CHAPTER FOUR

CURRENT LANGUAGE THEORIES

The contemporary connectionist position regarding language has resulted in a kind of reconciliation between the behavioral interpretation of the nature and acquisition of language and the initial cognitive position that thought, or the capacity for thought, precedes the acquisition of a natural language. Behavior analysts believe that language is behaviorally reviewable, but thought is not unless it is considered nothing more than sub-vocal language. Such a position is, of course, required by the behavior analytic epistemology, with the exception that visual images can also be considered non language-linked thought. However, the communicative part of thought in which most of us are primarily interested is reducible to natural language so far as the behavior analytic position is concerned. Cognitivists, however, do not necessarily equate natural language with thought since children display concept learning and perceptual integration before they acquire language. Behavior analysts, as we have seen, make the distinction that pre-linguistic children and animals "know how," but only creatures with language "know that." Nevertheless, many cognitivists separate the processes of thought from those processes involved in the use of a natural language. Fodor (1975, pp. 63–64) holds that

> Learning a language involves learning what the predicates of a language mean. Learning what the predicates of a language mean involves learning determination of the extension of these predicates. Learning a determination of the extension of the predicates involves learning that they fall under some truth rules. But one cannot learn that P falls under R unless one has a language in which P and R can be represented.

Fodor concludes that there must be language elements already present in order for a child to learn a natural language. This implies that the organism comes equipped, presumably by the evolutionary development of the species, with certain basic language abilities. Having accepted one or more of a few variations of this argument, cognitively oriented researchers turned to internal processes to account for much, but not all, of the nature of language. Golinkoff and Hirsh–Pasek (1990) have summarized a number of different types of theories concerned with the acquisition and use of language. Before these systems are discussed it is necessary to define a number of terms crucial to their understanding.

Innate Restraints on Language

The following terms are used by language theorists (e.g., Keil, 1990) when discussing the genetically determined constraints on the acquisition and representation of language:

1. *Innate*. A constraint on language determined in some unspecified way by the genetic code of the organism.

2. *Domain specific*. A constraint which applies to a specific knowledge system and not to other knowledge systems all of which are, nevertheless, considered to be part of language. For example, those processes involved in the acquisition and use of numbers may not be applicable to those involved in the acquisition and use of words.

3. *Domain-specific innate constraints*. Concept development consists of concept confirmation (Fodor, 1981), not concept learning, since concepts are available to the organism before a natural language is learned. There are non-language situations in which domain-specific constraints are clearly operative such as in the development of binocular vision which requires the innate arrangement of two eyes placed on the same plane of the body and the ability to focus on a single object. Domain-specific innate constraints are generally operative in all of the perceptual organs, for example, the eyes are sensitive to light waves, not to sound waves.

4. *Domain-general innate constraints*. Genetically given general characteristics of the nervous system which influence all knowledge acquisition.

Acquired Restraints on Language

In addition to innate constraints on language, some theorists recognize limitations on language acquisition which are imposed on the organism by characteristics of the learning process itself.

> 5. *Domain-specific acquired constraints*. Aside from accepting the proposition that all organisms possess innate constraints, this position assumes, for example, that a child is free of any domain-specific innate constraints. It is the consequences of verbal responses on other people which will produce specific constraints on language.
>
> 6. *Domain-general acquired constraints*. Cognitive structures emerge as a result of environmental triggering mechanisms which follow a developmental pattern keyed to the age of the organism. Piaget's concept of the development of problem-solving transformations is an example.

Language Acquisition Theories

Hirsh–Pasek and Michnick–Golinkoff (1996) list four types of theories which purport to explain language development. The social-interaction theories (1) emphasize the functional use of language. Children construct language through interaction with people around them. The implication is that not only are the meanings of individual words learned from this contact, but so are the rules of grammar and the size of various linguistic units. For example, "Come here" is probably learned initially as a single unit and only later does the child perceive the expression to be composed of the verb "come," the adverb, "here," and the implied subject noun "you." Domain-general abilities are consistent with this position. Cognitive theories (2) accept the influence of social interaction in the formation of language, but add the important caveat that there are cognitive categories consisting of agents, patients, actions, locations, etc. that aid in the child's interpretation of her environment. These categories are semantic rather than syntactical and constitute domain-general innate characteristics of language. The criticisms of these related positions are, in part, the same as those directed toward Skinner's theory of verbal behavior. Indeed, Skinner can be classified under the social-interactionist rubric. The first criticism of the environment-based theories (Hirsh–Pasek and Michnick–Golinkoff, 1996) is that they often make unacknowledged assumptions concerning the genetically determined characteristics of the organism. For example, it is assumed that number is available to the child and is expressed by the use of the singular, the dual, and the plural within language. Also, past, present, and future and relational categories such as cause and effect, as well as several other linguistic categories, are assumed to be available. There is no question that all theories of language, including those that are environment-based, make these or similar assumptions regarding the sub-doxastic, innate capabilities of the organism.[2] These either acknowledged or tacit assumptions (as with Skinner's theory of verbal behavior) are crucial since any organism which is capable of language has an evolutionary history and is the product of a genetic code. Kant's development of the categories of pure reason is, of course, one of the early modern attempts to describe the most basic kinds of reasoning, all of which are related to linguistic forms and which refer to an organism's dispositions in constant interaction with environmental conditions. In any case, even should these assumptions concerning the innate nature of a linguistic organism remain unacknowledged, there need be no effect on the legitimacy of the description of the acquisition and use of language.

The presumed second problem is that environment-based theories hold linguistic knowledge to be reducible to knowledge in other domains such as social or cognitive categories. This difficulty arises because environment-based theories do not take account that children quickly move beyond cognitive and social categories when they master the complexity of a language. This, as we have seen, is the core argument against the environment-based position. There seems to be evidence that linguistic categories are not gleaned directly from social context. Generally, the arguments against the environment-based positions stem from the observation that environmental conditions are not sufficiently complex and varied to account for the rapid language development observed in children, who are able to transcend the limited language instruction they receive and develop extraordinary subtlety in the use of linguistic utterances. Genetic-based theories (3) emphasize the innate nature of linguistic categories. Chomsky's theory of language remains the prototype for this way of thinking. The assumption is that there is domain-specific knowledge of linguistic grammar which unfolds in the developing child. A child cannot learn something which is not present in the surface structure of a sentence; hence deep structure is innately represented in human beings. There are structure- and process-oriented theories within the innate-based conceptions. Chomsky is a structure- and innate-oriented theorist. In process-oriented theories the focus is upon the means by which children discover their grammar.

