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ABSTRACT

While agreeing with psycholinguistic and neurolinguistic theories that suggest that innate language-related cognitive structures are the basis of language development, the author seeks to establish what it is that is innate and what is meant by innateness in the first place. The author considers the claims of psychological relevance made on behalf of Chomsky's transformational model and outlines a neuropsychological framework by which one could consider descriptions of genetically-determined cognitive-linguistic processes existing as the product of the evolution of the human nervous system. (VM)

INNATENESS CLAIMS IN PSYCHOLINGUISTICS

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ABSTRACT

The evidence in psycholinguistics and neurolinguistics clearly suggests innate language related cognitive structures as the basis of the child's acquisition of language. However, there are two questions which remain unanswered in psycholinguistic theory: What is it that is innate? And what does innateness mean in the first place? Some psycholinguists have attempted to borrow an answer to the first question from the field of descriptive linguistics, taking at face value the informal claims of psychological relevance which Chomsky has made for the transformational grammar. Most psycholinguistics theorizing has ignored the second question. In this paper I briefly discuss the status of current innateness claims in transformational psycholinguistics and outline a neuropsychological framework in terms of which one could consider descriptions of genetically determined cognitive linguistic processes existing as the product of the evolution of the human nervous system.

INNATENESS CLAIMS IN PSYCHOLINGUISTICS[1]

For many years, a controversy has existed between those who wish to explain human cognition principally on the basis of learning from the environment and those who posit innate mechanisms which eliminate the need for learning in certain domains. Of course, a totally environmentalistic position is logically untenable if only because there would be no explanation for the species-specific properties which distinguish Homo sapiens, both physically and psychologically, from other animals. No one could deny the existence of innate perceptual and motor equipment, or of reflexes and instincts which shape some patterns of human behavior. Biologists, philosophers, and psychologists all agree that human beings are the product of the interaction of nature and nurture, of genetic predisposition and sensory-motor experience. The parting of the ways comes in the greater or lesser emphasis placed on the relative influence of genotypic versus environmental factors within the cognitive domain. The only cognitive concession of some 'anti-nativists' is to grant different quantities of "non-specific intelligence" as the genetic legacy of various species. On the other hand, the 'nativist' posits substantive aspects of human knowledge and mental capabilities as present in the newborn infant without the need for learning from sensory experience.

Few aspects of the nature-nurture controversy are more widely discussed than the innate basis for the development of language by children. In Bloomfieldian structuralism, linguists considered speaking to be a secondary utilization of anatomical structures possessing basic biological functions such as breathing and eating.[2] Language was seen as a purely cultural artifact, on a par with other socially transmitted systems of behavior. In behaviorist psychology, the interest in "verbal behavior" led to an attempt to explain the child's acquisition of language by the selective reinforcement of stimulus-response associations without recourse to (unobservable) internal processes at

[1] This paper is a revised version of a talk entitled "The nativists are getting restless," presented at the University of California, Santa Barbara in November, 1972.

[2] See, for example, Sapir (1921). Notice also Lieberman (1968) which argues that the morphology of the human oral cavity and larynx is not optimal for breathing and eating but in fact has been specialized evolutionarily to allow a wider range of controlled phonetic output.

all, whether or not innate. The S-R behaviorists' rejection of language as part of human 'nature' was not based on conclusions from empirical data which demonstrated this, but rather followed from the a priori methodological assumption that the goal of psychology is to describe publically observable macrobehavior. An intervening variable such as the central nervous system was only seen to allow the formation of deterministic connections between input sensory stimuli and the motor responses they elicit. However, while there was an automatic temptation to reject innateness claims on methodological and epistemological grounds, there would be no theoretical difficulties in behaviorists' positing genetically controlled cortical "reflex arcs" for cognitive processes such as language.

There is no point in arguing that innate cognitive processes cannot exist, unless these arguments are based on empirical observation and experimentation which validly lead to this conclusion. Even if it becomes possible to teach English to a chimpanzee or a computer, we would not be justified in drawing conclusions regarding the status of innate, linguistically relevant structures in human infants. The existence of a non-nativistic explanation for a particular aspect of behavior is insufficient demonstration that innate structures are in fact not involved for the human species. Thus, the fact that turtles and garbage disposals chew food without teeth, does not bear directly on the question of whether <u>horses</u> have teeth. The easiest way to find out about equine dentition would be to look into the horse's mouth (Irving Fazzola, personal communication), and while the situation is more complex with respect to genetically determined cognitive neurological structures, it is still true that the existence of innate cognitive structures is an empirical issue to be resolved only by valid evidence for or against specific claims.

Psycholinguists' observations of child language acquisition have revealed regularities which are not explicable on the basis of learning from the environment. Independent of the particular language they hear and the culture they are exposed to, normal children proceed through the same universal stages of language acquisition at approximately the same ages. For example, there is nothing in the child's experience to account for the universally observable two-word Pivot-Open stage which is found at approximately eighteen months. During this stage, the child's utterances typically consist of two words (e.g., <u>Allgone Daddy</u>), one of which is drawn from a small class of "pivot" words (e.g., <u>allgone</u>, here, my) and the other of which is drawn from a large class of "open" words (e.g., book, table, Daddy,...). The data have led psycholinguists to the conclusion that the explanation for this and many other developments must reside innately within the child. (See McNeill, 1970; Menyuk, 1971; Slobin, 1971; Lenneberg, 1967). Confronted with the obvious question "What is it that is innate?", many psycholinguists have borrowed their answer from the field of descriptive linguistics in the form of transformational grammar. It is primarily within this framework that specific formal innateness claims have been made. The claims are open-ended in that they follow directly from whatever is the current view of the nature of transformational grammar. New varieties of the theory require corresponding modification of the set of innateness claims. (For presentation and discussion of innateness claims based on transformational grammar see Chomsky, 1968; Katz, 1966; McNeill, 1970. For a recent version of the standard theory see Chomsky, 1971. For earlier versions see Chomsky, 1957; Chomsky, 1964; Chomsky, 1965). Interestingly enough, the empirical evidence used to establish these claims does not come from psycholinguistics, psychology or biology. Independent neurolinguistic evidence has also been presented (Lenneberg, 1967; Whitaker, 1973; Whitaker, 1971; Geschwind, 1972) but, beyond mention in passing, this evidence has not been integrated into the formal theoretical concerns of psycholinguists.

