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ABSTRACT

The prelinguistic child's attempts at communication cannot be viewed as rudimentary language. More than cataloguing overt acts, we need to understand the functional character of both language and non-language communication capabilities, and in particular the maturational stages of the internal communication systems that produce overt behavior in human beings. To describe the child's behavior without considering the nature and organization of the neural systems that produce the behavior is unreasonable. Above all, it must be realized that the child's observable behavior is only the tip of a neuropsychological iceberg. The conclusion that developmental stages are mere theoretical constructs, abstractions from a process that is actually continuous in nature, could only result from ignoring this fact. The forebrain limbic systems that became elaborated in primates constitute the primary level of human communication. The second arises at about 12 months in the form of neocortically based conceptual systems, including gestural behavior encoding components of propositional elements such as agent, patient, dative, etc., until recently largely ignored by psycholinguists. Only from about 20 months does the child use syntactical and morphological indicators to systematically encode components of the underlying conceptual message, and only at this point can the acquisition of a language system be said to have begun. (Author/AM)

MATURATIONAL STAGES IN THE DEVELOPMENT OF COMMUNICATION SYSTEMS BY THE CHILD

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When the phonologically structured vocalizations of a child are recorded throughout the second postnatal year, it is observed that verbal productions go through a stage in which the mean length of utterances is one word, and a later stage when it hovers at two before climbing to three and beyond. These two stable periods of one and then two words are found universally for all children independent of the particular language they hear or the culture they are exposed to. While few psycholinguists deny their existence, it is not obvious how to interpret their significance. According to the more or less standard view, these and other stages form part of an orderly progression from rudimentary language beginnings at around 14 months to the full array of adult linguistic capabilities by age 4 or 5. Language acquisition is described by tracing increments in the mean length of utterances and by noting when and in which order particular sorts of linguistic forms are first produced spontaneously by the child. Regular progressions in the child's phonetic output have been discovered for all aspects of developing verbal behavior, some universally, some for particular languages, and some for individual children. Highly specific <u>stages</u> in the acquisition of phonology, syntax, semantics, and pragmatics have been proposed: stages in the production of fricatives, stages in the use of negatives, and stages in acquiring adverbs of time and place.

Several fundamental things are wrong with this general framework. For example, adult language is a system characterized by morphological and syntactic devices of a definite type. While ontogenetic development eventually equips the normal child with a language system, up to some point the child hasn't got one and communicates by other means. Even holding a nativist position, there is no a priori reason to assume that all phonologically structured output of the prelinguistic child must be relevant only to some straight-line continuous path to adult language. Until quite recently in psycholinguistics, there has been an overemphasis on the child's vocal output to the point of ignoring what the child communicates and how it is actually expressed. At the so-called one word stage, the child sometimes uses utterances to communicate and sometimes not. As is clear from the observations of Reed (1972), Carter (1974), and others, when a one word utterance does form part of an interpersonal communicative effort, it is merely one facet of a multimodal <u>gestural complex</u> that does not deserve the label "language," even though it is a means of systematic propositional communication. Two word, pivot-open utterances are not just part of a gradual accretion of bits and pieces of a linguistic system such as English, but a distinct phase of human development arising and then disappearing before the child begins to acquire a language system. It is irrelevant that from the adult perspective the sounds and words used during this period are parts of a language, what matters is what they are for the child.

Examining the evidence without an adult, vocal-language bias, one sees that the child's early communicative endeavors are no more rudimentary language than crawling is a rudimentary form of running. Both crawling and running are forms of locomotion and employ the same operators, but they arise from qualitatively different internal systems and serve in different functional contexts.

The occurrence of one after the other does not imply that crawling is a logical prerequisite to running, but only that this is the manner in which the maturation of human locomotor systems occurs. To understand the development of human communication it is not enough to only describe changes in the child's phonetic output, and even adding a concern for other aspects of the child's overt behavior such as gestures is insufficient. More than cateloguing overt acts, we need to understand the functional character of both language and non-language communication capabilities, and in particular the maturational stages of the internal communication systems that produce overt behavior in human beings.

