An Explicit Formulation of the Relationship Between Tool-Using, Tool-Making, and the Emergence of Language

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If man's propositional language did not begin with speech, but with a manual gesture or sign-language system, a plausible model can be built in which tool-making and tool-using play an important part in language emergence. Even in modern speaking cultures, we learn to use tools or weapons mainly by observation of their use by others, and by signs and gestures—rather than through speech. The motor and neural elements involved in manipulation of objects and in gestural communication are very similar. The fundamental visual basis of human cognition is stressed.

The problem of this paper is to make explicit the relationship between the emergence of human language and the rise of tool-making and tool-using. That language is analogous to tool-using is an old idea. In the *Cratylus Dialogue*, Plato has Socrates liken words to weaving shuttles, and he mentions other tools such as borers, lyres, and ships (Plato, 1963). The word used for tool is *organon*, which in Middle English was so strongly tied to language as to mean the speech apparatus. However, neither Plato nor most of his successors have done much with this suggestion, except to employ the tool-metaphor in discussions of language (Baier, 1951–52; Ryle, 1953; Wittgenstein, 1969; Meredith, 1962; Rossi-Landi, 1968). Our concern is not the aptness of a Platonic figure of speech.

The topic of this paper seems most productive when it is based on hypothesis that man's earliest language was gestural rather than vocal. This theory was launched in earnest in the eighteenth century (Condillac, 1746; Rousseau, 1755), elaborated in the nineteenth (Wallace, 1881, 1895; Morgan, 1877; Tylor, 1868, 1871; Romanes, 1888, 1889), and has supporters in the twentieth (Wundt, 1916; Paget, 1956, 1963; Johannesson, 1949, 1950). None has made serious efforts to connect language with tool-using. Only one major glotto-

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gonic theorist, Ludwig Noiré, linked glottogenesis and tools, but he espoused the notion that language arose from cooperative labor, in work-chants and in imitation of the sounds produced by various tools (Noiré, 1877, 1880; cf. Bunak, 1951; Golovin, 1961).

The question is not whether tools and their uses form a semantic domain in all natural languages, but whether language has had some causal relationship to tool-using. Such a connection has been referred to in many glottogonic theories, but explicit models have been remarkably few (Bunak, 1951, 1958, 1959, 1968; Clark, 1970; Count, 1962, 1965, 1968, 1969; Dart, 1959, 1960; Hallowell, 1960, 1961, 1962; Hockett, 1959, 1960, 1967, –and Ascher, 1964; Lancaster, 1965, 1958a, 1968b, 1968c; Semënov, 1959; Spuhler, 1965; Trân Dûc Thâo, 1966, 1969, 1970; Washburn, 1959a, 1959b, 1962, 1963, 1968a, 1968b, and J. B. Lancaster, 1971; –and Jay, 1967; –and C. S. Lancaster, 1969; White, 1940, 1942).[1] I propose that a quite plausible model can be built if we take the initial form of language to have been manual-gestural, but that a model which assumes that the earliest form of propositional language was vocal-auditory creates almost insuperable difficulties.

First of all I suggest that the tool/language relationship formed only a part of a much larger system exhibiting what Maruyama (1963) calls a deviation-amplifying "second cybernetic" effect, and which Bielicki (1969) has applied to hominization theory, wherein

1. Holloway (1969; cf. Durbin, Watson, and Holloway, 1971) has a lengthy discussion of relationships between language and tools; in several respects his conclusions agree with mine, especially on the similarity between the motor-skill performance program involved in tool-making or tool-using, and the neural programs underlying effective production of spoken language. In this paper, Holloway adhered to a vocal-auditory model for early language, and thus in my opinion missed several powerful points in the tool and language relationship. In Holloway's comment on Durbin and Watson (1971), however, he admits that he has been impressed by the reports on Washoe and Sarah's language acquisition, and is therefore less committed to a vocal-auditory language model. He reserves judgment on the significance of the Washoe and Sarah studies until chimpanzees can be observed teaching other chimpanzees some form of sign-language.