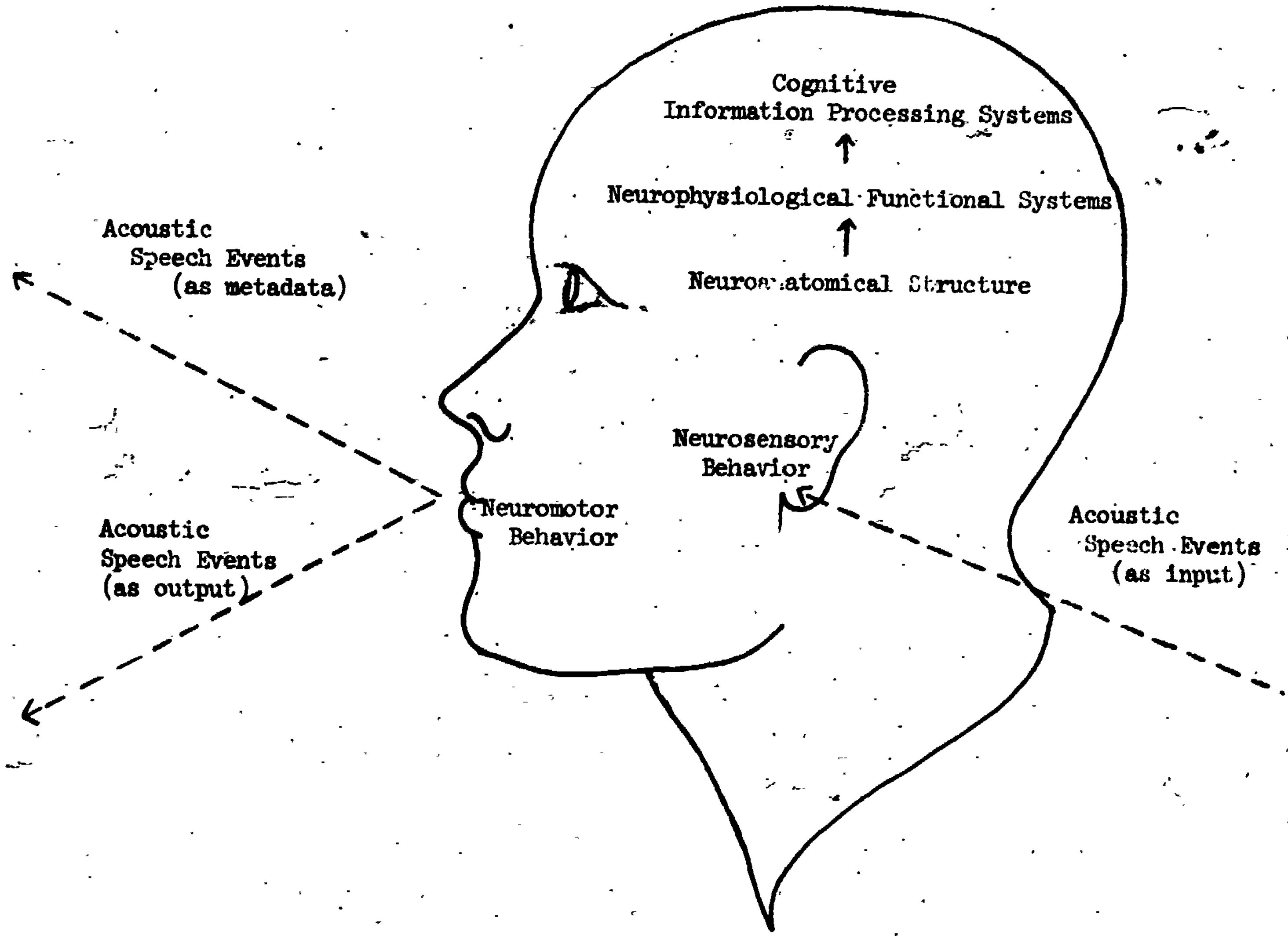
Transformational psycholinguists view one of their basic goals as explaining how Chomsky's "theory of linguistic competence" serves as the basis of "a theory of linguistic performance." With respect to child language acquisition, the approach has often involved recording speech production data at a given time in the child's development, and constructing a transformational grammar which describes the "grammar" which "underlies" this data. A comparison of this grammar with similarly derived grammars from later points in the same child's development and a discussion of the various rule differences between the grammars is taken to provide significant insight into the psychological processes involved in first language acquisition (See, for example, Brown and Fraser, 1964; McNeill, 1970). Because of the highly structured innate "Language Acquisition Device" attributed to the newborn infant by transformational psycholinguists, the actual process of learning a language appears a rather trivial matter of allowing linguistic data in the environment to deductively plug specific facts into innate 'blanks.' The validity of this approach to psycholinguistic concerns depends on the more basic issue: Are theories within descriptive linguistics, and innateness claims constructed in terms of them applicable to the psychologist's goal of describing cognitive processes?

