown, 1973, p. 11). If one were so inclined, one could even make a sound argument that this is proof that the structures of language have to be innate.

Enlightenment: The Brown Family

As was previously mentioned, Roger Brown did not do this study completely on his own. He had a group of graduate students that helped him gather and compile data. The relationships that Brown had with each of these students went far beyond the role of teacher and student. He served as more than a mentor did: he served as a father with each of his students becoming brothers and sisters. While studying with Brown, each of these students developed their own interests in child language development. . Dan Slobin, a member of the first group of Brown's graduate students writes, "the ways in which research directions of future years kept appearing in the margins of our discussions" (1988, p. 10).

The first researcher to investigate the universality of language after Brown's study was Dan Slobin. Slobin was one of Brown's graduate students who worked with Adam,

Eve and Sarah (Slobin, 1988, p. 9). After Brown's original study, Slobin decided to study the similarities of languages, specifically, Russian, English, Kaluli, Turkish and Hungarian (Slobin, 1988, p. 15). Slobin began to study "matched pairs or sets of languages that vary in the ways in which they express particular semantic or pragmatic notions" (Slobin, 1988, p. 15). He has spent many years trying to use the studies of these matched languages to answer the question written on the side of his notes from 1963, "Can anything important about grammatical development be learned by comparing the acquisition of native tongues?" (Slobin, 1988, p. 14). Slobin's career took him from his Ph.D. in social psychology at Harvard to the University of California at Berkeley (Slobin, 1988, p. 9). At Berkeley, Slobin began to develop a crosslinguistic approach to study three aspects of language acquisition: semantic, pragmatic and cognitive (Slobin, 1988, p. 9, 14). He explains this approach in the following way:

> Our work at Berkeley over the past 15 years or so has been to chart out the course of acquisition of basic notions and their means of expression in a broad spectrum of different types of languages. It is evident that along the way to discovering the full adult system of grammar, the child reveals crosslinguistically standard ways of organizing and simplifying systems of syntax and morphology. Children create grammars in which clearly identifiable surface forms map onto basic semantic categories .... Most recently, we have begun to see ways in which the emergence of grammatical categories arises [sic] from ways in which children view the world and interact with people (Slobin, 1988, p. 15).

This approach is heavily influenced by cognitive, or Piagetian psychology, but incorporates the Universal Grammar theory advocated by Chomsky.

The results of this approach have shown that "across languages, there is a common order of emergence of locative notions, regardless of how they are expressed grammatically" (Slobin, 1988, p. 15). This means in all languages studied, children start using words to express the locations of objects or people, such as prepositions, in a consistent order. This in itself provides evidence that "conceptual development provides the content for linguistic expression, while linguistic discovery procedures are necessary for working out the mapping of content according to conventions of particular languages" (Slobin, 1988, p.1S). In other words, children start using locatives, as they become aware of the various concepts oflocation, such as *in* or *on,* two of Brown's grammatical morphemes. In Piaget's cognitive development stages, the child acquires this knowledge through experience analysis. As more and more experiences are analyzed, concepts begin to emerge. These results show that the child expresses these concepts through the locatives of their own language. The child is not specifically told where the locative notions belong in their own language system; this suggests the child must have an innate, or internal, idea of how the language works.

Michelle Bowerman was the second of Brown's original group of graduate students to pursue a different research direction instigated by Brown's original study of Adam, Eve, and Sarah. She began her work by transcribing the tapes of language samples taken from Sarah (Bowerman, 1988, p. 24). Through this experience she became interested in how children induce the underlying structural regularities of their language (Bowerman, 1988, p. 24). She specifically was interested in determining the

grammatical rules that children formed at successive stages of language development (Bowerman, 1988, p. 24). At the time of her research, linguists and psychologists alike were trying to write a grammar, or set of rules, children used while acquiring language. By the mid-1970's these endeavors were proving to be unfruitful (Bowerman, , 1988, p. 26). Many of the problems in formulating a grammar for children stemmed from the concept of psychological reality. The problem of psychological reality is defined as "determining whether hypothesized linguistic concepts correspond to the structures and operations that function in the minds of individual speakers" (Bowerman, 1998, p. 27). The question that Bowerman was trying to answer is "how does one know what kind of linguistic structures the child is working with?"'