Other recent comments on language origins are by Washburn and J. B. Lancaster, 1971, in their comment on a paper by Carini (1970), and in Crombie (1971), who presents some elaborate schematic diagrams inter-relating various human behaviors, although Crombie's argument is basically concerned with paedomorphosis as a major feature of hominid evolution.

symbolic communication and tool-using interact with bipedal locomotion, increased brain size, predatory behavior, elimination of seasonal sexuality, food-sharing, mating rules, economic cooperation, and sexual division of economic functions. Although my focus is on tool-language connections, I assume that the real situation was much more complex. Bielicki is not committed to a gestural language origin theory. My own preference for it stems from its elegance, in keeping with the canon of parsimonious explanation. If mankind was at first and for a long time communicating chiefly by manual gesture, the problem of a relationship with tool-making and tool-using is much simplified. The early stages in this model apply to hominids of Australopithecine grade, where tool-making is first archaeologically documented.

The visual, kinaesthetic, and cognitive pathways employed in tool-making and tool-using coincide with those which would have been required for a gestural language system. Speech, on the other hand, utilizing the vocal-auditory channel, implied the surmounting of a neurological barrier—that of the cross-modal transfer of learning, which I think could only have taken place as a result of long-established natural selective pressures on the central nervous system, unlikely to have been completed in the early phases of hominization (Ettlinger, 1967; cf. Geschwind 1970a).

I argued for the priority of a visual-gestural language in a previous paper (Hewes, 1970; 1971; cf. Wescott, 1967; 1970a), and shall not repeat this argument here. In brief, I suggest that gestural language and tool-using developed together for a long time—say, for two million years—along with other aspects of Lower Paleolithic culture, and that the achievement of relatively easy cross-modal transfer of learning to the auditory and perhaps other sensory modalities was the result of a general cognitive enhancement, rather than a specifically language-based one, even though increasing language capacity played an important part in the process.

Today we are in a stronger position than we were even a decade ago, to evaluate glottogonic theories, thanks to more information about the Australopithecines, primate behavior, including anthropoid ape acquisition of simple language systems, child language research, neurological data on language and other sound processing, and psycholinguistics in general. The most striking addition to our

knowledge in this area has been the discovery by R. A. and B. Gardner (1969, 1971) and D. Premack (1970, 1971) that chimpanzees can master simple propositional sign languages, contrary to the expectations of most linguists and many psychologists, who have been insisting that the capacity to acquire language is species specific in Homo sapiens (cf. Chomsky, 1966; Lenneberg, 1964a, 1967; Brown, R. 1970; Bronowski and Bellugi, 1970; White, 1940, 1946, 1959). If language acquisition competence extends to Pan troglodytes, and possibly the other existing Pongidae, there is certainly no good reason to deny such a capacity to the fossil Australopithecinae, with brain cases at least as large as those of chimpanzees, bipedal locomotion, and tool-making traditions surpassing anything observed in apes (cf. Stopa, 1968). If a simple manual sign-language could somehow have come into being among the Australopithecines, it seems reasonable in the light of the Washoe and Sarah experiments (which are continuing), that such behavior could have been sustained, and in the very long run, gradually improved. It is not the same thing, however, to postulate that the Australopithecines could have acquired a *spoken* language; unless further evidence is forthcoming, we have no warrant to postulate a capacity for articulate speech in the Australopithecinae. The investigators who have recently reconstructed the parameters of Neanderthal speech (Lieberman and Crelin, 1971; cf. Lieberman, 1968; Lieberman, Klatt, and Wilson, 1969) have indicated, on the basis of preliminary work, that the Australopithecinae probably could not have produced articulate speech sounds, and perhaps that Homo erectus was not much better. While such pronouncements have been made in the past with respect to pre-Homo sapiens sapiens fossil men, they have been made by anthropologists or anatomists without technical backgrounds in acoustics or the modern technology of speech-synthesis. Although judgement should be reserved until other trained investigators can check the findings of Lieberman, Crelin, Klatt, et al., we have at least an independent evidential possibility for the gestural language thesis. Recent studies of the perception of speech sounds (Liberman, et al., 1968, 1967, 1970) strengthen the case for a very slow emergence of spoken language capacity. The modern human ability to produce and decode speech rests on a very intricate neurological apparatus, as well as on particular proportions and acoustical properties of the actual vocal tract.