If we attempt to evaluate the potential of transformational grammar for explaining language as a cognitive process, we run up against a confusing tendency to seesaw back and forth between technical discussion based on the formal metatheory and informal discussion which deals with psychological processes by metaphorical extension.[3] For example, it is quite common to "loosely" extend the formal notion syntactic deep structure phrase marker, and equate it with whatever psychological structures and processes actually underlie the production and comprehension of language. Such terms as rule of grammar are used in an unsystematically ambiguous way to refer to both formally defined phrase structure rules and to whatever unknown way in which people store and process information in long-term memory. This is an unfortunate habit, since it is precisely the relevance of the formally defined constructs of a transformational grammar to these undefined psychological structures which must be established before transformational grammar could be used to explain child language acquisition. An empirically based formal description of language data does not necessarily provide an empirical basis for informal discussion of internal cognitive processes. Chomsky's distinction between "competence" and "performance" and the imputed status of transformational grammar as a "theory of linguistic competence" has provided a smokescreen behind which cognitive claims are informally made, without the necessity of backing them up with formally derived, empirically verifiable psychological consequences. As the term is used, a "theory of performance" amounts to a transformational grammar plus X, where X stands for whatever factors it would take to give this grammar relevance to the real world of cognitive information processing.

Lamendella (to appear) discusses the formal status of transformational grammar while considering the general question of what would count as a description of internal cognitive processes and what would not. This question was considered in terms of seven different frameworks, cited in Figure 1, each having its own goals, considering different evidence, and ending up with descriptions of different aspects of the same reality.

[3]For discussion of the dangers of using formal notions metaphorically, see Chomsky (1959).

Figure 1



(2) ANATOMICAL DESCRIPTION

↓

(3) PHYSIOLOGICAL DESCRIPTION

(1) BEHAVIORAL TAXONOMY

↓

(6) ABSTRACT CHARACTERIZATION

(4) BEHAVIORAL ISOMORPHISM MODELS

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(5) PSYCHOLOGICAL ISOMORPHISM MODELS

↓

(7) PSYCHOPHYSICAL ISOMORPHISM MODELS

(1) A behavioral taxonomy involves corpora of observations of overt macrobehavior and the attempt to establish lists which give the associations among external states and events. Within linguistics, structuralism attempted to record sentences and describe them solely on the basis of macroempirical evidence. Thus, for example, the structural linguist might have described the sentence Open the door! syntactically by decomposing it into a verb followed by a noun phrase which in turn consists of a determiner and a noun. This structural description was purported to be determined on the basis of the distributional similarities between constituents of this sentence and other sentences such as Open a window!, Close the door!, etc. Within psychology, behaviorists have considered the uttering of a sentence like Open the door! as the stimulus which elicits a 'door-opening response.' This association is established because of a significant, temporally ordered correlation between these two events. A complete account of all possible human responses to all possible stimuli would constitute a complete taxonomy of human behavior. By explicit intent and actual fact, behavioral taxonomies may not be taken as descriptions of internal processes, but rather as an enumeration of the associations among the external events which result from internal processes.

(2) Within the field of biology, the anatomist constructs descriptions of hierarchically organized morphological components as defined by material substances possessing spatial integrity and continuity. An anatomical description of the nervous system cannot be considered to explain cognitive processes, but it is relevant to our concerns here in two ways. First, this level of description forms the fundamental basis for any innateness claims inasmuch as it is primarily anatomico-histological structure which is controlled directly and indirectly by genetic factors during ontogeny. Secondly, the nature of physiological structures and processes, both innate and acquired, follows from anatomical structure.

(3) It is the level of physiological description which states the manner in which static anatomical entities function in microbehavior. Note that while all macro- and micro-events in the universe are viewable at the same level of subatomic particles, such reductionism would disallow the explanation of physiological phenomena of interest to the biologist. Similarly, the explanation of the nervous system constructed by physiologists fails to explain cognitive processes at a level which is of interest to the psychologist. Cognitive

processes represent a new topological organization of physiological processes on criteria which the physiologist as physiologist will never consider. Cognitive innateness claims, while clearly involving physiological functional systems, require more than a physiological description for their explication.

The notion of "function" in physiological systems is inseparable from the anatomical structures performing the behavior in question. However, there is a more general notion of function which is divorced from physical manifestation. Consider the notion mousetrap. Something is a mousetrap if and only if it catches mice; the physical form it takes is irrelevant to its functional status. (Cf. Fodor, 1968: pp. 113-120 with Luria, 1966: pp. 23-30) Similarly, there is a class of information processing functions which has been defined in the field of cybernetics involving such notions as input device, memory store, matching function, and so on. (See, e.g., Singh, 1966)

(4) If we consider a human being as a (large) black box capable of receiving sensory input and performing motor output, we could attempt to construct an automaton which was the macrobehavioral functional equivalent of a human being. Given a behavioral taxonomy which listed all human input-output relations for a given domain, we might devise a robot whose behavior was isomorphic to the overt behavior of people. Such a device I have called a behavioral isomorphism model. Note that the only constraint on the contents and internal workings of the robot is that its overt behavior be isomorphic to the overt behavior of the system being modeled. There is, of course, no guarantee that the internal organization of the robot's functional components would also be isomorphic to the actual organization of human cognitive processes, and therefore, models reaching only behavioral isomorphism cannot be considered to describe internal cognitive processes. Notice also that functional isomorphism models may be constructed at any level of micro- or macrobehavior. Computer simulation models have been constructed of entire countries, economies, social groups, individual neurons, and subatomic particles. (Borko, 1962; Dutton and Starbuck, 1971; Martin, 1968; Maisel and Gnugnoli, 1972; Reitman, 1971)

Within the field of psychology, there has developed a methodology for characterizing cognitive processes as information processing functions and constructing black box functional equivalence models. Many models of human visual and auditory pattern recognition, problem-solving of various sorts, short and long-term memory processing, learning and concept formation have been presented.