To answer this question, Bowerman began by working with the concept of categorization. Categorization is "the process by which we reduce infinitely varied experiences to manageable proportions by regarding different things as equivalent" (Bowerman, 1988, p. 28). She states "children are never exposed directly to the categories of language. They must infer these from instances of the categories encountered one-at-a-time in individual sentences distributed across time" (Bowerman, 1988, p. 29). She further explains "the psycholinguist attempts to classify the utterances [of children] according to the categories that are functional in the child's linguistic rule system" (Bowerman, 1988, p. 28). To clarify, a child's rule system can be identified by their use of grammar and grammatical complexity. Each of Brown's fourteen morphemes signals grammatical complexity. In order for the child to correctly use these morphemes, they must know which category of words these morphemes can be correctly applied to.

To test this theory, Bowerman looked at the errors children make when using these morphemes. She justified this approach by stating "As long as children speak in the way adults around them speak, we cannot be certain whether they are *constructing* their utterances or simply repeating what they have heard" (Bowerman, 1988, p. 37, 39). If a child is repeating, or parroting, adult speech, they will not make errors with Brown's grammatical morphemes because adults already abide by those rules of grammar. However, if a child is constructing their own utterances, they will make mistakes as they are beginning to understand the rules of language. "Errors provide the evidence that children can and do work out categories of meaning to fit the syntactic and morphological patterns they have discovered in their language" (Bowerman, 1988, p. 44).

The results of this approach have shown that there are many patterns to the errors that children make when learning grammar. The most obvious patterns of errors occurred when the child used the past tense. Irregular verb forms, which do not necessarily require a *+ d* ending, are typically used correctly before the child starts making errors such as *catched.*. Once the child starts using the regular past tense verb form, (the +d ending), they extend the treatment to all verbs, even verbs that are irregular, and had been used correctly in the past. It is when the child stops making these errors with irregular verbs that we can be sure that they have fully acquired the rules for past tense endings (Bowerman, 1988, p. 39). Furthermore, children do not apply the past tense endings to words that were not verbs. This suggests that children do not learn the categories of language as a consequence of learning the general grammatical rules associated with a class of words (Bowerman, 1988, p. 44). These results provided further evidence that Chomsky's Universal Grammar is at work in children learning language.

The final researcher that came out of Brown's first group of students was Richard Cromer. Cromer came to Harvard in 1962 with an undergraduate degree in cultural anthropology, as a result he was more inclined to favor a Whorfian view of language development (Cromer, 1988, p. 223). Whorfian hypothesis is hypothesis of the influence of language and cognition developed by Benjamin Lee Whorf and Edward Sapir. The theory "states the way our language 'carves up' the world influences how we think about the world ... there are some suggestions that characteristics of the language children are acquiring exert an influence on their cognitive development" (Hoff-Ginsberg, 1997, p. 119). The question Cromer wanted to answer was "Does the language we speak affect the way we think?" (Cromer, 1998, p. 223).

At the end of the Brown's study, Cromer concluded that the Whorfian hypothesis was not adequate in explaining developing cognitive abilities (Cromer, 1988, p. 224). It was from this conclusion that Cromer began to lean toward a more Piagetian model of language acquisition and development (Cromer, 1988, p. 224). Cromer consolidated Piagetian theory with evidence from Dan Slobin's crosslinguistic studies to create his own cognition hypothesis which stated, " 'We are able to use the linguistic structures that we do largely because through our cognitive abilities we are enabled to do so, not because language itself exists for all merely to imitate'" ' (Cromer, 1988, p.22S).

This theory was in effect, the exact opposite of the Whorfian hypothesis. Cromer shifted his belief and now hypothesized that language did not impact cognition as much as cognition impacted language. In other words, language does not dictate how we think, but rather how we think impacts our use of language.