I do not wish to appear to minimize the value of the work of such investigators of spoken language capacity as Geschwind, Lenneberg, Orr, and Cappanari. Lenneberg's heavy emphasis on the importance of cerebral lateralization and its connection with language (1967) is, in fact, very germane to my tool-language argument, as is Geschwind's lucid explanation of the role of the limbic region in the mediation of language symbols (1964, 1967, 1968). I simply say that such work makes even better sense if language for a long time did not employ the vocal-auditory channel, but took the path of least biological resistance in becoming established first of all in the gestural-visual channel, which is also where tools mainly operate.

The difficulty of forming cross-modal learning in monkeys is well known (Blakemore and Ettlinger, 1967; Ettlinger 1961a, 1961b, 1969; Ettlinger and Blakemore, 1969; Wilson and Shaffer, 1963), although anthropoid apes may be less handicapped. The inability of apes to acquire even a few quasi-articulate speech sounds does suggest that their cortical auditory centers are somewhat isolated from the centers where visual inputs and voluntary, precise motor outputs are integrated with comparative ease. Apes and monkeys can respond to complex visual stimuli with cognitive sophistication, and with subsequent manipulatory acts in a fashion which only our species can surpass. Visual stimuli, *including visible manual gestures*, can clearly elicit constructive, voluntary finger, hand, and arm movements; whereas as in other non-human animals, sound stimuli do not. Instead, sound signals only seem to trigger various holistic "emotional" responses—such as alarm, attention, fear, fright, attraction—followed by more or less stereotyped behavior patterns—such as flight, attack, protective mothering, submission. Of course, primates, like other hearing animals, can be conditioned to sound signals, as were Pavlov's dogs. But this is not at all the same thing as reacting to new elements or configurations in a complex sensory input by constructive motor outputs. The informational content of most sounds—except for such exceptional, intricately modulated ones as bird-songs, echo-sounding in bats or sea-mammals, or human speech—is exceedingly limited.

I shall have something to say later about the kind of neurological restructuring which the hominids must have undergone in order to transform what is basically a kind of alarm system into a mechanism encoding and decoding rich and complex information about the

environment, being provided not only through hearing, but by sig ht, touch, and smell.

It is scarcely original to observe that the same kinds of environmental pressures which were leading early hominids into more open landscapes—tool-making and tool-using, new patterns of food-getting through scavenging and hunting—two or three million years or so ago (as shown by recent finds not only at Olduvai and in various South African sites, but around the northern end of Lake Rudolf in Kenya and the lower Omo Valley) were probably also driving them toward propositional language. In addition to the exigencies of tool-making and tool-using, including the relatively new role of part-time predator, I should like to stress the cognitive demands of terrain and trail mastery required in more open environments—involving factors recently investigated by Stea (nd.; 1970), and implicit in Krantz's model of pursuit-hunting (1968). Emil Menzel, Jr., working with a group of young chimpanzees at the Delta Regional Primate Research Center, has been studying informational exchange and object-searching behaviors (Menzel, 1969a, 1969c) and has also had an opportunity to observe some extremely interesting, although unplanned-for, instances of chimpanzee collaborative and constructive behavior (Menzel, 1970; cf. and C. M. Rogers, 1970), which I think bears significantly on this matter of trail and terrain cognizance. The observations of new food-handling methods and new uses of the environment (particularly the littoral environment) in Japanese macaques by Kawamura (1963), Kawai (1963; 1965; cf. Menzel, 1966) and others are also very relevant, even if we accept K. R. L. Hall's contention that diffusions of new food-habits among these macaques were based on unintentional attention-directive behavior rather than "deliberate" communication of the gestures or manual and other activities. Maturana (1970) has emphasized the connotative rather than denotative function of primate behaviors which we may interpret as "communication". I do not find these strictures damaging to my hypothesis, any more than I find Roger Brown's reservations about the syntactical character of Washoe's early sentences (1970) upsetting. On the latter point, however, it is worth noting that Brown did not have access at the time he considered syntax in young chimpanzees and in human children to the results of

Premack's work with Sarah, whose syntax is quite acceptable (Premack, 1971; cf. Toulmin, 1971).