(See Lindsay and Norman, 1972; Neisser, 1968; Reitman, 1965) The attempt is made to go beyond behavioral isomorphism by constructing automata whose internal organization is isomorphic to the actual information processing functions which people employ. In addition to the facts from a macrobehavioral taxonomy, psychological isomorphism models utilize many other types of data, including metadata from human subjects concerning the chronological ordering, organization, and nature of the internal cognitive processes involved in particular classes of behavior. No claims are made regarding the organization of the actual physiological operations which constitute the cognitive processes, since it is the abstract black box notion of function which is involved here. Nevertheless, this is the first level of theorizing which in any way may be considered to describe internal cognitive processes and therefore to provide a valid theoretical framework for the field of psycholinguistics. The developmental psycholinguist operating from this point of view would in effect be attempting to 'build' an automaton which was functionally equivalent to the child in all relevant domains. Those functional components which were determined to be innate in the human species would be 'wired in' [illegible] the automaton would be exposed to the equivalent of the environment in which a child develops. An adequate model would 'acquire' language, exhibiting external behavior and internal organization which was isomorphic to that of an actual child.

(6) Informally, it is quite common to talk about a transformational grammar as though it were a psychological isomorphism model; as though transformational rules were psychological isomorphism functions which dynamically formed surface structures from underlying deep structures rather than what they are formally: static, non-directional mappings between two sets of trees. As Chomsky (1971) has correctly pointed out, there are no processes defined in a transformational grammar; no logical or chronological orderings such that first one structure is defined and then another. It is simply the case that the standard theory of transformational grammar describes the set of grammatical sentences which is taken to constitute the "language" by associating with each sentence four formal objects: a phonetic representation, a deep syntactic structure, a surface syntactic structure and a semantic representation. Insofar as it goes beyond a behavioral taxonomy, a transformational grammar provides an abstract characterization of relations among sentences.[4] It accounts for people's

[4] A relatively direct mathematical translation between an abstract characterization and a psychological isomorphism model is possible. Transformational grammar as a theoretical framework is either devoid of psychological import or clearly wrong depending on whether or not this translation is performed.

linguistic knowledge only in the same sense that the multiplication tables account for people's arithmetic knowledge. Neither number theory nor transformational grammar attempts to construct a functional equivalence model of the cognitive structures which store information in long-term memory.[5]

One may argue that nothing more than an abstract characterization of linguistic data is feasible at the present time, or that it is the most reasonable first step to take, but the formal standing of the theory should be made clear and its value to psycholinguistics understood. As an abstract characterization, a transformational grammar organizes facts which could be used as part of the evidence in constructing psychological models. However, transformational grammar itself is not a psychological model. We must deny the basic assumption on which Chomsky's innateness claims rest and, therefore, the claims themselves are without psychologically valid empirical support. The field of psycholinguistics, as a bona fide branch of cognitive psychology, must look elsewhere for the answer to the question "What is innate?".

Unfortunately, not even a psychological isomorphism model would suffice to <u>fully</u> explain language acquisition or provide an adequate framework for considering the nature of innate cognitive processes. One of the problems is that there are not enough constraints on abstract black box modeling. At best this approach could develop a large class of models, all of which had equivalent empirical consequences, but radically different internal structures. When such models are discussed for language, there is a tendency to posit gross black boxes such as <u>Auditory Perception Component</u>, or <u>Speech Output Component</u>, with no constraints on their internal structure beyond input-output isomorphism. (cf. Stevens and Halle, 1967) It is clear on neurolinguistic grounds that any account of language comprehension and language formulation which ignores the organization of subsystems of speech perception and speech production in this manner has little chance of coming close to an adequate description of the information processing operations

[5] For presentation of models of information processing in long-term memory and discussion of some of the constraints on such models see Lindsay and Norman (1972), Norman (1970), Adams (1969), Kleinmuntz (1967), Pribram (1971), Pribram (1969), Tulving and Donaldson (1972), Minsky (1968).

actually employed by people. If we make our black boxes more specific, it becomes pointless or even impossible to ignore neurophysiological processes, given the goal of describing cognitive activity.

(7) The processes involved in language are not disembodied functional notions; they are realized in the human nervous system. Innate cognitive structures exist only as aspects of neurophysiological development. If we hope to understand human language and the psychological capacities on which it rests, we must first ask what it is, as it actually exists. What is needed in order to fully explicate innate cognitive structure is a psychophysical isomorphism model; a model which shows how the physiological functions of the nervous system form the basis of the cognitively relevant subset of information processing functions. The development of such a model should be the prime goal of psycholinguistic theorizing.

If we established a valid first order set of "substantive linguistic universals," no matter which linguistic framework they were described in terms of, most likely for some subset it is reasonable to turn to innate structures as the cause. Since normal members of the human species have essentially the same articulatory-motor equipment and the same auditory perceptual equipment, and since there is clear evidence that this equipment and associated neural structures have been modified in the evolutionary process to accomodate a vocal communication system, it should come as no surprise that there are many apsects of phonetic output and phonological systems which are found universally. The more difficult questions have to do with syntactic and semantic universals. Not everyone is willing to grant that human neurological equipment has become specialized to include innate linguistic knowledge. Whatever one's position on this matter, it is unreasonable to assume that substantive universal aspects of language data can only be explained as the result of built-in linguistic knowledge in the long-term memory of newborn infants. In the first place, as Nagel (1969) points out, "it does not follow that every innate capacity to acquire knowledge must itself be an instance of knowledge." In the second place, it is open to question how many substantive linguistic universals are due to innate linguistic structures per se, versus innate or acquired more general cognitive capacities. This has become an issue of major importance in the field of psycholinguistics.

Slobin (1971) presents an extremely interesting discussion of "operating principles" (cf. the "perceptual strategies" of Fodor, Garrett, and Bever, 1968) which seem to underlie many of the observed universals of child language development and linguistic change. Even transformational psycholinguists grant that general sensory-motor and conceptual learning strategies interact with formal substantive linguistic universals (cf. McNeill, 1970). Nevertheless, the attempt to establish the innate causes for the existence of linguistic universals has been hampered by ... ly misleading notion of "innateness" and, for some scholars at least, by taking at face value Chomsky's informal claims regarding the relevance of transformational grammar to psycholinguistic concerns.