---

[2]Doxic refers to fundamental beliefs and opinions which precede learning. Hence sub-doxastic refers to unacknowledged, biological proclivities which influence these doxastic beliefs.

Pinker (1994) also holds that language is domain specific and unlearned. He cites the Darwinian notion of language as an evolved ability of one person to communicate with another in increasingly complex ways because increasingly complex information has survival value. What he does not say is that the mechanism of evolution which increases the probability of species survival is the process of reinforcement from the environment which increases the probability that a particular verbal utterance will appear in the future under similar circumstances. The very idea of Darwinian evolution requires the concept of behavior being reinforced by its consequences. This places Pinker's assumptions in unacknowledged and unexpected juxtaposition to Skinner's basic contention. I will return to this notion later in the chapter. Pinker goes on to make the now familiar point that children use language creatively, mentioning that phrases such as "Don't giggle me" and "I holded the rabbit" could not have been taught to the child and yet they are meaningful to a listener. He also makes the valid point that all sentences are unique and therefore could not have been learned directly. From this he concludes there must be a universal grammar. Pinker's process orientation is shown in his description of the evolution of Pidgin into Creole. Pidgin is a language with an arbitrary word order developed by people who need to communicate with one another, but whose natural languages are different. The children of people who speak Pidgin then develop a Creole language, which has a definite grammar. This presumably indicates that the early development of language is both universal and unaffected by specific language learning.

Other theorists (e.g., Gleitman, 1990) emphasize the necessity for postulating inborn linguistic restraints (4) because of the poverty of information generated from various phonemes. Any noun, such as "cat," is quickly understood to refer to the whole animal and not to one of its parts, such as its paws, fur, etc., even though those who provide the word to the child do not indicate this. This process, however, cannot be wholly linguistic: it must have its origin in the domain-specific perceptual process. An object such as a cat, to which is attached a single noun, also provides the stimulus for a visual response which allows for the recognition of the whole animal as the referent of "cat." The animal moves as an entire entity and is visually bounded by an outline and is thus perceived as such. This experience is undoubtedly part of the initial process that determines the child's ability to use nouns holistically. The general criticism of the genetic-based theories is that children do not correctly understand the grammar of their natural language from the beginning of acquisition and use incorrect along with correct grammatical structure over a number of years.

Fodor (1975, 1983) understands that a reduction of explanatory concepts to either environmental or physiological origins is necessary in understanding thought or, for that matter, any human process. That being said, he contends that the process mediated by the environment and the relevant physiological conditions of the organism need to be described and that this is the proper function of the linguist or language psychologist. Choices, intentions, and the language inventiveness of people are set against the causal explanations of the behavior analysts and physiologists. What Fodor does not acknowledge is that analyses can exist side by side with linguistic description without one either logically contradicting the other or replacing it. Fodor also contends that the natural languages cannot be the medium of thought since nonhuman animals think without the benefit of natural language. Animals solve problems and remember without showing any evidence that they possess a natural language. If, he argues, thought has evolved without language it follows that there are central nervous system logical and grammatical functions which are independent of language and which have evolved into natural languages in human beings, but not in other species except in, perhaps, a rudimentary manner. This position is the one taken by virtually all domain-specific cognitive theorists, and is one which the behavior analysts do not oppose or, at least should not oppose, since it is not incompatible with their own system of language explanation. Given this position, Fodor's task is to describe how representations and computations work within natural languages or as innate computational (rules of universal grammar) and representational (phonemes and morphemes) capacities in human beings.

Fodor contends that there are six input systems in human beings consisting of the five external senses and the one for language. He calls these input systems, modules. If we consider the ability of the human eye to perceive color it is clear that there are mechanisms to accomplish this that consist of the functions innately performed by the lens, aqueous humour, retina, fovea, optic nerve and occipital lobe. These structures and their attendant functions are characterized by constraints on the kind of information they are able to process and on the range of appropriate information they are able to access. That is, the visual input system or module is constrained in that it can only process light. It cannot process, for example, sound. It is also constrained in the length of light rays it can process since, for example, ultra-violet and infra-red waves are excluded. Fodor conceives language modules to consist of similar constraints *mutatis mutandis*. This contention requires that a listener process a speech sound or utterance differently than he does non-speech auditory stimulation. This suggests that all known and all possible human languages should have universal linguistic characteristics. Thus we come once again to a search for these universals. Fodor indicates that one such universal is captured by the observation that you cannot hear speech as noise even if you so choose. This is similar to the recent discovery that the perceptual visual mechanisms function in such a way that face perception seems to be separate from other types of recognition, that is, you cannot see a face as other than a face.

These universal characteristics which Fodor assigns to innate, central nervous system activity, provide a good context for examination of the relationship between the grammarians and behavior analysts. Input systems are modular in that they are informationally encapsulated and are unaffected by the feedback of information about the stimulus except in certain situations. One such situation (Fodor, 1983) occurs in speech when a stimulus phoneme is only partially presented (as when the "s" sound is masked by another sound in the word "legislature" and is still heard as "legislature" with a sound in the background). Fodor concludes that this information feedback is processed by the listener's mental lexicon being searched for a best match to what is actually heard. Possibly this search process is the same as, or similar to, what occurs when the "spell check" on a computer program supplies a missing letter based on what is available from the program input. Similar points, without the specificity that Fodor provides, have been made by Gestalt psychologists regarding many kinds of visual phenomena. However, aside from this exception, Fodor's contention is that some input systems do not have access to the higher level systems suggested in the above example. The various visual illusions, such as the Muller–Lyer, phi phenomenon, and various reversible configurations, are obviously independent of the characteristics of the stimulus. Even after one *sees* that the measured Muller–Lyer lines are equal, one line still *looks* longer than the other. These visual examples establish the modularity of certain perceptual phenomena.