To test his new hypothesis, Cromer returned to the original Brown data. He found data on temporal, or time, reference during the acquisition of language in the language samples from Adam and Sarah (Cromer, 1988, p. 225). He traced the development of these time concepts through the use of several of the grammatical morphemes. He studied hypotheticals, which he defined as possibilities, both past and future, and verb modifications, specifically past tense markers, both regular and irregular, and present time markers, such as the progressive *+ing* ending (Cromer, 1988, p. 228). In his review of the data, Cromer, (1988) found evidence that children understood the concepts of hypotheticals, past tense and present tense before they had started using the actual grammatical morphemes each of these concepts entailed (p. 228).

Other studies done in the early 1980' s focused on the cognition hypothesis as well. In 1984, Smolak and Levine studied the relationship between object-permanence and relational language. Their hypothesis was that a child who had reached the later stages of object permanence would be able to use relational words, or the past tense to refer to an object that was removed. Their results concluded, "the child must attain a particular stage of object concept development before a general language ability - the use of relational language-can occur." (Cromer, 1988, p. 251). McCune-Nicolich and Tomasello and Farrar had similar results in similar studies (Cromer, 1988, p. 231).

As the results for these studies were being published, many researchers began to notice the various shortcomings to the cognition hypothesis. Cromer himself (1988) identified three: nonlinguistic cognitive processes can not explain language acquisition, the effects of language on cognition, and nonlinguistic cognitive processes may not be necessary for language acquisition (p. 234,237,241). Through studies of other species

of animals that do not have a human grammar structure, it was shown that grammar is not needed to understand and express a concept.. For Washoe, a chimpanzee who was taught sign language, grammatical concepts such as word order were not present, however the animal was able to communicate concepts, such as hunger, to her teachers, the Gardeners (Cromer, 1988, p. 234). Another shortcoming of cognition hypothesis was the concept that language may effect cognition. In several studies looking at the relation between language and concepts, it was suggested that conceptual ability and language to express the concepts develop at the same time (Cromer, 1988, p.237). The final shortcoming Cromer (1988) listed was evidence that non-linguistic cognitive processes may not be necessary for language acquisition (p. 241). This shortcoming is addressed when one takes into account the fact that IQ and language development are relatively independent (Cromer, 1988, p. 251). Children with lower IQ scores due to impaired or limited cognitive development are still able to acquire a grammar (Cromer, 1988, p.243).

While Cromer's cognition hypothesis did have some shortcomings, it represented a shift in the field of developmental psycho linguistics. In the 1970' s, cognitive development research came into the foreground while specific research on children's grammar faded into the background. Piagetian theories of cognitive development were becoming more central to the field while Chomsky's theories of the structure of language were slowly becoming secondary to the cognitive development of language.

Challenge and Renewal: The Work of Steven Pinker

Brown had several other graduate students after this first group. He continued to develop the individual interests of each of his students who in turn helped to expand the

field. Each year, a new generation was added to the Brown family tree. The final generation of Brown's students produced Steven Pinker, who burst into the field in the late 1970's and continues to be the driving force in developmental psycholinguistics today.

Steven Pinker arrived at Harvard in 1976 with no intentions of going into developmental psycholinguistics, but rather cognitive psychology (Pinker, 1988, p. 98). In a "publish or perish" atmosphere for graduate students, he turned to Jill de Villiers, a teacher and advisor in the psychology department and a member of Brown's second generation of graduate students. He wanted to publish a paper reviewing formal models of language acquisition, a collection of works which he referred to as "learnability theories" (Pinker, 1988, p. 99). Consequently, he developed an interest for the field, and soon became one of Brown's final graduate students.

Pinker deplored the shift from traditional Chomskian grammar theories to Piagetian cognitive development. He stated "my chief grievances with the field were that it had abandoned the issues and methods that Brown himself had initiated 15 years earlier" (Pinker, 1988, p. 101). He was inspired by the later theories of Chomsky, and in 1982, he wrote a chapter on his own theory of language acquisition (Pinker, 1988, p. 103).