As we try to relate innateness claims in psycholinguistics to a cognitive neuropsychological framework, one of the first things we notice is the vague way of referring to "capacities" or "principles" being present at birth. This is misleading since the particular day a child happens to be born has no special significance for innateness claims. Before birth, there is both sensory experience and motor activity, hence the possibility of learning. (Carmichael, 1963; Gottlieb, 1970) Also, there is genetically controlled development of neural structures even beyond the time of puberty, so that the day of birth is not a landmark with respect to the contribution of 'nature.' If we wish to preserve the term "innate", we must consider it an etymologically inept way of referring to the presence of genetic factors in the fertilized ovum which will determine the response of the individual to the environment in which development takes place. The only sense in which cognitive structures are present at birth is the same sense in which the 30th floor of a skyscraper is present as the workers are constructing the 5th floor. The 30th floor is not present as a "capacity" or "principle" of the partially built skyscraper. It is not simply the case that the 30th floor requires "stimulation from" or "interaction with" the environment in order to be "overtly manifested." From most points of view, it is not there yet.

When we discuss innate structures we are necessarily referring to the genotype of individuals since the human species has no existence apart from the set of individuals which make it up. The fact that the genotype contains idiosyncratic as well as species-general characteristics is significant in considering innateness claims since the process of natural selection operates on idiosyncratic features in such a way that new species-general characteristics and eventually new species develop from the progeny of particular individuals. If the genetic material of all members of the human species has been specilaized to determine the development of the same linguistically relevant neural structures, presumably this is the evolutionary result of a genotypic idiosyncracy of some ancestral individual or group of individuals. Nonetheless, the genetic material of human beings continues to manifest some homologous traits shared with vertebrates, others with mammals, some with all primates, and still others with extinct hominid species. The current cognitive nature of Homo sapiens may be viewed as the result of continued neurobiological specialization in the direction of more abstract and complex information processing capabilities and away from adaptation to a narrow ecological niche.

One of the basic assumptions of most fields which study human beings is that the genetic material of all races and ethnic groups leads to identical neuropsychological equipment. Among psycholinguists, this belief is manifested in the commonly made observation that any human infant can grow up a native speaker of any language. In psycholinguistic theory, this belief leads to the search for linguistically relevant cognitive structures which became 'wired in' during the process of evolution.

The ancestors of Homo sapiens diverged from other Hominoidae at so early a date that in all likelihood, common origin accounts for only the lowest order cognitive capabilities shared with other living species. Unfortunately, none of our near relatives have survived down to the present time and the closest living primate species, the chimpanzee, is qualitatively and quantitatively quite far removed in terms of cognitive capacity. This makes comparative phylogenetic evidence for the evolution of human cognitive abilities hard to come by. For example, the existence in many diverse species of innate communication systems cannot be viewed as giving direct evidence of primitive stages of human language for reasons discussed in Lenneberg (1967) (pp. 227-239). Nevertheless, it is instructive that the vocal call systems of existing primates, including humans, involve homologous, bilaterally represented neural structures involving the sub-cortical limbic system which mediates the expression and modulation of emotions (see Robinson, 1972; Whitaker, 1973). It is only in the human species that further evolutionary development has led to lateralized cortical systems which assume control over linguistic information processing at some point in ontogenetic development.

While we have only indirect evidence of the linguistic and other cognitive capabilities of the early hominids, it is certain that the human species evolved from one or more groups of early hominids who did not share our cognitive equipment. The point at which we would agree to date the transition from pre-human to human depends to a large extent on the criteria which we choose. The beginnings of premeditated 'cultural' tool manufacture had occurred at least by the time of australopithecine subspecies 1,750,000 years ago (Tobias, 1971; Pfeiffer, 1972). From paleo-neurological evidence we know that although the brain of the australopithecines was not larger than that of the modern gorilla, it had a more 'advanced' organization than any modern non-human primate (Holloway, 1966). However, it is also clear that Australopithecus was not anatomically equipped to articulate human speech and we have no direct way of knowing what sort of communication system was employed in this early Pleistocene tool 'culture.' Significant, is the fact that the drastic and distincitive elaboration of the human nervous system took place after this time and, in the context of a rapidly developing cultural mode of adaptation.

The specialization of one cerebral hemisphere for functions not performed by the opposite hemisphere is one of the neural hallmarks of human cognitive and linguistic systems. Among mammals, only humans exhibit cerebral lateralization of any sort and the general preference for the use of one hand. The fact that fourteen out of fifteen baboons killed with frontal blows by Australopithecus were killed with right-handed blows (Birdsell, 1971) provides the first inkling of such a preference and, even if this was merely a cultural tradition indicates that our ancestors 2,000,000 years ago were on the road to the innately determined lateralization of function which we find in Homo sapiens. The majority of stone tools found in the deposits at Choukoutien were chipped by right-handed members of the species Homo erectus approximately 500,000 years ago (Oakley, 1972) but it is not known whether by this time this preference had become innate. The specialization of the left cerebral hemisphere for many important language functions has evidently existed long enough for anatomical differentiation between the two hemispheres to take place. Geschwind and Levitsky (1968) and Wada (19) have shown the existence of left-right asymmetries between the temporal speech regions of the two hemispheres for modern Homo sapiens. Wada (19) has further shown these differences to be present in newborn infants.

In a reconstruction from the fossil evidence, Lieberman and Crelin (1971) characterized the vocal tract of Neanderthal Man, a closely related "cousin" of Homo sapiens who lived from approximately 120,000 to approximately 40,000 years ago. It was determined that "classical" Neanderthal was equipped to produce a significantly different and limited range of phonetic output as compared with modern adult Homo sapiens. It should be noted that this question has no bearing on the possibility that Neanderthal had a relatively complex communication system of some sort but the overt product of this system could not have resembled human speech and, if it was vocal, would have been limited to a relatively small repetoire of phonological oppositions.

