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Symbolic and Syntactic Capacities [and Discussion]

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Symbolic and syntactic capacities

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Three kinds of information invite renewed speculation about the origin of language. Studies of manual signing in chimpanzee have now shown that this species has a rudimentary symbolic capacity, but they have not shown that chimpanzee has any syntactic capacity. Diverse instances of something like language invention in historic times converge on the conclusion that iconicity is the primary principle of symbol invention, and the iconic possibilities are far greater with manual symbols than with vocal symbols. The study of fossil endocasts may eventually show when, in the fossil record, the hominid brain became organized in ways associated with linguistic capacities in present-day *Homo sapiens*, but it is unlikely ever to be able to distinguish the brain substrate for manual language from the substrate for vocal language. These several pieces of evidence suggest that the symbolic capacity developed before any syntactic capacity and was at first manifest in manual iconic form.

My title is, I think, an imperfect disguise for the fact that this is another paper on the slightly eccentric subject of the origin of language. Human beings will not let that hopeless problem rest. Fragments of new information can still entice us into trying once again, and I have three new things in mind: (1) experiments that attempt to teach a sign language to a great ape, about a dozen chimpanzees and one gorilla to date (Fouts 1973; Gardner & Gardner 1978; Patterson 1978; Terrace 1979); (2) instances of something like language invention occurring in the present day; (3) new thoughts and findings from archaeology, palaeoneurology and palaeoanthropology.

Signing in apes

The controversy concerning the nature of the capacities that have been demonstrated in studies of language-like behaviour in the great apes is especially heated just now. The rise in temperature results from the publication of a book and several papers by Terrace (1979) of Columbia University and his associates (Terrace *et al.* 1979) reporting the results of their four-year effort to teach a sign form of English to the male chimpanzee that they call Nim. Terrace's surprised conclusion from his own study is that there is no evidence that chimpanzee can create a sentence though there is evidence that chimpanzee can learn words. This is also my present opinion, but I prefer to speak of syntax rather than the sentence and symbol rather than word.

I will use symbol to mean a token or vehicle that is associated with and represents a referent on the basis of arbitrary convention (after C. S. Pierce and many others). Syntactic capacity means to me the ability to put symbols in construction so as to express compositionally meanings that are other than the sum of the meanings of the individual symbols. A simple paradigm for English is the contrast between *dog chase cat* and *cat chase dog*.

The studies of signing in the great apes have all been developmental, and my way of trying to understand their results is by comparison with what appear to be invariant features in the early stages of development of spoken and sign language in present-day *Homo sapiens*. The data base for *Homo sapiens* is, of course, far from adequate. It includes studies of a large number of historically unrelated spoken languages, Finnish, Japanese, Samoan, Luo and Mayan Cakchiquel among others (see, for example: Bloom 1970; Blount 1969; Bowerman 1973; Brown 1978; Tolbert 1978), but the studies of sign language are all of the American Sign Language (A.S.L.) (see, for example: Ashbrook 1977; Bellugi & Klima 1972; Hoffmeister 1977; Lacy 1972*a*, *b*; McIntire 1977). There are three differences between child language and ape sign language that lead me to think that young children have a syntactic capacity and that young apes do not.

Syntactic capacity

(i) *Mean length of utterance* (*m.l.u.*)

The m.l.u. in morphemes for a sample of child speech or of child sign language is calculated in a standardized way, and this index of linguistic development rises steadily with age for several years for all normal children (Brown 1973). Terrace has calculated m.l.u. values for Nim, and they do not rise at all but hold steady at values between 1.1 and 1.6. M.l.u. most directly reflects the complexity of construction that the child's brain is able to accomplish, and its steady rise probably results both from the maturation of the brain and the accumulation of linguistic information. A failure to increase suggests that the symbol combinations being produced are not in construction at all but are only strings of single symbols. In young children, for several years, the longest construction produced in a sample is closely related to the mean length of construction and is not much above the mean. Terrace reports for Nim that the upper bound or longest unbroken string is unrelated to the m.l.u. and may assume very large values when the m.l.u. is not greater than 2.0. This fact suggests that utterance length does not reflect complexity and so reinforces the impression that Nim's strings were only strings and not constructions. Nim's longest string was made of 16 signs and reads in English: 'Give orange me give eat orange me eat orange give me eat orange give me you'. There is no evidence in this string or in the other long strings reported for any great ape that the information transmitted increases with the length of string.

(ii) *Symbol sequencing*

In many languages, word order has syntactic significance and children learning such languages, from the time when they first begin combining words, follow the ordering rules of the model language. Probably sequencing is the first syntactic device that children can utilize, and it is largely because they utilize it that the constructions of child speech are roughly intelligible from the start (Brown 1970, 1973). It is fair to look at sign sequencing in Nim and all the other non-human primates for evidence of syntactic construction as opposed to symbol stringing because all of them were taught a kind of pidgin signed English that preserves English word order (Terrace *et al.* 1979). This simplest fair summary is that chimpanzees tend to produce their multi-sign combinations in all possible orders, and that suggests the absence of syntax (Brown 1970; Terrace 1979).