Trân Dûc Thâo, a perceptive Vietnamese scholar, has developed a schema for the emergence of propositional language from basic pointing gestures which could ultimately generate a wide diversity of signs in connection with Australopithecine hunting, tracking, tool-making, and tool-using, along with plant collecting which may also have been developing in a more human direction and away from the foraging patterns of apes and monkeys (Trân Dûc Thâo, 1966, 1969 a, b, 1970). Pointing has high face-value iconicity (cf. Wescott, 1967, 1970b, Swadesh, 1971). We may suppose that some gestures have greater inherent comprehensibility than others. The idea of a kind of natural selection in language as new signs were invented—although the items being selected were conceived of as spoken "roots"—goes back to Steinthal, and also was discussed by Whitney. I should think that differential effectiveness of manual gestures could be tested with chimpanzees.

I do not intend to worry much over the question of priority: tools before language, or the reverse. Since chimpanzees use some very simple tools (van Lawick-Goodall, 1964, 1968; Kortlandt, 1965, 1967 and van Zon, 1969; Menzel, Davenport, Rogers, 1970), this may seem to settle the matter, except that chimpanzees also appear to use a few simple manual or arm gestures. Simple pointing, since it requires no handling of extrasomatic objects, is conceptually less complicated, but I think a prolonged discussion about which came first, tool-using or gesture-language, would not get us far.

The limited record of stone implements is one of extremely slow technological progress: perhaps two million years on an Oldowan level, and then on to a very gently rising handaxe-, cleaver-, or more sophisticated chopper-chopping-tool and flake-using plateau for another half million years thereafter. While we are ignorant in detail of the other kinds of tools almost certainly in use during this long period, in which only the use of fire appears as a major technological addition, it is still reasonable to extrapolate from the snail-like progress of stone tools to language development. Just for the sake of illustration and not because vocabulary size is the sole measure of the cognitive growth of language, let us assume that by the year 100,000 B.C., about 250 distinct gestural signs were, on the average, in use

among the hominids. Starting with the earliest stone tools, which go back 2.6 million years, and assuming a straight-line rate of growth, this would yield a rate of one new sign every 10,000 years, certainly not a dizzy increment. Our hypothetical vocabulary of 250 signs is two or three times that so far achieved by chimpanzees in a few years, but under infinitely more efficient conditions of deliberate human instruction. It seems more reasonable, however, that the initial rate of vocabulary growth would have been slower than 1 per 10,000 years, and that toward the end of the 2.5 million year span there would have been acceleration. But even if we increased the lexicon to 1,000 signs by 100,000 B.C., this would entail only tiny adjustments in the growth curve. Semënov (1959) has shown in a series of ingenious diagrammatic illustrations, how the cognitive complexities of dealing with Oldowan tools, handaxes, and later prehistoric stone implements would have developed, and his model can be readily applied to growth in a manual gesture language. For later prehistoric times, see André Cailleux's 1953 paper.

In comparing tool-kits and lexicons, of course, we must remember that the applications or uses in both greatly exceed the number of items in each set. An Oldowan tool-kit with three components (hammer, chopper, and scraper) could be employed in dozens of different tasks, just as a gesture-language of half-a-dozen signs could handle far more than six situations. Despite the fact that no existing natural language is restricted to 1,000 or 250 signs, as countless authors of linguistics textbooks remind us, I think we must admit that at some time in the remote past, our ancestors managed with such limited lexicons.

Cerebral lateralization or hemispheric dominance plays a central role in all recent discussions of language and human cognition (Lenneberg, 1967). When and why this occurred in the course of hominization is a crucial part of any model of that process. I see it developing slowly, in connection with the evolution of tool-making and tool-using, and the rising complexity of hominid subsistence and social life generally, along with the growth of a manual-gestural language system. Hence, lateralization may have occurred to a significant extent prior to the emergence of articulate vocal language, although when it came it provided a further impetus to lateral dominance. The

distinctions between the precision and the power grip, for which Napier is best known, seem particularly cogent. Bruner has shown, in connection with the cognitive growth of the young child (1968) how the dominant hand comes to employ a variety of precision grips, while the subordinate (usually left) hand comes to act as a holder or steadier of whatever is being worked upon. More to our point, Bruner also observes (following Latif, 1934) that the left, subordinate hand plays a role comparable to the grammatical subject, and the right, dominant hand to that of the predicate. Goodnow has contrasted the diffuse functions of the subordinate hand and the focal role of the dominant hand (1969; cf. Semmes, 1968). I think there is more than metaphor here, and that both language and tool-manipulatory behavior reflect underlying cognitive mechanisms which have long been localized mainly in a single hemisphere, in order to reduce interhemispheric interference. In view of the complexities of some birdsongs, it comes as no surprise to hear that there is evidence for a degree of hemispheric lateralization in songbirds (Nottebohm, 1970).