It is not unreasonable to hypothesize on anatomical and cultural evidence that Cro-magnon Man, did possess truly human cognitive capabilities 40,000 years ago, and, perhaps, human speech and language (cf. Geertz, 1962; Marshack, 1972). Actually, we may assume with certainty that these capabilities must have evolved sometime before 30,000 - 50,000 years ago since by this time the races found in modern Homo sapiens had evolved and been established in separate localities as isolated gene pools. By 25,000 - 30,000 years ago the ancestors of the American Indians had crossed over into North America (See Macgowan and Hester, 1962) and the ancestors of the Australian Aboriginies had entered Australia (Mulvaney, 1966). Given the desire to maintain the hypothesis of the psychological unity of the human species, the most reasonable assumption is that there has been no significant evolution of innate cognitive structures, but only the development of more complex cultural traditions since that time. This position obliges one to also assume that any innate linguistic structures would have had to be already established and that, at least in the past 30,000 or so years, languages have become neither more complex nor different due to genetic factors. Any new qualitative or quantitative differences due to cultural and social factors cannot yet have become incorporated into the common genetic material of our species.

Granting that the human nervous system and human cognitive capacities have had a long evolutionary history involving cumulatively more complex, 'higher' stages, is this also true of human language? Has this system of vocal symbols evolved in human culture from more humble 'animal-like' beginnings, or did it arise spontaneously in all its complexity? Barring divine, or at a minimum extraterrestrial intervention, this latter possibility seems unlikely. While some linguists and anthropologists get uneasy discussing the primitive beginnings of language, it must have begun at one or more particular times and places, developing gradually over a long period of time from a limited repetoire of emotion-laden calls to its present level of complexity. The fact that we have little evidence of how this evolution took place, is irrelevant to our conclusion that it must have happened. Speculation on the nature of the stages of language evolution may prove unverifiable except in principle, but the conclusion that therefore this evolution could not have happened, would be a non sequitur.

An important issue for innateness claims is whether our species first developed its current psychological equipment and only then began to develop language, or whether the stages in human cultural and neurobiological evolution went hand in hand, each having a causal influence on the other. Those who consider cultural evolution a totally distinct phenomenon from biological evolution fail to take account of the fact that acquired cultural knowledge exists as network structures in the nervous system. Granting that neural structures developed ontogenetically cannot modify the genetic makeup of the next generation, there is certainly a natural selective value in increased communicative efficiency between members of a social group which depends on the group as the mode of adaptation.[6] Those individuals who had the kind of nervous system which facilitated the learning of these social communication skills at appropriate stages of maturation would be more likely to be established as an isolated gene pool and to reproduce more successfully than their less verbal cohorts. Not only universal aspects of overt language

[6] Notice that the existence in so many diverse animal species of innately determined communication systems does provide ample evidence that neural structures relating to communication systems are frequently (if independently) the object of natural selection during evolution.

behavior, but the evidence from physical and cultural anthropology, human oral-pharyngeal morphology, and the organization of the central nervous system prove that in fact such an evolutionary specialization must have taken place (cf. D'Aquili, 1972). What results is a picture of mutually supportive interaction between cultural and biological evolution in the development of a complex species-specific linguistic system based on innate cognitive processes.

Nevertheless, the seriousness of our claim that cognitive aspects of human communication systems are innate will depend in part on our ability to <u>formally</u> define what we mean by the term "cognitive process." While this expression is currently being used in many different ways, it is perhaps best used to informally refer to neurophysiological systems with information processing functions of specified sorts, whether or not we can become consciously aware of them. Thus, all aspects of the information processing involved in problem solving, learning, remembering, reasoning, attention and awareness, thinking, language comprehension, language formulation, and so on, may be viewed as "cognitive" even though our conscious awareness extends to only limited aspects and levels of all of these processes.

The explanation of cognitive processes is not to be found in the gross anatomy of the human brain: its size, configuration, or the extent of cortical convolutions. Neither histological structure nor physiological processes per se explain psychological processes any more than computer hardware could explain the real world utility of computer software. The most reasonable neuropsychological assumption is that cognitive processes exist diffusely over cortical and subcortical physiological functional systems as network phenomena. Cybernetic theory has shown how information processing functions may be embodied by network structures and [illegible] remains for the cognitive psychologist to formally explain how neurophysiological functional systems embody neural network phenomena with cognitive information processing functions.[7]

As we consider the various types of nervous systems found in the animal

[7] Lamendella and Storer (to appear) takes a step in this direction by defining a cybernetic theory of neural systems whose formal neurons have valid anatomic and physiological properties.

kingdom, the evolution of the human nervous system, and the embryological development of the human brain, we find that the level of cognitive functioning corresponds to the extent to which there exist systems of neural integration. In the lowest order nervous systems, we find strictly local control of input and output functions, as well as stereotyped responses to a limited class of stimuli. Both the phylogenetic and ontogenetic development of higher order nervous systems involve in part the transfer of control processes to increasingly higher levels of organization which receive input and send output to a wider and wider range of subsystems.

A complicating factor in our understanding of neuropsychological processes is that as higher systems are developed in evolution, the old structures continue to exist, function as a system for a time during ontogeny, and then turn over only some part of their original functions to the higher systems. A superceded system maintains partial responsibility for the control of systems lower than itself in a way which makes the correlation of anatomical structure and cognitive function very difficult to ascertain. It is in this sense that a given cognitive process may be diffusely distributed not only over various cortical regions, but up and down the entire nervous system.

The genetic material determines the response of the individual to the environment in which development takes place and it is ultimately the genetic material which provides the impetus for the change to each successive stage until the nervous system is mature and the full range of species-general capabilities is present. The actual mechanisms by which neural maturation is controlled need not concern us here (for a good overall introduction to developmental neurobiology, see Jacobson, 1970; for an introduction to genetics, see, e.g., Burns, 1972). However, in formulating innateness claims it is important to consider exactly what it is which may be controlled since this sets the psychophysical limits on what may be posited as innate. We might give the following classification of those (relevant) neural structures and processes whose development in humans is triggered according to an innate developmental schedule:

CELLULAR

1. <u>mitosis</u> Production of neurons by the cellular division of

neuroblasts. Ceases toward the end of the first postnatal year when almost the full complement of neurons is present.