Homo sapiens did not arise in a biological vacuum. We are mammals and we are primates. We continue to share the bulk of our anatomical and physiological equipment with our animal relatives as a legacy of a common ancestry. Our peculiarly human specializations are, after all, only our way of carrying out the basic biological functions that other animals approach at different levels, a reflection of the ecological niches we have fallen into over the course of our evolution. More than 100 million years ago, mammals with a social mode of adaptation evolved forebrain equipment to carry out biologically necessary communication functions. We humans still have this equipment and, at a point soon after birth, it becomes operational. Similarly, the last 50 million years or so has seen the evolution of our primate ancestors with their own functional systems for more specialized communicative interaction. The overt sign complexes produced by these neural systems express agonistic states such as fear and regulate social interactions such as that between mother and infant. Again, we have not lost these systems and they too take their place in the underpinnings of the child's communicative repertoire at an early point. Higher level human cognitive and communicative functions are the result of the particular line of hominid evolution that gave rise to our species over the last 20 million years or so. New developments in the communicative activity of the human infant after about 12 months appear to be based not on neural systems homologous among existing primates, but rather on species-specific adaptations of defunct hominid lines. These adaptations arose only because of the mutually supportive, bootstrap interaction of many small advances in communicative, cognitive, and cultural organization. Language is the end product of hominid communicative evolution, but there is every reason to believe that along the way simpler systems evolved and formed the basis for the advance to a higher level.

The means by which human evolution has occurred and the means by which its history is imperfectly repeated as each human child develops has been the progressive modification of the genetic material of our ancestors. It is the information coded in genes that directs the stages of pre- and postnatal growth of anatomical structures such as the vocal tract and the stages in the maturation of physiological functional systems that control behavior such as articulation. With a mind-boggling precision of timing and effect, gene assemblies act prenatally and postnatally to induce the unfolding of hierarchically organized, tightly integrated components of complex functional systems, including the nervous system. At definite points in ontogeny, given neurophysiological functional systems become operational and take control over their designated subset of functions. It is the state of differentiation of the nervous system that constrains the behavioral capabilities of the human infant at any given time. Stages in the development of communicative behavior arise the way they do only because of the potential that new levels of neural information processing systems give the child as they become operational.

To describe the child's behavior without considering the nature and organization of the neural systems that produce the behavior is unreasonable just to the degree that one is interested in understanding the causes of overt behavior, in explaining behavior instead of merely describing it in relation to other observable acts. An example of the truth of this statement may be seen in the general inability to explain the causes for stages of phonological development if only overt behavior is considered. When first looking at child language development, behaviorist psychologists fully expected to find a high positive correlation between the frequency of sounds in the language of the environment and the order in which children learn to articulate sounds. Instead, the work of Irwin and others led to the discovery of two different trends in articulatory development, sequences that appear universally no matter which sounds the child hears from others. For example, during the <u>babbling period</u>, from about 6 months to 12 months, one finds an early preponderance of back consonants with a gradual shift forward until at about 12 months front consonants are the sounds most frequently produced. After this point the child begins to acquire a phonological system, but appears unable to use back consonants that are still freely produced as noises. From 12 months on, a general trend is observed in the child's mastery of phonological production from front consonants to back consonants: the mirror image of the earlier sequence.

There is no logical reason why this curious dual progression in phonetic behavior should occur, and the explain it we need to know that separate neural systems underlie each of the two different sequences. As Whitaker and others have pointed out, the relevant portions of the systems that produce babbling mature between 6 and 12 months as part of a more general process of gaining voluntary control over motor activity. Intentional motor acts involve neural systems localizable in the back portion of the frontal lobes of both cerebral hemispheres. This region is called the <u>primary motor cortex</u> and it contains a topography preserving projection of the body's muscle systems, including a representation of the vocal tract. Voluntary control of vocal tract musculature develops progressively as these motor subsystems mature, with mastery of back articulations occurring first and front articulations only at about 12 months. On the other hand, the control of phonologically structured vocalizations is carried out by phylogenetically newer, higher order systems partially localizable in <u>Broca's convolution</u> of the dominant hemisphere. This secondary motor region is located adjacent to the portion of the primary motor cortex for the vocal tract. It too contains a projection of the muscle systems for articulation, one that organizes especially to control motor speech activity. While this representation also matures in a definite direction, unlike the primary motor cortex, it matures from front to back, with front consonants possible from about 12 months and back consonants only later. In this manner, the genetically regulated maturation of these two neural systems accounts for the two progressions in a way not possible when only overt behavior is considered.

Primary motor systems develop with a high degree of genetic specificity, and even when a child does not produce an actual behavioral output, these neocortical systems still tend to develop in a more or less normal fashion. Up to some point, even a deaf child continues to babble and shows the pattern of back to front consonant production. By contrast, the innate neural systems involved in phonological development are subject to a much smaller degree of specific genetic encoding. Though the early phonological systems acquired by the child appear to be governed by universal constraints, in order for normal development to take place, an appropriate interaction with the language of the environment is required. The lateralized motor systems of Broca's area are a unique adaptation of our species, part of our specialized hominid neural equipment for a vocal system of communication. The actual anatomical and physiological nature of these specializations remains unknown, but from a general functional point of view they involve the capacity to process and retain certain kinds of information with greater facility. Such species-specific predispositions are manifested in varying degress across species and range from abilities that are unequivocably restricted to humans down to functions that humans are set up to perform more efficiently. For example, several primates have been found able to make cross-modal perceptual associations based on neocortical systems. Nevertheless, humans can recognize an object by touch after only one visual presentation, while chimpanzees require 500 trials to achieve 90% accuracy, and monkeys need about 1000 trials.