The informational encapsulation of input systems operates in the same way as it does in reflexes, but with a computational function as well. Ordinarily, reflexes operate with total informational encapsulation as when my hand pulls back quickly from a hot stove even though I believed it to be cold when I placed my hand on it. Fodor's linking of reflexes with the concept of the module, however, neglects the fact that reflexes can be "overridden" by nonmodular systems as when I deliberately place my hand on a hot stove and tolerate the ensuing pain. Why I might do such a thing might be explained by saying that I am reinforced by a stronger set of contingencies than that involving pain to perform such an act. As we know from human history, the example is not far-fetched. Fodor addresses an analogous dilemma when he discusses why certain words such as "dog" and "cat," "salt" and "pepper" and other such common two-word associations have come to be. He dismisses the associationist interpretation that these words are linked because they have been presented in combination many times in the life history of the individual who makes the association. He accepts the idea that things or processes that are linked in experience enter the lexicon in that way. However, such connections are not knowledge or judgment, both of which require the functioning of innate language processors. Mere associations, therefore, simply do not provide enough information nor do they account for linguistic and thought processes so as to account for the functioning of a thinking human being. Associations do, however, function as quick peripheral processes, as do other encapsulated inputs. Of course, few modern psychologists hold to the older interpretation of the determinative power of mere association and do use the concept much the way Fodor suggests, as an accidental set of relations established by processes other than mere association.

Fodor is most convincing when he speaks of the epistemic relationship between a speaker and the grammar of her language. There are sub-doxastic beliefs which are unconscious and inferentially unintegrated. These sub-doxastic beliefs are separate from inferentially integrated beliefs such as those we fashion as hypotheses about the nature of the world. They are, however, not generally encapsulated as they are in an input system. For example, we accept sub-doxastically the rule of *modus ponens* (that method of reasoning which holds that if the antecedent is affirmed then the consequent is affirmed). Fodor argues that our sub-doxastic beliefs about validity and confirmation are available in virtually all mental processes which we use in a number of different situations, ranging from judgments of scientific validity to deciding where to plant the hydrangeas so that they will receive optimum amounts of sun and rain. One's sub-doxastic beliefs about validity confirmation must then be different from one's sub-doxastic beliefs about the rules of grammar if the rules of grammar are encapsulated modules which are domain specific. Fodor's distinction rests on the ubiquity of application of a sub-doxastic belief such as the rule of *modus ponens* and the fact that the rules of grammar are constrained and applicable only to the language modality. This distinction provides a retort to my observation raised above that Fodor's sense of grammar is the same as Kant's sense of the categories of mind. By separating sub-doxastic beliefs in validity and confirmation from those of language on the argument that the latter are encapsulated, Fodor can legitimately maintain the distinction between grammar and Kantian categories of mind since the latter are not encapsulated nor are they domain specific, and grammar, according to Fodor, is both.

Since input systems are modular and domain specific they must share some kind of fixed neural architecture as do other more obvious domain-specific systems such as vision. In contrast to this point, Fodor indicates that there is "no known brain center for *modus ponens*" (1983, p. 98). This follows from the argument that processes of confirmation and validity are domain general; consequently they cannot have a fixed neural structure, but are rather general brain functions characteristic of an equipotential architecture. Fodor cites evidence that input systems can exhibit specific and characteristic breakdowns such as is seen in instances of agnosia and aphasia. In contrast, damage to the cerebral cortex can result in only temporary loss of certain reasoning abilities which can be restored over time as a result of the cortex's ability to function "equipotentially." Fodor summarizes his position with regard to input systems by saying that they constitute a family of modules, "domain-specific computational systems characterized by informational encapsulation, high speed, restricted access, and neural specificity" (p. 101).

However, Fodor believes some cognitive systems are non-modular. The *modus ponens* discussed above as well as *modus tollens* and other sub-doxastic aspects of the process of confirmation and validation are candidates for non-modularity. These mechanisms serve to connect the domain-specific processes and, therefore, cannot themselves be domain specific. This lack of domain-specific encapsulation renders these cognitive systems non-modular. These central processes are marked by the scientific sense of the process of confirmation and validity, which is based upon the tacit belief in the connectedness of phenomena, which then allows the scientist to propose this connectedness in any area with the intent of establishing specifically causal connections among various observed events. It is Fodor's belief that understanding these global cognitive processes is virtually impossible. Because of this difficulty, various theorists have given up belief in the correspondence notion of truth. The conservative position holds that various scientific theories are confirmed and valid if these are consistently predictive. This consistent predictability does not mean that they are necessarily true. The correspondence idea of truth requires that a demonstration of the truth of the principles of confirmation and validity are established independently of the predictions made by a successful theory. These principles, as we have seen, are not demonstrable because they are sub-doxastic and domain general. Among Fodor's conclusions with regard to this point is one that rounds out this discussion: stable neural architecture is associated with perception and language, but not with thought. However, we would not want to conclude that human thought is epistemically open because it is non-modular. We are, after all, the products of a definite evolutionary history with given genetic characteristics which bind our thought in some way although we have not, and probably never will, discover how these boundaries operate.

Non-Modularity in Language

North American psychologists have usually been unwilling to attribute any innate behavioral predispositions to human beings. This position was needed at the turn of the century to counteract the ossified structuralism which had been imported from Germany. However, there is no question that innate, structurally bound predispositions to behave in certain ways exist in human beings. For example, if one wonders why an arm can bend in only one direction and not in the opposite at the elbow, the answer that satisfies practically everyone is that the bone underlying the skin is built so as to mechanically allow movement in only one direction. Upon viewing a skeleton and seeing how the bones in the arm are constructed, most people would be satisfied with this empirical demonstration of the principle. If, further, one wonders why the arm at the elbow sometimes moves in the one direction that it can and at other times it does not move at all, the answer provided by various behavioral psychologies over the years has to do with a condition external to the organism which does not include arm structure. Cognitive psychologists have focused on describing the function that necessarily follows from a given structure.

For cognitivists certain aspects of language are the function of that structure which we call the central nervous system. Unfortunately there is considerably less useful information about the structure of the brain than there is about the structure of the arm. Consequently, we are left less satisfied with our knowledge of the brain structure/language connection than we are with our knowledge of the arm structure/movement connection. Fodor has given a specific interpretation of the nature of the innate aspects of language with his emphasis on modularity. More recently Karmiloff–Smith (1995) suggested a non-modular view of the innate quality of language. She recognizes that Fodor's "module" and "input system" are synonymous. Since linguistic modules are encoded in the genetic material of human beings and are domain specific they are available to the organism within a relatively short period of time after birth much as are similar domain-specific processes such as vision and hearing. Karmiloff–Smith, however, argues for the existence of a developmental process that produces modularization. Infant minds are most likely constrained by innately specified domain-specific predispositions which may or may not be modular, but over time, brain circuits become involved in different domain-specific computations such that environmental input plays a much larger role in brain development and the formation of modules than Fodor accepts. Karmiloff–Smith's analysis of thought and language turns away from the description of innate domain-specific processes and toward those developmental processes which presumably more accurately account for the acquisition of language and thought in human beings.