2. <u>differentiation</u> Development of the various types of neurons. Differences are in intracellular structure, size and shape of cell body; shape and extent of axonal and dendritic cell processes, and the number, location, and type of pre-synaptic junctions. Such differences have major ramifications for the physiological functioning of cell types.

SYSTEMIC

1. <u>connected systems</u> Individual neurons of particular types are organized into functional systems of specified nature, extent, and location. Within the system dendritic and axonal connectivity is both ergodic and determined.

2. <u>metasystems</u> The establishment of systems of neurons which interconnect and integrate the functions of other systems and in so doing, constitute metasystems with epifunctional significance.

3. <u>lateralization</u> The differential specialization of corresponding cortical regions of opposite hemispheres for one or another function. One hemisphere, usually the left, is "dominant" for important aspects of language processing.

4. <u>myelinization</u> The laying down of insulating myelin sheaths around the axons of specified neural systems. In general, proceeds chronologically from the lowest order sensory and motor systems to the higher order metasystems beginning at approximately the time the systems become capable of functioning. Mostly completed at puberty when the corpus callosum commissural fibers become myelinated.

The period of maturation of the human nervous system may be dated from approximately the second week after fertilization, when the neural groove is first indicated on the surface of the embryonic disc, until the time of puberty when the genetically determined species-general development is assumed to be fully played out. The field of developmental anatomy has characterized especially the first ten months of neural development in great detail, and the general patterns of histological development and morphogenesis are clear (cf. Arey, 1965; Marshall, 1968; Conel, 1939-1967). When physiological systems are established by cellular differentiation and migration, intrasystemic synaptic connections between individual neurons are due, in part, to accidents of physical proximity and are only partially developed at birth. In order for normal development of arborization of dendrites and axons, and the growth of the axonal process to establish new interconnections, there must be normal patterns of sensory input and motor output at every developmental stage. Notice, however, that in terms of specific neuron-neuron connections, the individual is in the position of a typist given a typewriter with a blank keyboard and the task of finding out which key will cause which letter to be typed. For example, in learning hand-eye coordination, even with innately given systems and systems' relations, the infant is initially unaware of the connections between a particular voluntary motor impulse which causes the arm to move, and the location of an object in the visual field. After a great deal of trial and error, the infant is able to establish the neural code which specifies which sort of impulses will send the hand where.

As the result of evolutionary specialization, certain inter- and intrasystemic neuron-neuron connections are innately determined. The reflex arc is the lowest order innate neural connection and characteristically involves a full circle of connections between sensory receptors and motor effectors without recourse to higher levels of control. For lower order nervous systems, reflex connections are extensive but their importance in the overall behavioral repetoire of animals diminishes as one moves up the phylogenetic scale. In human beings, even the simplest reflex network such as the patellar knee-jerk reflex involves connections to cortical regions. Higher order human reflexes involve cross-modal sensory-motor interaction as in the reflex which turns the head toward the source of a loud sudden noise in order to bring the sound source into the visual field. By definition, even the most complex reflex arc involves particular sensory input stimuli which lead directly to a response in specified muscle groups.

Instincts represent a qualitatively different sort of innate structure since what is determined is the implementation of a complex behavior pattern on the basis of the (conceptual) recognition of some state or event in the environment.[8] The entire existence of some species, such as bees, is organized around a series of instinctual behavior patterns, but, like reflexes,

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[8] Here, "imprinting" is taken to be a specific type of instinct with the emphasis on the recognition component and the attachment of an innate behavior pattern to a particular individual. See, e.g., Salzen, (1970); Gottlieb (1971). cf. also the "attachment behavior" of human infants, discussed in Bowlby (1969).

these innate neural structures also become less important in higher order nervous systems. While it is possible to observe many instinctual behavior patterns in newborn infants and young children, in older humans most instincts become subject to learning and voluntary control as part of the general developmental trend of shifting control functions to higher systems as they come into existence. Instinctual behavior is often only a remnant of the history of the species, and may disappear entirely in later stages of neural maturation. Because they involve conceptual recognition and goal-directed behavior of a relatively abstract sort, instincts occupy an intermediate position between obviously non-cognitive neural networks such as the knee-jerk reflex and obviously cognitive activity such as linguistic communication. Instincts share with higher order cognitive processes diffuse network representation as a new topological organization of neural systems.

During the maturation process, innate reflexes, instincts, and cognitive structures exist at various stages and levels of neural organization. They interact with the acquisition of non-innate neural structures at each stage on the basis of 'normal' sensory stimulation and motor experience. How this happens for a given cognitive process such as language is unknown at present, but it is clear that the situation is too complex to view ontogenetic maturation only in terms of a straight line development toward the "goal" of the adult nervous system. A given developmental stage may be a necessary prerequisite for the succeeding stage only because this is the way neural development has been built into the genetic blueprint during evolution. The existence in modern <u>Homo sapiens</u> of more than a hundred vestigal organs illustrates the reluctance of the evolutionary process to discard a development entirely. (Arey, 1965: p.8) Changes according to an innate developmental schedule anticipate future environments and needs, while simultaneously manifesting a modified recapitulation of the history of the species.

Phylogenetic recapitulation is involved in developmental stages not just before birth, but during the entire period of genetically controlled maturation. Much of human neural development takes place only after the infant leaves the carefully controlled uterine environment, but this merely changes the quality of the environment, not the nature of the maturational process. Thus, for example, newborn infants have the temporary ability to support their own weight when suspended, possibly as a reflection of an ancestral stage when pre-hominid infants clung to their mother's fur immediately after birth. More germane here is that children begin producing phonetic and phonological distinctions in an order which results from the maturational schedule of the nervous system. This latter, in turn, reflects evolutionary stages in the development of the species. The newborn human infant is incapable of articulating human speech sounds both because of an anatomically more 'primitive' vocal tract (cf. Lieberman, 1968; Lieberman and Crelin, 1971) and because of the immature state of the cortical motor systems which will later be involved in initiating complex instructions to the muscles of the vocal tract (Marshall, 1968; Conel, 1939-1967). The initial stages of infant vocalization are due most probably to the phylogenetically older limbic system homologous among primates.