This type of differential capacity to learn something with greater or lesser ease is not just characteristic of cross-species differences, but can also be found to a significant degree between different individuals of the same species. The basic cause is simply that with the exception of monozygotic twins, all individuals are genetically unique. Furthermore, without exception, each individual's interaction with the particular environment in which development takes place follows a unique path. One result of this uniqueness is that even a wide variation from individual to individual does not constitute proof that variant developmental schedules are not the product of specific genetic encoding (i.e., are innate). Many psycholinguists seem to assume that developmental stages must be manifested in all individuals and in exactly the same order before they may be considered innate. This is too strict a requirement. It could merely be the case that different human genotypes give rise to varying ontogenetic schedules in particular subsets of individuals. It is also entirely possible that when a development is found to be universal, it could have resulted from learning in one subset of the population and from more specific genetic encoding in another. Merely observing the presence or absence of developmental universals of behavior is in principle incapable of providing an adequate explanatory basis for what is observed.

Above all, it must be realized that the child's observable behavior is only the tip of a neuropsychological iceberg. The conclusion that developmental stages are mere theoretical constructs, abstractions from a process that is actually continuous in nature, could only result from ignoring this fact. The superficial appearance of continuity arises from several factors, one of which is our knowledge of where the child is heading. We tend to emphasize only those aspects of development that represent progress toward the 'goal' of the adult system. A second factor, one built into the ontogenetic process itself, is the general principle that new information processing functions are first carried out by old systems, and new systems at a higher level first carry out old functions. A prime example of the maturation of different control levels may be seen in crying behavior. During the period immediately after birth, crying is initated by brain stem systems of the reticular formation as a global motor response to states of disequilibrium. At about 2 weeks postnatally, the lower levels of the limbic system become operational, inhibit portions of the reticular formation, and take over the crying function. Differentiated crying responses soon develop, along with other multimodal behavioral reactions to internal physiological states or specific perceptual stimuli such as the human face or voice. Between any two developmental stages of communication, it is common to observe transitional periods in the child's overt behavior. Around 15 months, after both the gestural stage and the phonological naming stage have been attained (See Handout), one can find a child first producing a gesture complex and then afterwards a label for one of the conceptual components of the message. Production of this sequence is followed shortly by the insertion of the label into the gestural complex to produce what has been called a holophrastic utterance. Similarly, the two word stage is frequently preceded by a period during which the child juxtaposes two one word utterances before combining them into one two word utterance. If only the idiosyncratic development of one individual were involved, such behavior could presumably be accounted for by whatever modifications of neural systems underlie learning. However, when the majority of new individuals of our species make the same transitions as part of a regular maturational schedule, then one might legitimately suspect that the process involves a shift of control functions from one genetically specified neural system at a lower level to another system at a higher level.

The forebrain limbic systems that evolved in mammals and became elaborated in primates constitute the primary level of human communication. It seems foolhearty to continue describing first year communicative activity without taking into account the systems that are actually doing the communicating. Limbically controlled behavior continues throughout adulthood and, even after the child has gone on to acquire other sorts of communication systems, failure to achieve an interaction goal often results in recourse to limbic sign or signal complexes. The second general level of human communication arises at about 12 months in the form of neocortically based conceptual systems. The first of these to emerge is a gestural system that encodes components of propositional messages such as agent, patient, dative, and so on. Once one notices a child's gestural behavior, one wonders why until quite recently this preverbal encoding of propositional messages has gone all but unacknowledged among psycholinguists. The main reason is probably that many of these same gestural elements stay with us as adults, but mostly as an unconscious substratum to our linguistic communication. Adults might disparage a one year old's gestural structures as hardly worthy of note, but the significance of this level of symbolic behavior is not lost on psychologists who work thousands of hours training chimpanzees to use systems at this same level. Because of their emphasis on vocal communication, psycholinguists have rarely begun observing children before 14 or 15 months, after the first 'words' begin to be produced. Other than transcribing vocalizations in the proverbial "broad phonetic transcription," little was done beyond adding a few notes on the context in which utterances were made, and informal impressions of which adult sentences the child was presumed to be attempting. Only with the use of video tapes has it become feasible to examine over and over again the child's actions in a particular instance in order to analyze the structure of gestural communication, or even just to notice that it exists.