As can be expected for a scholar that held Chomsky in such high regard, Pinker found numerous problems with the Piagetian and Skinnerian models of language acquisition. The first problem with the "nurture" theories was that they completely rejected the idea that there were innate language learning mechanisms (Pinker, 1988, p. 99). Pinker, like Chomsky before him, pointed out that no one actually *teaches* a child

language, a child hears the language around him or her and subsequently acquires the language. The second problem that Pinker (1988) outlined was that psycholinguists of the 1970's and the1980's were concentrating on the types of input that children learning language are exposed to (p. 100). Psycholinguists at that time were concentrating on the ways that children were being spoken to. "Motherese" (the way that a mother simplifies her language when speaking to her child) was the focus of many studies at the time; no one was concentrating on the child. The third flaw Pinker (1988) found with nurture theories was that these theories did not account for the child's ability to hear a sentence and then map out the components and construct a sentence of his or her own (p. 100). The final flaw that Pinker (1988) identified was no one was paying attention to the *process* by which the child forms new rules for language, instead they preferred to study speech samples and dialogues (p. 100).

In his theory of language learnability, Pinker went back to the data from Roger Brown's original study. In this data he was able to unearth three overlooked results that supported the contention that there had to be a formal model of language acquisition. They are: negative evidence of a behavioralist approach to learning language, the semantics of early speech, word order, and the acquisition of closed-class morphemes (Pinker, 1988, p. 104, 107, 111, 114).

The first finding that Pinker discovered in the data was that the behavioralist notion that a child learns language through the positive and negative reinforcement of correct and incorrect grammar was wrong. Using data from a side study conducted by Brown during the original study, Pinker (1988), was able to see two results from this study that disproved this model of language acquisition (p. 105). First, the number of

negative responses given by parents to children was related more to the truth value of the child's utterance than it was to the grammatical correctness of the child's utterance (Pinker, 1988, p. 105). The second result was that parents' number of replies to a child's questions and negations was again, not reinforced for grammatical correctness (pinker, 1988, p. 105). The child was not being reinforced at all for using correct grammar; ungrammatical utterances were positively reinforced as long as they held a truth-value.

The second discovery Pinker (1988) made in reviewing Brown's data was that in child's speech only a small amount of semantic relations were present, not the complex adult grammar (p. 107). The word combinations of the child were simplified into the following categories: "agent-action," "action-object," entity-location," and "possessor-possessed" (Pinker, 1988, p. 107). The child did not select words based on their classification in the English grammar, such nouns or verbs. Rather, they found semantics in the input that they receive from the speech around them, however they have to be able to identify something about the word that tells them where and when to use it semantically. This phenomenon is called bootstrapping (Pinker, 1988, 110).

Pinker's (1988) third finding was that the children in Brown's study had almost always obeyed the word order for adult grammar (p. 110). The child always knew what order the words in his or her utterance needed to be in. This provided further evidence that the child had to have some kind of premise on how to organize words in their grammar.

Like Chomsky's Universal Grammar, Pinker's learnability theory upset the entire developmental psycholinguistic community. The previous generations of Brown's graduate students could not believe the implications of Pinker' s theory. They had devoted

their careers to pursuing research directions originating in the Brown study. Pinker had just used that same study to show them many of the answers they were searching for. It literally tore Brown's family apart. Brown's students were not the only researchers upset by Pinker's learnability theory. Two behavioralists, David Rumelhart and James McClelland, challenged Pinker's learnability theory. Their contention was that children did not need implicit rules for learning language, rather they could use what is known as Parallel Distributed Processing.

Parallel Distributed Processing (PDP) is a computational theory of language acquisition (Rumelhart and McClelland, 1987, p. 195). Rumelhart and McClelland (1987) suggested that "implicit knowledge of language is stored in connections among simple processing networks organized in units" (p.195). They went on to explain while these networks abide by certain rules, language use and acquisition were parts of these units and therefore did not adhere to any rules in and of themselves (Rumelhart and McClelland, 1987, p. 196). This theory grew out of an earlier theory called the interactive activation model of word perception.