Karmiloff–Smith (1995, p. 6) offers definitions of key terms which, although used familiarly throughout the cognitive literature, bear repeating here. A *module* is "an information-processing unit (that is, an input system that is self contained in that it is minimally influenced by environmental factors) that encapsulates that knowledge and the computations on it." All domain-specific processes are not necessarily modular. Domain-specific processes may involve significant input from the environment and not be encapsulated or be a function of some neural system. "Domain" designates a functional system which develops independently of other functional systems. Thus domain can refer to functioning in mathematics or language or part of language. A domain must be defined at the time of its use or discussions concerning it will be meaningless. However a domain is defined, evidence should support the notion that there are behavioral and neural substrates consistent with this definition.

Piaget's conception of development is classifiable as a domain-general acquired system. Karmiloff–Smith points out that Piaget believed that a newborn child possessed only sensory reflexes and the domain-general attributes of assimilation, accommodation, and equilibration, and no domain-specific abilities. She then links Piaget with Skinner in that both positions are free of domain-specific knowledge, with Skinner accepting only the domain specificity of sensory systems and the ability to respond to environmental conditions in a manner which produces an increase in probability of response in future situations under similar circumstances. Karmiloff–Smith ignores, or is unaware of, Skinner's somewhat mysterious reference to behavior being subject to Kantian a priori's. As we have seen, Skinner never discussed exactly what he meant by this statement other than that human beings as behaving creatures have inescapable characteristics and limits. Although it is true that both Piaget and Skinner may be classified as theorists with "domain-general" assumptions in regard to verbal and other behavior, it seems that differences between the two systems weigh more heavily than their similarities. At any rate, since Skinner never discussed "Kantian a priori's," whatever he meant by them cannot enter a discussion of what he obviously emphasized in his interpretation of verbal behavior. However, his statement may allow us to place his system more accurately within the firmament of theories of language acquisition.

Karmiloff–Smith's position, if placed on an assumptive continuum, lies somewhere between Fodor's innate emphasis and Skinner's and Piaget's domain generality. Her major point is that there is a great deal more variability in the way that the brain functions than Fodor's innateness hypothesis suggests and more domain specificity than either Skinner's or Piaget's systems express. Her emphasis on the plasticity of the brain as it affects function allows her to conclude that the modularity insisted upon by Fodor is misplaced. In order to settle these issues developmental research has focused more and more on pre-verbal infants than it has in the past with attention to input systems. What infants do best is suck, cry, and look. These are the three responses available to infancy researchers which can be manipulated as criterion variables. There are three manipulations.

1. An infant is exposed to the same stimulus until it shows lack of interest by turning away until some criterion set by the experi-

menter is met. If the infant attends to (looks at consistently) a new stimulus it is concluded that the second stimulus is perceived to be different from the first. The stimulus can be visual, auditory or tactile.

2. Sucking amplitude is measured by a special apparatus. If it decreases, interest in a stimulus is said to also be decreasing. This technique has been used to study linguistic sound preferences in infants.

3. The time an infant spends looking at a stimulus is recorded. Each time the stimulus is presented, the infant looks at it for a shorter period of time. A variation of this technique entails presenting the infant with two visual stimuli simultaneously and recording the length of time the infant spends looking at each. These techniques are variations of that listed under (1) above. Infancy research involving these techniques will be discussed later.

Karmiloff–Smith proposes that the infant brain stores information in a number of ways. There are innate predispositions to behave in certain ways. These predispositions can be either specific or non-specific. Environmental input is necessary for the activation of both types of dispositions. When a specific predisposition is manifested, the environment acts as a trigger for the underlying neural components to select one response over others. When the predisposition is non-specific the innate mechanism and the environment function together in a much more complicated way involving feedback loops that actually alter mind and, presumably, brain structure. Mind (which, I believe, Karmiloff–Smith takes to be the brain functioning) can access its own stored information to develop new representations. She calls this process representational redescription and presents as an example the sequences through which one must pass in learning to play a piece on the piano. At first single notes are played in succession such that, should an error be made, the learner must return to the beginning of the sequence. After some practice, whole segments of notes are played more easily, followed by the playing of the piece from beginning to end without interruption. During these sequences the player cannot start in the middle of the piece nor play variations on it until after the piece is played easily as a whole. Karmiloff–Smith interprets this sequence as involving a process of representational redescription where knowledge of the variational elements of the piece, such as its notes and chords, becomes increasingly available as information which can be manipulated by mind. This process is presumably unconscious, that is, not verbally reviewable.

Karmiloff–Smith contrasts the process of learning to play a piece of music with learning to solve Rubik's cube which she believes entails a "propioceptive solution" which involves bracketing any conscious, rational attempt at solution. Later, when Rubik's cube is solved at this more primitive level, it is possible to verbally describe the procedure as a series of logical steps. She believes her representational redescription model explains both processes.

Representational Rediscription Model

The intent of the representational redescription model is to explain how children's representations of the world become more manipulable and flexible as their experience accumulates and a conscious access to knowledge appears. Karmiloff–Smith hopes to describe how implicit (innate) information in the mind becomes explicit (conscious and verbally reviewable). She stresses *in* the mind and *to* the mind, the implication being that in the latter case the mind has been modified by its innate properties interacting with information from the external environment. This process occurs within, and sometimes across, domains. Representational redescription is posited to be a part "of an internal drive toward the creation of intra-domain and inter-domain relationships" (1995, p. 18), which seems to contain one concept too many. Relegating representational redescription to be part of a drive is theoretically unwise without specifying in some detail why it is a drive and not simply a process which is described by its own empirical and theoretical referents (but more on this aspect of cognitive theorizing later). Karmiloff–Smith considers representational redescription to be domain general in that it operates similarly in all specific domains. It is a phase model rather than an age-related stage model under which, for example, Piaget's theory is typically classified. There are three recurrent phases to representational redescription, the first occurring during early childhood where the child focuses primarily on information from the environment. During the second phase, internal representations are the major focus of change and the influence of the external environment diminishes. During the third and final phase, there is a reconciliation between external and internal control. It is the phase where internal and external linguistic inputs recombine to form correct natural language usage. These developmental phases are cyclical rather than age-related in that they repeat their sequence over time for varying representations.