Considering their bias toward overt behavior, it is not surprising that psycholinguists fail to differentiate between non-communicating labeling utterances and the use of these labels in encoding messages, particularly since it frequently happens that the same phonological forms occur in both functional contexts. Considering their vocal language bias, it is understandable how they have misconstrued the nature of the one word stage and (mis)posited a "holophrastic" utterance that is supposed to communicate an entire proposition all by itself. Both Reed's data and Carter's data show instead that at this stage it is the entire gesture complex that systematically communicates the separate elements of propositional messages. When the child does begin to shift the encoding of conceptualized messages from multichannel gestures to the single vocal channel, there occurs a necessary temporal serialization of the message's component parts. Nevertheless, it is a mistake to assume that the child of 18 months who strings two words together has ipso facto acquired rules of grammar. Only from about 20 months does the child use word order and morphological indicators to systematically encode components of the underlying conceptual message. It is only at this point that the acquisition of a language system can be said to have begun.

Lack of time prevents discussion of specific aspects of the ontogenetic stages of human communication within the limbic, conceptual, and linguistic levels. You are referred to the handout for a summary of what I would say, time permitting. While I believe all of the conclusions represented here to be empirically defensible and, as far as I know, not contradicted by any extant data, not all of these claims enjoy the same degree of empirical support. I give them here only to provide an illustration of a neuropsychologically based interpretation of the maturational stages in the development of communication systems by the child.

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OUTLINE OF THE MATURATIONAL STAGES IN THE DEVELOPMENT OF COMMUNICATION SYSTEMS BY THE CHILD

I. PRECONCEPTUAL LIMBIC STAGES

From about two weeks postnatally, the infant exhibits a fixed set of multimodal sign complexes that allow a receiver to infer a closed set of graded messages. The perception of specified internal or external conditions results in the automatic implementation of a set of differentiated responses produced by action schemata of subcortical components of the limbic system. From about 6 mo., higher level paleocortical limbic components integrate with the neocortical motor systems that control voluntary motor activity to allow the intentional production of existing limbic responses as a conscious means of communicating motivational states to those in the environment. The infant becomes more responsive to the affective and conative content of adult behavior and, from about 9 mo., prosodic features such as intonation contours become part of limbic signal complexes. Certain universal limbic 'words' (e.g., mam "food"), while retaining roughly the same phonetic form, make the transition from involuntary sign to intentional signal.

II. PRELANGUAGE COMMUNICATION SYSTEMS

A. Gestural Stages: Multimodal gesture complexes output by secondary neocortical movement schemata are systematically and willfully used in particular contexts to communicate the substantive and relational content of an open set of propositional conceptualizations. As various components of gesture complexes become non-representational and conventionalized, the transition is made from signal to symbol. Vocalizations have no special high status as against the other components of a given schema such as facial expression, visual orientation, body orientation, body configuration, rhythmic and patterned movements.

B. Phonological Labeling Stages (Naming Stage): Phonologically structured names act as labels on object-level and propositional concepts in such a way that hearing a given phonological form can lead to the retrieval of a concept from long-term memory. Perceptions that lead to the conceptual recognition or recall of a given generic or token concept may result in the overt vocal production of the child's label for that concept. Such articulatory output is organized by lateralized neocortical movement schemata based in Broca's convolution. Though apparently not used to communicate propositional messages, labeling vocalizations are used in social interactions to identify objects and as vocatives.

C. Propositional Focus Stages (Holophrastic Stage): Neocortically based communication systems insert phonologically structured labels into previously existing gesture complexes. One function of the verbal component of a gesture complex is to draw an addressee's attention to the information focus of a given propositional message. The conceptual content of one word utterances becomes increasingly differentiated over and above that of the gestural substratum. For the most part, both the messages the child encodes and those decoded from adult speech are still approached in terms of an immediate action strategy.

D. Propositional Focus-Assertion Stages (Pivot-Open Stage, Two-Word Stage) Two word utterances accompany gestural complexes, functioning to identify the information focus and also to make an assertion or predication regarding this focus. While relational concepts are still expressed almost exclusively by gestures, or by relying on the contextual situation, the child increasingly opts for the auditory-vocal communication channel. Vocalizations more and more begin to independently communicate substantive concepts that are part of the message.

E. Lexical Stages (Telegraphic Stage): The mean length of utterances goes up as the child outputs strings of lexical items capable of assuming a major burden in communicating the substantive content of messages including some relational notions. No syntactic structure exists, although word order may be fixed. Even though lexical strings remain subject to misinterpretation, the limbic and gestural systems are of diminished importance in the child's overall communicative repertoire.

III. LINGUISTIC STAGES

Lateralized neocortical systems produce sentences that communicate both relations and substantives by means of syntactic devices and grammatical morphemes used with lexical items. In general, the conceptual grasp of a given distinction precedes its linguistic expression. The mastery of linguistic forms is subject to certain universal constraints. Sentences become increasingly independent of accompanying gestures and situational context.