Neither tool-using actions nor words, whether gestural or vocal, normally appear as isolated bits of behavior. Instead, they are components of more complex programs of action. Such programs can be disorganized or destroyed in cases of damage to the brain, and the disturbances of language are remarkably similar to those in motor skills. Some forms of aphasia are syntactical—the patient can still produce words, or recognize them, but cannot combine them into meaningful sentences—just as some forms of apraxia exhibit a deficit in programming sequences of meaningful action, rather than in isolated motor acts such as reaching or holding. The condition known as ideomotor apraxia (Goodglass and Kaplan, 1963; Poeck and Kerschensteiner, 1971; De Renzi, et. al., 1968; cf. Geschwind, Quadfasel, and Segarra, 1968) suggests a disturbance in an underlying deep structure very similar to that which makes propositional language possible. Both motor skill sequences and sentence constructions are adversely affected by the same lesion in many instances. It could be that this fundamental capacity to acquire and utilize complex patterned sequences, expressible in tool-manipulation, in gesture-language, and later in speech, is the "deep structure" Chomsky really should have been writing about, and that in the long course of hominization, it is the evolutionary growth in this kind of

syntactic capacity that has been so important, and not its separate manifestations in technology and language.

Motor guidance is a means of teaching new manipulatory or gestural behaviors, which consists of the mentor's actual positioning and movement of the learner's hand or hands or other body parts in conformity with the new pattern. Roger Fouts found that this was the most effective way to teach young chimpanzees new gestural signs (1970, 1971), and this method is widely used in teaching motor skills to children or adults. If such a teaching procedure came to be used during the early growth of tool-using and gestural language, it would have accelerated cultural growth. Unfortunately we have no way of determining the antiquity of this teaching method. It is important to note that such methods are not especially applicable to the acquisition of spoken language (as teachers of speech to the profoundly deaf have discovered), and that the normal hearing child must acquire speech in other ways.

Play should be mentioned as a possible arena for the interaction of tools and language. Among modern children, play is often imitation of adult motor behaviors. In older children it includes manipulation of mock-tools or weapons, and in less technologically developed cultures, of "toys" improvised from convenient natural environmental materials such as sticks, stones, sea-shells, or mud. With a postulated manual gesture language system, we would expect such play to include similar imitations of adult gestural behavior, just as it now contains much imitation of adult speech. Denzin has recently called attention to the prelinguistic gestural behavior of children (1971), in a paper which seems very pertinent here.

Without trying to justify each statement, I shall now outline my notions of the early phases of the interrelated development of language and tools.

I. For a long time, protohominids moved slowly toward bipedal locomotion in more open environments, shifting to a mixed diet (cf. Jolly [1970] on the possible part that grass-eating may have played), catching of small animals, and the making of simple tools on the order of termite-fishing twigs, palm-nut hammers, or water-soaking pads, along with tree-branches and rocks. Social communication continued to be based, as in other primates, on body postures and move-

ments, facial expressions, and vocal calls, along with some displays making use of extrasomatic objects such as sticks and branches, large stones, and handfuls of soil, sand, or gravel.

A few manual and arm gestures, describable as "pointing", may also have become part of the protohominid behavioral repertoire.

II. As territorial ranges expanded, more pressure was placed on landmark-based terrain orientation, trail-recognition, and perhaps a concomitant development of gestural signs related to terrain intelligence. Certainly ineptness at following routes through larger, open territory would have exerted a strong and, at times, even lethal pressure on individuals unfortunate enough to lose their way. Tools underwent further evolution and came to consist of some Oldowan lithic items, more carefully selected, prepared, and utilized sticks, etc., and possibly some osteodontokeratic tools of the kind which Dart has discussed. Transmission of the skills in selecting the raw materials and later fashioning of these tools, to say nothing of using them, would depend, as it does in the chimpanzee, on visual observation by juveniles of the manipulations or gestures of their elders. Observation would have sufficed for the acquisition of ways such tools would have been used to cope with the environment, whether in hunting, butchering, digging and other ways of getting plant foods, processing hard-shelled and otherwise not readily eatable foods, or the gestural signs used in integrating information about these and other activities. So far little pressure would have been generated for further development of cross-modal transfer of learning capacity, beyond what may exist in the modern pongids.