There are four levels of internal representation that operate within these phases. Within the first implicit level, representations allow for the processing of stimuli from the external environment. This processing is domain specific and restricted to sequentially specified procedural encoding which is independently stored. This first level allows for rapid, but relatively fixed, responses to environmental stimuli. The second explicit level involves representational redescription that loses many of the details of the level one encodings. Karmiloff–Smith gives as an example of this level's function the ability to represent a zebra as a striped animal linguistically and the ability to recognize that the picture of a stylized zebra on a road sign refers to the visual experience of zebra. The redescribed representation of the zebra is simpler than the perception of zebra and is more cognitively general which allows for such labeling as is found in, for example, North American football where referees who wear shirts with broad black and white stripes are sometimes referred to as "zebras." While explicit level-two representations are being made, level-one encodings are still operative. At this second explicit level, representations can be related to other redescribed representations.

The third explicit level involves conscious, but not verbal, processes. This concept is not consistent with the general conception of consciousness as the ability to verbally report which I have used throughout this book. Karmiloff–Smith recognizes that her concept is unusual, but argues in its favor by indicating that we sometimes can spatially represent problems that we are incapable of verbalizing, as when we draw a diagram to communicate a problem we find difficult to talk about. Conceivably a picture of an internal combustion engine with the pistons exposed to illustrate their operation may be an easier means of communication than verbally attempting to describe how the engine works. This third level with its focus on spatial representation is an important part of Karmiloff–Smith's representational redescription theory. The fourth and final level allows for the development of natural language where knowledge is re-represented in linguistic form. It is now possible for the child to cross-code information from different input sources.

Karmiloff–Smith's explanation of the acquisition and use of language follows from her representational redescription conceptualization. Children can analyze their own knowledge, but non-human animals can not. This ability to analyze one's own knowledge includes a creative use of language which, as we have seen, is one of the major starting points of the cognitive, but not of the behavioral, position. An innate ability to organize speech patterns was suggested by Hirsh–Pasek et al.'s (1987) demonstration that seven to ten month old infants attended longer to samples of a mother speaking to her child which were segmented at phrase boundaries than they did to similar stimuli which were segmented randomly. An alternative explanation of this finding is that infants are capable of being rapidly reinforced to attend to their mother's voice, which is used in certain ways (in phrase patterns), and the infants are, therefore, not as attentive when mother's voice is used in a manner (non phrase patterns) that has not been previously reinforced. That is, mothers tend to speak to their children in phrases, not in single, disjointed words. The discovery of the early age in which this sensitivity develops is important, but does not support one interpretation over the other.

Children learn the meaning of words by attending to various speakers, but it is the general cognitive position that this is not sufficient for learning to occur. Children also utilize three assumptions (Karmiloff–Smith, 1995) concerning words and their referents: whole object, taxonomic, and mutual exclusivity. Children assume a new word applies to the whole object, not just one of its parts. They also extend this label to objects that fit the same taxonomy, and they do not apply it to objects for which they already have a label. These abilities are taken to demonstrate innate, domain-specific constraints on the acquisition of language. If a child has not yet learned the category "dog" when one is pointed at and the word spoken, he assumes it applies to the entire animal rather than to its fur, ears etc. When seeing another dog, even of a different breed, the child will classify it under "dog." Children will not use this label to refer to birds or lizards if they already possess these labels. None of these caveats is taught directly by an adult, and hence whole object, taxonomic, and mutual exclusivity responses are considered innate language representational abilities. Whether or not they are unique to language or are part of domain-general abilities, however, is open to question. The issue of whether the processes of confirmation and validity are domain general or specific was discussed earlier in this chapter in conjunction with Fodor's work. Whole–part distinctions, as illustrated by the principles of Boolean algebra such as the concept of the subset, by taxonomic classification, and by the idea of mutual exclusivity in probability theory, although obviously expressed through language, involve logical operations and not strictly linguistic categories. This means that these processes are domain general rather than domain specific and are more consistent with Kant's domain-general categories than they are with Chomsky or Fodor's domain-specific attributes of language.

As the child matures and becomes fluent, image–schematic representations (Mandler, 1983) form and mediate between perception and language. The child passes from one representational format to the other by means of representational redescription. This suggests that children are able to move beyond the linguistic representations of early childhood and to discuss some of the rules that govern their linguistic output. For example, by age ten children are able to correctly give the reasons they use "a" instead of "the" before a noun.

Karmiloff–Smith periodically reiterates her commitment to the idea that language has definite and strong innate components. She points out that children with severe cognitive retardation can sometimes acquire language rather easily while chimpanzees, even though provided with intensive training, can at best learn strings of manually encoded lexical items. However, she also emphasizes the plasticity of the brain which is considerably different from the fixed qualities assigned to it by Chomsky and Fodor.

Connectionism

Some of the earliest assessments of the neural underpinnings of language and thought followed the behavioral idea, prevalent in the 1920's, that learning occurred by the establishment of a series of connections among appropriate stimuli and responses. Neurons were presumably connected to one another in a way that facilitated this learning process. In 1949, Hebb provided a specific explanation as to how this might occur with his concepts of the cell assembly and the phase sequence (see below). More recently a number of cognitive psychologists have re-introduced the idea of neural connection as the proper model underlying thought and language. One of the latest and most extensive treatments of the contemporary connectionist position has been provided by Elman, Bates, Johnson, Karmiloff–Smith, Parisi, and Plunkett (1996). These authors depend heavily upon certain recent discoveries in neuroscience to build their interpretation of language, and to utilize computer modeling as a *modus operandi*. They cite certain recent neurological discoveries that support their developing theory of language, most of which give evidence of the plasticity of the human brain and of human genetic material in general. Similarly, in 1927 Lashley recognized that the brain could operate such that some of its parts were equipotential and, therefore, could assume the functions of a damaged area given sufficient time. It appears that genes are not static in their effects on development, but rather can recombine with other genes and foster species-surviving mutations. Genes can now be created in the laboratory. Brain tissue from the visual cortex transplanted to the sensorimotor cortex will function in the same manner as its host. Above all, the considerable plasticity of the brain has been demonstrated by its ability to reorganize under conditions of significant bodily change.