The interactive activation model of word perception was a proposed mechanism for capturing perceptual facilitation of letters in familiar words (Rumelhart and McClelland, 1987, p. 196). The mechanism consisted of three sets of units, word units, letter units, and feature units (Rumelhart and McClelland, 1987, p. 196). In order to perceive units, the feature units of the letters had to be activated. Feature units were sensitive to the characteristics of sounds, such as frequency and voicing (Rumelhart and McClelland, 1987, p. 196). Once the feature units were activated, they activated the letter unit of the letter with the appropriate features. The letter units then activated the

word unit for the word with the appropriate letters (Rumelhart and McClelland, 1987, p. 196). The result was that a child heard the word and then perceived the word based on the features of the different sounds that combined to make the word.

Many researchers saw inherent problems with this kind of system. The two major arguments against PDP were 1. PDP models don't have the computational power needed to carry out operations that are handled by rules, and 2. The details of language behavior and acquisition process provide evidence that you learn language through acquiring a set of language rules rather than by a PDP model (Rumelhart and McClelland, 1987, p. 197). Rumelhart and McClelland set out to disprove the second argument through a PDP study of the over-regularization of irregular words in the past tense (Rumelhart and McClelland, 1987, p. 197). Bowerman had previously looked at the same phenomenon through a different scope, and concluded that children make errors of this type as they are learning the rules of the language. Rumelhart and McClelland were now hypothesizing that a child did not need rules to learn the regular and irregular past tense of verbs, rather they could compute the correct past tense using a PDP model (Rumelhart and McClelland, 1987, p. 195). This theory came to be known as connectionism.

To do this study, Rumelhart and McClelland (1987) set up a computer with a PDP model. The structure of the model contained a fixed encoding network, a pattern associator, and a decoding network (p. 200). The fixed encoding network generated the feature representations from input strings of phonemes, while the pattern associator learned the relationships between the base form of the verb and the past-tense form of the verb (Rumelhart and McClelland, 1987, p. 200). The decoding network then converted the featural representation of past tense forms into a word (Rumelhart and McClelland,

1987, p. 200). In this structure all learning was done in the pattern associator, which was comprised of two units: the input pool and the output pool (Rumelhart and McClelland, 1987, p. 201). The input pool represented the input pattern corresponding to the root form of the verb to be learned (Rumelhart and McClelland, 1987, p. 200). This concept goes back to the original notion that excited or activated feature units in turn activated letter units, which in turn activated word units. The output pool generates an output pattern, or the computer's guess at the correct past tense of the verb supplied (Rumelhart or McClelland, 1987, p. 201). The pattern associator also contained a "modifiable connection linking each input unit to each output unit. Initially these units are all set to 0 so that there is not influence of input units on output units" (Rumelhart and McClelland, 1987, p. 201).

As one can expect, the way this system works is rather complex. The computer is presented with a phoneme string corresponding to the root of a word, specifically in this case, a verb. This verb is then encoded as a pattern of activation of the input units (Rumelhart and McClelland, 1987, p. 201). The computer sets the unit values that are needed for this string to 1; the model then computes the net input from all inputs set to 1 (Rumelhart and McClelland, 1987, p. 202). The result of this is that some outputs will get a unit value of one, and therefore be hits, and others will remain at a unit value of 0 (Rumelhart and McClelland, 1987, p. 203). For example, when a child starts using the past tense, they are aware of a few verbs that are irregular. As the child learns more past tense verbs the proportion of regular verbs to irregular verbs goes up. More verbs follow the same pattern and the child over-generalizes the irregular forms they already know.

Rumelhart and McClelland conducted this study by "teaching" the computer over 400 verbs. By using the PDP model, the computer was able to generate many of the past tense verbs and verb errors that children sometimes make (Rumelhart and McClelland, 1987, p. 245). The conclusion that the researchers made was that language rules did not have to be innate. Through a PDP model, a computer was able to acquire past tense verbs through a complex process of computing statistics and patterns that did not need rules (Rumelhart and McClelland, 1987, p. 245).