III. By the time culture had reached a "developed Oldowan" level, a modest gestural vocabulary may have been in existence. Technology, gesture language, increased terrain or geographic cognizance—now including some understanding of the movements and habits of game animals, of the ecological settings favorable for particular plant foods, under different seasonal conditions—and even some new social patterns, such as mating constraints, food-sharing, and the like, may have combined to initiate cerebral lateralization. Preferential handedness could have been important both in tool-manipulation and gestural language, and thus specifically instrumental in lateralization.

represented even though at some stage in hominization it became possible for propositional communicative functions to operate more independently of the manipulatory, constructive function.

Nothing in what I have been saying minimizes the possibility that onomatopoeia and sound-symbolism might have been of some service to hunters. Even the characteristic noises made in using certain tools could have generated some "onomatopoeic" names, although I doubt that this was a major source of any vocabulary. I am struck by the fact that in our noisy world of modern mechanical devices, some children exhibit a remarkable capacity for mimicry in this direction, even though such sound-imitations are very rarely converted into normal words. Hockett's idea that closed primate vocal calls would have led to more complex, blended new vocables, however, strikes me as unlikely (Hockett and Ascher, 1964).

A minor carry-over from the world of tools and tool-using to speech may survive in the form-classifiers which occur in many language families, although other sources for them can be suggested.

A factor which has not been emphasized and one which does not really constitute a linkage with tools, in connection with the emergence of spoken languages, is what we may call the biological benefit of Babelization. Among birds, "dialect" differences in song-patterns function as territorial markers, ultimately promoting survival through population dispersion. The diversity of spoken languages is usually regretted as a barrier to cultural contacts or as a frequent factor in military conflict, and so on. But it seems possible that diversity in local spoken language might have had some of the advantages that different birdsong dialects possess, or that territorial marking in general confers on many other species of animals. Now, as I have suggested, gesture-languages may have exhibited minimal ambiguity, and high iconicity, given the competing stimulus complexities of the visual field. But spoken language occupies a clear channel most of the time, and iconicity, aside from some traces of sound-symbolism, is unimportant. Phonetic drift and diversification may have been characteristic of speech almost from the start, whereas gesture even now may retain a basic universality.

Along these lines I may also suggest that not only did speech create new neural mechanisms for its rapid decoding, but that the olfactory sense, weak among the higher primates, may have been

cross-modally linked with visual inputs, also in connection with the hunting way of life. Human powers of smell are no more acute than those of apes, but we may surpass the apes in our ability to link visual memories with complex odors. It is not only French novelists who have been aware of the tremendous evocative power of old, familiar smells, and our remarkable capacity to re-experience complex events in visual settings when we sniff some unusual combination of odors out of times past.

Some traces of these postulated evolutionary events may explain recently detected sex-differences in sensory perception and analysis of percepts. Boys tend to exceed girls in their ability to analyze or identify environmental sounds, including animal calls, whereas girls are superior in analysis and identification of human speech sounds, on the basis of experiments with dichotic hearing (Kimura, 1961; 1967; Knox & Kimura, 1961). The experimenters believe their procedures rule out obvious experiential differences between boys and girls. No one seriously supposes that the consistent precocity of girls in acquiring speech, and their lower incidence of speech defects can be attributed to cultural learning differences (Gray and Buffery, 1971). The point is that these differences are compatible with our reconstructions of early hominid behavior, in which males would have been the principal hunters, trackers, and protectors of the group—with a survival premium on ability to analyze environmental noises, as well as spatial and constructional abilities—whereas females, as the main transmitters of speech to infants, as well as the sex with the greater need to detect the emotional overtones of vocal messages, could be expected to be more precocious in language-learning and less prone to speech-defects (Gray and Buffery, 1971).