This relatively new information has encouraged Elman et al. to reconsider the connectionist framework, particularly in the way that global behaviors seem to be accounted for by local information. In short, they have turned their attention back to the environment in contrast to the Chomsky–Fodor focus of the earlier years of the cognitive objection to various forms of behaviorism. Their assessment begins with attention to the perceptual process, but since the focus of this book has been on thought and language, I will attend to that aspect of Elman et al.'s work. Most of their analysis is based upon computer simulation of artificial networks. Their position has settled somewhere between the extreme emphasis on innateness, accounting for important aspects of thought and language characteristic of Chomsky and Fodor, and the behavior analyst's equally strong emphasis on the influence of the environment. As the authors realize, this middle ground is not new nor is the concept of there being an interaction operating between innate and environmental factors. They recognize the necessity of specifying the contributions of the genome to innate behaviors. Without some specific genetic and neural information, the idea of innateness remains vague and provides minimal explanatory power. Unfortunately, there is still a lack of clarity regarding the fact that between the gene and its eventual behavioral referents there remains a number of other cellular and systems interactions.

Elman et al. identify three ways of conceiving of innateness. Representational constraints have already been discussed and are typical of those espoused by Chomsky and Fodor. The idea that human infants are born with an innately determined knowledge of grammar, which is, at most, triggered by environmental stimuli, is just such a notion. From a connectionist position, such a condition is described as being composed of patterns of activity occurring in a group of neurons with preexisting weights among the interconnections which specify the representations. The best neuronal information at present suggests that such representations could be stored in the micro-circuitry of the cortex, but there is still a great deal of conjecture about how this actually works. Neural architecture offers a stronger possibility in accounting for restraints on behavior. There are neurons with different structures found in different parts of the brain with different firing thresholds and refractory periods. There are also different numbers of cellular layers in various parts of the brain and various networks of cells are connected differently. The most obvious example of this latter arrangement is found in the perceptual systems (vision, hearing etc.). Developmental or time-related constraints are also dependent upon innate genetic factors which are demonstrated by the fact that the child does not begin speaking at birth and that it takes some time for it to efficiently speak its natural language even after it has learned a few words. Artificial lesion research (e.g., Marchman, 1993) indicates that lesioning at different times during development produces different and predictable interruptions in the language acquisition process. This research depends upon the legitimacy of applying computer simulation results to human brain functioning, a proposition that has received its share of criticism, but more of that later.

Innate content and domain specificity are perhaps the most controversial aspects of language theory. The following experimentally-produced results in newborns constitute some of the data (e.g., Elman et al. 1996, p. 107) which nativists and connectionists need to consider:

1. Newborns show a preference for face-like stimuli over other stimuli.

2. They are able to imitate facial gestures.

3. They perceive different categories of speech sounds.

4. They perceive the difference between straight and curved shapes.

5. At birth they discriminate linguistic from other sounds.

6. At four days they are able to discriminate the sound of their natural language from other languages.

These results pose no problems for a nativist since each ability is considered to be a module with appropriate representations. The connectionist position, however, holds that any predispositions functioning in these behaviors are subcortical, presumably operating at the sensory level, and that there are no prespecified contents at the cortical level of functioning. Certain architectural and time-related constraints function to channel an infant's attention to certain parts of the environment rather than others. Representations presumably emerge from complex interactions between brain and environment and among brain systems themselves. This position, therefore, considers development to be the crucial general aspect of language acquisition and use. The development of the ability in infants to discriminate speech sounds indicates that babbling (Pettito, 1987) contains multiple contrasts relevant to all human languages, which are then reduced to those sounds relevant to the child's natural language. Japanese children show an initial ability to discriminate the "l" and "r" sounds, but gradually lose it as this discrimination is not used in Japanese.

Much of the evidence presented by the current connectionists in support of their model is generated from computer simulation. The simulation is an attempt to duplicate the activities of actual neurons. The connectionist position depends upon the possibilities of various parallel distributed processes to achieve sufficient complexity to account for the complications of language.[3] It must be said from the outset, however, that whatever degree of success computer simulations have in accounting for various aspects of language behavior, these simulations may or may not duplicate the actual activity of human neurons in accomplishing the same behavior. That is, there are theoretically many ways neuronal activity may occur so as to be consistent with the way people actually use language. Nevertheless, a computer simulation that does account for certain language activity must be taken seriously until its limits have been discovered. There has been much written about the nature of artificial intelligence and the legitimacy of computer simulation of human activity, so I will summarize only a few points necessary for the present study.

[3]The domain-general artificial intelligence model holds that a large number of simple processing units working in parallel with one another send excitatory or inhibitory signals to units to which they are connected. In this way varied and complex forms of excitation can be accounted for by the action of relatively simple neuronal-like units.

Wagman (1995) lists five assumptions made by artificial intelligence theorists:

1. Knowledge, conceptualization and reasoning-like computation are essential to human functioning.

2. Cognition is separate from (domain-specific) perceptual–motor skills.

3. Natural languages are accurate in describing cognitive processes.

4. Cognition is separate from learning (it is therefore, at least in part, innate).

5. Cognitive architecture is uniform in the species.

John Searle (1984) has argued against the idea that computers can think. His argument rests on the belief that computers operate syntactically, but not semantically. Hardware is created that can manipulate input on the basis of a set of rules built into it, but has no content of the sort that humans possess, presumably because of their experience with the external in-putting world. He illustrates this point by the construction of an elaborate example. Suppose you are in a room with boxes of Chinese symbols and you do not understand the meaning of any of them the way you do English words. You are also given a translation sheet that says when you see a squiggle with two curved lines underneath choose the English phrase, "boy walking up hill" and so forth for other Chinese characters. When someone passes a card with an English word through a slot in the door of your room, check the translation sheet, select the proper Chinese character from the baskets and pass it through the slot. The recipient outside the room receives a correct translation into Chinese of an English word or phrase in the same way that she would from a digital computer with an English-to-Chinese translation program. Searle's point is that you no more understand Chinese the way a native speaker does than does the computer which also succeeds in "translating" English into Chinese. Neither you nor the computer possesses a semantic content, only a simple syntactical rule. However, Searle's example is flawed. Semantic content can only be gained by experience with an external input source both for the computer and the human being. Learning that a squiggle and two curved lines underneath means "boy walking up hill" is a matter of linking the two in memory. Consequently, when you have passed enough Chinese symbols through the door after checking your translation sheet, there will come a time, if you are attentive and motivated, when you will no longer need the translation sheet. It can then be said that you have a semantic content and "know" Chinese. If it is possible to construct a computer that possesses semantic content and can "learn," then Searle's argument is broken. He does not believe this to be possible in principle. His argument is further challenged by the fact that it is possible to construct computers that learn (e.g., Fahlman and Lebiere, 1990; Rumelhart and Zipser, 1986) in that they are capable of selecting outputs not directly programmed. This, in a sense, means that they possess a semantic content.

In addition, Searle concludes that mind is caused by the brain, that is, mind is brain operating. The more recent connectionist methodology, of course, attempts to discover precisely what this brain activity is by simulating neural activity. Searle holds that computer simulation is not thinking, but it is not necessary to believe that it is in order to use it to discover something about the way the brain works. Computer simulation can provide models of how neurons operate in their causal relationship to thinking. Searle skipped this step in his argument.

There are those, however, who believe that the question of whether or not computers think is meaningless (Turing, 1950) and focus instead on the behavior of machines and compare it to the behavior of human beings when they are said to be thinking. Others (e.g., Scriven, 1953) hold that behavior cannot be an indication of consciousness since human beings can seem unconscious when they are paralyzed and seem conscious when they are radio-controlled (e.g., as in direct electrical stimulation of the reticular formation or hypothalamus). This point requires that thought be considered independent of behavior. The self-reflexive characteristic of thought, believed to be unique to human beings, can be programmed in a machine so that it can scan itself and recognize principles of its operation (Putnam, 1960). It can recognize that it is in, for example, "state A" when and only when "flip-flop 39" is on. It can be said that under these conditions the machine both "knows how" and "knows that," the latter ability usually considered restricted to human beings. The controversy of whether or not machines can duplicate human thought is far from over and will undoubtedly continue. However, it is equally clear that each rapidly evolved generation of computer is capable of more activity that seems like human thought.

Current computer simulation (Elman, et al. 1996) connects simulated neural networks with linguistic behavior so that the particular network *could* be an adequate model for the way actual neurons perform when that linguistic behavior is displayed. As mentioned above, the major problem with computer simulation of linguistic behavior is that any particular computer model that accounts for some aspect of language may or may not be the actual way that neuronal networks operate. The ultimate answers must come from research addressed directly to neuronal activity. The degree to which computer simulation is helpful remains to be seen, but it can not be ruled out ipso facto.

Elman et al.'s Modeling Procedure

Elman et al.'s modeling procedures postulate the existence of nodes (units) which are analogous to neurons and which act as processing units. Some receive input to the system from the outside world. Others are connected only to other nodes, and still others behave as effectors sending signals out into the world. How these nodes operate in conjunction with one another are modeled by various networks as shown in Figure 3. The connections between nodes have weights which multiply the output of the node. Knowledge is conceived to be the gradual build up of these weights which have real number values, for example, +2.0, –1.254 etc. A node may receive input from a variety of sources which results in a net input. The weights are multiplied to determine the excitatory or inhibitory response of a particular node. Hence if a node with weight 0.5 receives a signal from a node to which it is connected which has a –2.0 weight, the signal received is of weight –1.0 (.5 X –2.0) which is inhibitory. As with actual neurons, a node does not necessarily respond in a manner consistent with input. Some inputs may be insufficient for the node to respond and the weight of other inputs may exceed that which is necessary for the node to respond. It follows from this weighting system that the input to the node does not require a necessarily linear output from it. The knowledge in these nodes is based in part on their architecture and in part on the input which they receive. Different layers of nodes process words, letters, and other features of language.

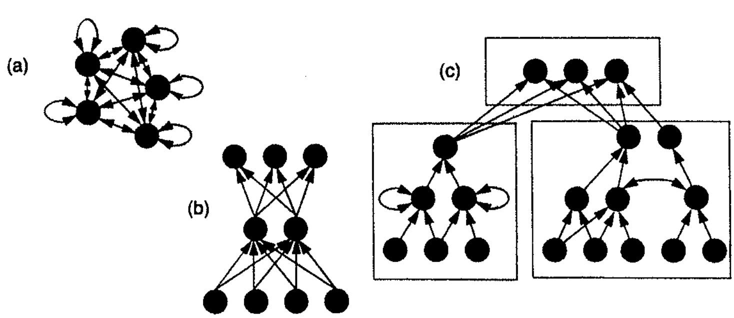

Figure 3: Various types of connectionist networks: (a) a fully recurrent network; (b) a three-layer feedforward network; (c) a complex network consisting of several modules. Arrows indicate direction of flow of excitation/inhibition. From Figure 2.1, p. 51, of Elman, J.L., Bates, E.A., Johnson, M.H., Karmiloff–Smith, A., Parisi, D., and Plunkett, K. (1996), *Rethinking Innateness: A Connectionist Perspective on Development.* Reprinted with permission of The Massachusetts Institute of Technology Press, Cambridge, Massachusetts.