Pinker responded to this challenge in his book, *Words and Rules*. In it, Pinker devoted a chapter to the Parallel Distributed Processing model. He began this chapter by pointing out that even irregular verbs have some forms of rules or patterns. He used the following list to demonstrate the patterns he saw in irregular past tense verbs: *blow-blew, grow-grew, bind-bound, find-found, drink-drank, sink-sank, and bear-bore, swear-swore* (Pinker, 2000, p. 83). Pinker (2000) noted that each of these combinations shared much of the same stem, as do most regular verbs, the exceptions being the combinations *go-went* and *be-was* (p. 90). He also noted that there were patterns in the vowel changes for each of the combinations listed, again, as is the case with many irregular verbs (Pinker, 2000, p. 91). He called the first pattern stem-stem similarity and the second pattern change-change similarity (Pinker, 2000, p. 91).

Pinker points out that these patterns are all that remains of old language rules. In 1948, Chomsky published a theory proposing words have a form in memory that is not necessarily identical to the pronunciation of the word but is related to the features of the word, called the universal rule of language (Pinker, 2000, p. 97). Chomsky contended that mental representations of words do not change over time, the only changes are

phonological rules, or pronunciations (Pinker, 2000, p. 97). The difference between Chomsky's universal rule of language and Rumelhart-McClelland's parallel distributed processing model is the kinds of mental operations needed to create the past tense of irregular verbs.

While Chomsky's universal rule theory was not free from problems, such as the possibility of merely memorizing irregular past tense verbs, Pinker pointed out four major problems with the Rumelhart-McClelland model.. For instance, Pinker pointed out that the computer, unlike a child, only produced past tense verbs, it did not, however, recognize past tense verbs when they were presented (Pinker, 2000, p. 110). Children not only produce and recognize past tense verbs, they also know when and where to use them when constructing a sentence, another problem Pinker (2000) identified in the **PDP** model (p. 111). A third discrepancy that Pinker identified was that the computer relied on the sound features of a word to identify the correct verb, and subsequently the correct past tense verb. Therefore, if two words had the same set of sound features, the computer would not be able to tell them apart (pinker, 2000, p. 110). Again, a child acquiring language is able to accomplish this task.. The final problem Pinker identified with this study was the fact that Rumelhart and McClelland had to constantly modify their program to get the computer to simulate a child's stages of language development (Pinker, 2000, p. 111).

However, this is not to say that Pinker did not find any merit to some of the concepts that Rumelhart and McClelland proposed. Pinker combined the concept of the pattern associator with his Words-and-Rules theory to create a new theory he called, the Modified Words and Rules theory (Pinker, 2000, p. 119). The original Words-and-Rules

theory states, "there are two tricks, words and rules. They work by different principles, are learned and used in different ways, and may even reside in different parts of the brain" (Pinker, 2000, p. 2). The modified version states,

> Regular verbs are computed by a rule that combines a symbol for a word stem with a symbol for the suffix. Irregular verbs are pairs of pairs of words retrieved from ... a part of memory .... Memory is not a list of unrelated slots ... but is associative ... like the Rumelhart-McClelland pattern associator memory (Pinker, 2000, p. 117).

Pinker goes on to state, "If the modified words-and-rules theory is correct, it would have a pleasing implication for the centuries old debate between associationism and rationalism: Both theories are right, but they are right about different parts of the mind" (Pinker, 2000, p. 119).

Into the Future

The history of the field of language development over the last thirty years has almost come full circle. The field started in 1965, when Noam Chomsky published *Aspects of the Theory of Syntax,* a rationalist approach to human language with implications that stunned the Piagetian and Skinnerian schools of thought.. The move from Chomskian theory to empirical science was realized in the career of Roger Brown. In 1973, he published *A First Language: The Early Stages,* which stands as the cornerstone for the field of developmental psycho linguistics. Until *A First Language,* the field of developmental psycholinguistics could not truly be called a science. Brown's legacy also included a brilliant and creative group of graduate students. They took the

field of developmental psycho linguistics in new research directions, such as the cross-linguistic comparisons of thought, questions of thought and language and the cognition hypothesis. By the late 1980's, the stage was set for a reevaluation of the field. There was a resurgence of Skinnerian, or Neo-Skinnerian approaches to language development. As a reaction to this, Steven Pinker, one of Brown's last students, brought the field back to Brown's original methods of studying child language development, and is now returning to Chomsky's original notion that every child is born with a method for understanding language. In a field that has grown so rapidly in such a short span of time, one can only imagine where it will go from here.

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