It has been commonly observed in the psycholinguistic literature that during the prelinguistic "babbling" stage (roughly from the fourth to the twelfth months) there is a characteristic sequence of consonant production from back consonants in the early parts of the babbling stage, to front consonants occurring more frequently in the later parts of this stage. Psycholinguists operating from an abstract characterization framework have no hope of going beyond these observations to an explanation of why this sequence should be found. This is because the sequence directly reflects observed stages in the maturation of the areas of the primary motor cortex which contain the motor-homunculus projection of the vocal tract (the lower portion of the precentral gyrus; see Drachman, 1970; Sloan, 1967; Ehlinger, 1971; and Whitaker, 1973). The overt behavior of the child during the babbling stage, therefore, is the external manifestation of the child's developing abilities to produce controlled articulations based on a maturing motor cortex and the changing anatomy of the vocal tract.

The post-babbling stage, during which a true phonological system begins to underlie articulations, has also been observed to involve a characteristic sequence of consonantal development, but this time from front to back. Jakobson and Halle (1956) abstractly characterized this sequence in terms of a series of hierarchically structured feature oppositions. However, the reason why this sequence is observed in overt behavior lies in the stages of development of the secondary cortical motor areas, in particular

Broca's Area, the motor speech cortex (the foot of the inferiór frontal gyrus), which begins maturing at about twelve months postnatally. The reversed order in which consonants develop during this period compared with the babbling stage is explicable since the cortical projection of the vocal tract onto Broca's Area is the mirror image of that on the primary motor cortex. The different times at which these two cortical motor systems mature explains why a child who has no difficulty articulating velar stops as part of a non-linguistic vocalization may not be able to utter velar stops as part of a linguistic utterance. In later stages of ontogenetic development, the secondary motor cortex may 'take over' in such a way that even a conscious attempt to imitate noises or foreign sounds may be mediated through the phonological system of the speaker's native language.

Notice that these postnatal ontogenetic developmental sequences are not only innately determined but arise from neural maturation which recapitulates the phylogenetic history of the human species. Language acquisition can only be explained in this context since there is no independent cause for the existence of this succession of synchronically observable stages. Too often, one gets the impression that psycholinguists consider it sufficient to "explain" the existence of a stage b by saying that it "arises out of" the previous stage a. In fact, it may be a mistake to consider early stages of child language to be causally involved as the cumulative basis of successive stages. This is clearly seen in phonological development but it may be that even the more 'cognitive' naming stage, holophrastic stage or pivot-open stage are merely vestigal phylogenetic recapitulations which exist, operate for a time, and then are sloughed off just as many other structures of neuromaturational development. This is precisely the sort of ontogenetic manifestation one might expect to occur given that language has been built into the human nervous system through discrete evolutionary stages. Of course, this sort of speculation must be tempered with the realization that ontogeny does not literally recapitulate phylogeny. (cf., Atz, 1970) Crawling is an innate developmental stage which precedes walking, and is actually a modified remnant of the means of locomotion of an ancestor who did not have bipedal gait. It would be wrong to automatically assume the existence of an ancestral Homo crawlensis. It would also be wrong to ask how the child learns the more complex skill of walking based on the motor schemata involved in crawling, because there is no connection between these two motor skills apart from the stages of the maturation of the nervous system. Similarly, while there may or may not have existed a species of hominid whose communication system was identical to the child's pivot-open stage, it may be useless for psycholinguists to attempt to show how the pivot-open stage forms the basis of the later, more "elaborated" stages. The system underlying the pivot-open stage might be totally discarded at the appropriate point in neural maturation and a new innate (or non-innate) system come into existence.

At some point in the development of the individual, the sequence of innate stages is played out and further learning is a function of phenotypic and environmental factors with widely different results for different individuals and different environments. When this point arrives is perhaps the major bone of contention between the "nativists" and the "anti-nativists." Whatever the case at the present time, since cognitive evolution has not stopped, it may well happen that in the far distant future more and more aspects of linguistic communication, including aspects of reading and writing, or even of a particular language, may become part of the genetic endowment of Homo sapiens supersapiens.

In any event, it is certain that the child approaches the language learning task not once, but several times; not with just one set of innate structures, but rather a succession of them corresponding to developmental stages of human neuropsychological equipment. It must be remembered that between one developmental stage and the next, in a very real sense there arises a different 'animal' with a different type of nervous system, different cognitive capabilities, and a different conceptual view of the world. As each new stage appears, the language data in the environment is recast in terms of new cognitive capacities and perhaps new innate language learning strategies. Any innateness claims formulated in psycholinguistics which fail to take these facts into account, will also fail to be correct.

There is a tendency among psycholinguists to consider so-called "biological factors" as something interesting, worthy of mention in passing, but basically foreign to their concerns. Insofar as a psycholinguist seeks only a taxonomy of external speech behavior or an abstract characterization of language facts, this view is perhaps defensible. For cognitive psychologists interested in explaining cognition there is no way to avoid considering these "biological factors" since they include the cognitive processes whose explication is being sought. For cognitive psycholinguists seeking to explain child language acquisition, there is no way to avoid considering language acquisition as one aspect of general cognitive neuropsychological development. In order to adequately answer the question "What is innate?" our theoretical framework must be neuropsychological since it is only from this viewpoint that the linguistic, psycholinguistic, and neurolinguistic data can be integrated into an adequate formal account of the innate structures which underlie the acquisition of language.

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