Learning in Networks

In 1949 Hebb suggested that learning involves change in neural cell structure or metabolism when there is a persistent excitation of a cell by a particular axon. He called the result a cell assembly which developed over time and depended upon frequent stimulation of the same cells. A cell assembly required lower thresholds of firing capacity at those synapses that were frequently excited compared with other nearby synaptic connections. A phase sequence, "Activity in a super ordinate structure . . . is then best defined as being whatever determinate, organized activity results from repeated activity in the earlier-developed (cell assemblies) or subordinate structures giving rise to it" (Hebb, 1949, p. 98). Cell assemblies and phase sequences are concepts which transcend the linearity characteristic of earlier associationistic neural theory. Hebb's system is limited to learning that occurs in cell pairs or in pairs of cell assemblies. It is necessary to postulate the existence of hidden units underlying what we think of as mediational processes to account for the kind of logical abilities not accounted for by Hebb's system. Hidden units are nodes which operate between the received input and output and are built into computer simulation models. They are what we commonly refer to as internal representations. These internal representations emerge as a result of local interactions between input and output networks. Coordinated internal representations are thus a product of this local activity and not a result of domain-specific innate structure. Grammar, and the universal preference for speaking grammatically, is the result. When English speakers are confronted with non-words in certain sequences such as "bliffle" and "dliffle," the first is processed much more easily than the latter. Elman et al. explain this preference by suggesting that the non-word input activates words that resemble it such as "blissful" and "blister," considering the first two letters, and "piffle," "muffle," and "ruffle," considering the last syllable and the first letter followed by a vowel rather than a consonant as in "dliffle." The word-like attributes activate more nodes than the non-word sequence and hence many words such as those listed above are activated. The non-word sequence activates fewer such nodes and fewer words are activated. Elman et al. make the point that what looks like "rule-guided phonotactic knowledge" is actually a matter of the differences in probability of various phonemes arising with each of the non-word sequences. This phenomenon is taken to be an example of emergent behavior in a connectionist network.

Elman et al.'s model attempts to account not only for the internal representation of a word, but also for its grammatical context. The reader is encouraged to consult the arguments there directly. In this account, language is subject to modularity as a result of both neural development and experience with the external world that alter the neuronal substratum. This is a different interpretation of linguistic modularity than that proposed by Fodor. Elman et al.'s position attends closely to the actual activity of neurons and constructs a model for their function where information is lacking. The result may or may not be correct, but their direction of attack on the problem of the nature of language is open in a way that Chomsky's and Fodor's are not. Elman et al. also take great pains in disassociating themselves from behaviorism, but lump all of the various behaviorisms together without identifying a specific theory to which they object. Presumably they are referring to behavior analysis since Skinner is the only behaviorist with a detailed theory of verbal behavior. They see themselves conceptually between Chomsky and Fodor at one end of a continuum and Skinner at the other. The former insist on innate, immediately appearing (at birth) modular structures that are composed of the universal rules of grammar and minimize environmental influence and the study of biological determiners in understanding the way that language works. The behavior analysts also minimize the necessity for studying the biological determiners of verbal behavior and perceive the concept of modularity to be an empty mediational explanatory category. Elman et al.'s brand of connectionism is an attempt to bridge the gap set by the other two theories of language by the use of computer modeling of the representational process such that the resulting connections are consistent with, and aid in the accumulation of, knowledge of the way neurons work in the central nervous system.

It is not unusual in the history of science, particularly in psychology, that explanation is attempted that incorporates the strongest points of two extreme positions. The behavior analysts have not typically attempted to extend and clarify Skinner's position, and theorists holding to the innate nature of language and thought can do little else but provide linguistic situations that seem to indicate the domain specificity of thought and the way language is used.

Elman et al.'s theoretical position can be summarized in five principal tenets:

> 1. Constraints on language mechanisms (not content) occur because of (a) representational restraints that are produced by the specific nature of cortical activity; (b) architectural constraints having to do with neuronal firing arrangement, that is, their network connections; and (c) time restraints, that is, the time at which they appear in the development of the organism.
>
> 2. There is a non-linear relationship between language mechanisms. Behavior is also frequently non-linear.
>
> 3. What appear to be single events unconnected to others may actually have many causes some of which are distant in time.

This point is shared with the behavior analysts although not acknowledged by Elman et al.

4. Specific synaptic connections in the brain are the first links in the causal chain that yield language behavior; therefore, understanding how they work is the top priority of connectionist theorists.

5. Development is crucial in the appearance of certain linguistic behavior. Forms emerge over time which can be described by connectionist concepts.

The essence of the difference between domain specificity and domain generality in the explanation of language lies in the different emphases on either architectural innateness, which is acceptable to both, or representational innateness, which is acceptable only to those espousing domain specificity. The connectionists accept the idea that there are innate architectural structures which provide limitations on functional dispositions. Once there is representation of the external world the environment becomes an important factor in representation. Connectionists have set their efforts in solving the problem of explaining how symbolic abilities occur with the assumption that there is no representational innateness — or that it is severely limited in some way. Their method is to construct computer simulated models which presumably reflect the actual arrangements and behaviors of neuronal networks. This work has shown that certain networks *could* support grammatical representations without assuming that these representations are direct functions of an unspecified neuronal substratum. There is, however, no conclusive evidence that any particular model is the definitive one. Continued work in computer simulation, however, has the possibility of eliminating models that clearly do not account for the representational process and this is valuable information to have. It is most likely not possible to ever conclusively understand the nature of language and thought, as theorists from diverse theoretical positions have stated.

Finally, it is interesting to see that Skinner's position with regard to the nature of language and thought has re-emerged in the professional linguistic community at least for one of its members. Julie Andresen (1992) notes the theoretical and epistemic relationship existing between Skinner's behavior analysis and the current work on connectionist networks and parallel distributed processing. She notes that the Chomskian innatist criticisms of Skinner's theory of verbal behavior took four forms: (a) the aesthetic appeal of generative grammar as a description of native proclivities of the human brain versus the seemingly mechanistic operational and rather inelegant functional analysis supplied by Skinner; (b) the political climate of the 1960's which immediately followed Chomsky's review of *Verbal Behavior* which favored computer analogs to brain function in analyzing artificial intelligence rather than neural networks with no set dispositions; (c) the emphasis by most people, whether professional linguists or not, to tacitly or explicitly assume that human beings are capable of a central agency that produces action, the most important of which are speaking and thinking; and (d) the textual tradition of classic linguistics which was evident in Chomsky's continued denial of the legitimacy of Skinner's neologisms such as mand, tact, and autoclitic and his attempt to translate them back into familiar linguistic terminology. For example, Chomsky's substitution of the common "B wants A" for Skinner's "event A reinforces response B" indicates that Chomsky does not accept the idea that the concept of reinforcement functionally clarifies the very situation that occurs when someone says, "I want A." Andresen points out that current research in linguistics has swung back toward connectionist modeling and has reduced the heavy emphasis on the nativist conception of grammar held by Chomsky, Fodor and others. In addition, she indicates the somewhat unexpected connections between Skinner and certain postmodern ideas, particularly those of Derrida, which will be examined in the penultimate chapter of this book.