We could break off our account here, with language now firmly vocal, except that the Upper Paleolithic exhibits an explosive upswing not only in technology, but in evidence of greatly increased cognitive and communicative powers. As André Leroi-Gourhan show us, Upper Paleolithic art can be regarded as "frozen gesture," embodying very complex cognitions. Alexander Marshack has recently examined much European Upper Paleolithic "art" on the assumption that some of it is a sophisticated notational system, partly for calendrical purposes (Marshack, 1964, 1970). Only a few millennia later, growing out of a comparable pictorial and notational art,

the first writing appears in the Middle East. Tools were now employed in direct relation to language—to engrave, impress, or paint the little pictures of animals, people, body-parts, plants, but also tools and weapons—which make the earliest writing systems more like manual gesture signs than like speech. But it was not long before the pressures of spoken language made these scripts into partly phonetic systems, and eventually into nearly completely phonetic writing—in the form of syllabaries or the alphabet. Pictorial graphics did not disappear, and they have enjoyed a significant modern comeback, despite the expansion of literacy based on phonetic scripts. Such pictorial signs have become frequent along international highways, in airports, and in great cities catering to travellers from different language areas.

I hesitate to join McLuhan in the claim that we are already in the post-Gutenberg Era, but the impacts of photography and the more recent electronic visual media force us to take a new look at writing, and even more fundamentally, at the spoken word. We are so used to speech and writing, and so impressed with the enormous powers their use has conferred on our species, that we may fail to see how awkward they are. Both spoken language and writing could be considered clumsy makeshifts, forced on a creature whose basic contacts with reality are visual and tactile. Until our own times, technology was unable to record for instantaneous transmission over immense distances, broadcast or to particular individuals, total facsimiles of complex visual events, in movement and color, and with sound accompaniment. Until 140 years ago, in fact, the replication of a single, motionless frame representing a visual scene required the work of a skilled artist for many hours or days, and further duplication, with great loss of fidelity, the work of engravers and printers. Such single frames of visual experience can now be prepared in milliseconds. The connection of tools to language has taken a most unexpected turn: many of the purposes for which language came into being in the first place can now, in principle, be taken over by tools, although it is clear that such tools or machines could not have been created without the antecedent use of language. Writing, much less speech, is not about to disappear, even though for many purposes machines have been created which handle non-language information at fantastic speed, not merely recording and storing it, or disseminating it, but analyzing it in ways very remote from spoken or written words.

Given the foregoing web of speculation, it is appropriate to ask if any part of it can be tested, or is falsifiable. Some points, as I have indicated, are based on experimental, clinical, or field observational work, though little of it so far has been conclusive. Validation of the entire hypothesis would require a huge research investment. Certain approaches are foreclosed: we cannot repeat Psammetichus' experiment on primordial speech, as reported by Herodotus. It is not feasible to wait for more wild boys from Avyeron, Caspar Hausers, or Indian wolf-children. On the other hand, there are great prospects for further work with chimpanzees, not only with language but with tool-using, just as we can expect much more to come from studies of aphasias, apraxias, child language, the deaf, speech pathology, and psycholinguistics. On the technological side, I would hope that prehistoric archaeologists interested in technology, as well as in ancient environments and social organization, might join with physical anthropologists knowledgable in primate behavior and the hominid fossil record, along with students of perceptual and motor skills. So far the interchanges among anthropologists, psychologists, and neurologists have tended to deal with such questions as man's inherent aggressiveness. I should like to see more attention devoted to what has given man his characteristic position on this planet: his tools and his language.

I am much indebted to Drs. R. Allen Gardner and Beatrice Gardner for several opportunities to visit them and their chimpanzee Washoe in Reno, Nevada. I am also grateful to Dr. David Premack, Santa Barbara, for a similar visit with him and the chimpanzee Sarah. In the summer of 1971 I was able to visit the chimpanzee group at the University of Oklahoma, in Norman, under the general direction of Dr. William Lemmon, where Dr. Roger S. Fouts is continuing the sign-language study with Washoe and several other chimpanzees. On that same trip I also visited the Delta Regional Primate Research Center, Covington, Louisiana, where I observed experiments with chimpanzee groups being carried on by assistants of Dr. Emil W. Menzel, Jr.

In 1968, thanks to a faculty fellowship from the University of Colorado, I was able to visit various African game reserves—in Kenya, Tanzania, South Africa, and Nigeria—where I observed wild baboons and other primates, but unfortunately no chimpanzees. I am also pleased to record my gratitude for hospitality provided on two visits to the Japan Monkey Centre at Inuyama and two monkey colonies on islands near Nagoya.

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