(iii) *Prompting and imitation*

A number of sessions between Nim and one or another teacher were put on videotape. A frame-by-frame examination of these permanent records revealed to Terrace that Nim had seldom signed spontaneously, on his own initiative, but almost always required human prompting to sign at all, and when he signed with a teacher the signs that he produced were very often complete or partial imitations of those produced by his teacher. Child speech, by contrast, is characteristically spontaneous rather than responsive, and imitations constitute a small proportion of all utterances, a proportion that rapidly approaches zero. As far as prompted imitation accounts for multi-sign combinations, there is, of course, no reason to invoke creative syntax.

In this rapid review of three reasons for believing that the great apes have not yet demonstrated a capacity for syntax, apes have been represented primarily by one chimpanzee, Terrace's Nim. It might reasonably be contended that Nim is unrepresentative by reason of training method, individual intelligence or whatever. Such is, in fact, the position of the trainers of other apes using sign language, including A. and B. Gardner, F. Patterson and R. Fouts. They may be correct, but none of them has as yet published m.l.u. data different from Terrace's nor has any published different sequencing data or data on prompting or imitation that are different from Terrace's. For the most part, they have simply not made full reports on these matters. Looking at the reported data in studies earlier than Terrace's rather than at interpretations of data, I find no reason to believe that Terrace's findings are essentially different from those of anyone else.

Symbolic capacity

It is perfectly clear that the chimpanzee and gorilla are able to make recognizable approximations to manual responses that, in the hands of humans, function as symbols. We must, however, not make much of response topography. It was excessive attention to topography that led earlier generations of psychologists and primatologists (see, for example: Hayes & Hayes 1951; Kellogg & Kellogg 1933) to concentrate on vocalization in their search for language-like behaviour. This was just the wrong place to look since vocalization in apes and monkeys is neurologically and functionally closer to vocalization in lower mammals than it is to human verbalization (Myers 1976). Superficial topography cannot establish certain manual responses as symbolic; only evidence that they are associated with, and representative of, referents can do that.

There is completely convincing evidence, both experimental and naturalistic, that all the apes so far studied associate manual signs with referents (see, for example: Gardner & Gardner 1971; Terrace 1979). The ability of apes to maintain a sizeable repertoire of conventional signs and to use them to name referents on sight and also apparently to request them when out of reach seems to me to constitute an at least rudimentary symbolic capacity, and that is the most solid new thing that these studies have taught us.

I qualify the symbolic capacity demonstrated as rudimentary because there are some kinds of evidence of representation of a referent that one always obtains from children which seem to be missing from apes. For example, a child, having looked out of the window and seen his father's car draw up, will go to his mother in the next room and announce *Daddy*, which seems to be a report. The single-word utterances of children are also used to name the agent of an action, the owner of an object or the location of something sought, and in several other ways (Greenfield & Smith 1976). It seems clear that a symbolic capacity of this sort would have far more selection value than a capacity that does not go beyond naming and requesting. As soon as a report is possible, one individual can benefit from the experience of another, and the process of making experience cumulative across individuals and across time, which is the essence of cultural evolution, can begin.

Language invention in the present

Six congenitally deaf children, born to hearing parents who would not sign to their offspring because experts on the education of the deaf advised against it, proceeded to invent their own sign language. A group (Feldman *et al.* 1978) at the University of Pennsylvania has studied the development of this language over an age range from 17 months to 54 months. The number of signs in construction increased with age, and rules of sequencing constituted the first syntax. The principal point of present interest is the fact that the invented signs were not ever arbitrary but were always iconic; that is, such as to suggest the nature of their referents. To sign *hammer* one child pounded the air, and to sign *jar* another child twisted his hand as if to remove a lid.

On the Polynesian island of Rennell, the anthropological linguist Kuschel (1973) found a congenitally deaf man, Kangobai by name, who was said to be the first deaf person born on that island in 24 generations. Kangobai had, all his life, the necessity of communicating with people whose language he could not learn. He invented a large number of signs but not, as far as Kuschel noticed, a syntax. Kangobai's signs were all iconic. To sign *drink*, he raised his cupped hand to his mouth.

Writing is language in a form that leaves an enduring trace, and, since the first writing systems were independent of speech, they constitute a record of a kind of invented language. All early writing systems known to me are stongly iconic. For instance, in the Zapotec hieroglyphs from 660 B.C. (Marcus 1980), one can still easily tell the hill-with-two-peaks glyph from the hill-of-the-puma glyph, the latter having a lion's head on top.

All naturally evolved communal sign languages have a clear strain of iconicity that is much stronger than the trickle of onomatopoeia in spoken languages (Mandel 1977; Schlesinger & Namir 1978). Manual icons do not always mime actions performed on referents; they sometimes approximate referent appearance. The two hands half-open with palms upward constitute the sign for *book* in many sign languages, and the two hands hooked at the thumbs with the fingers spread and fluttering like wings are often used to mean *butterfly*. Experiments have shown that normal hearing children, mute autistic children and adults with no knowledge of any sign language are able to learn iconic signs much more easily than non-iconic signs (Brown 1978; Konstantareas *et al.* 1978).

To say that there is always a clear iconic strain in sign languages proper is not to deny that in most respects they operate with arbitrary conventions. The evidence is clear that iconicity plays little or no role in the learning of these languages by deaf children in early childhood and that it plays no role in the processing of these languages in highly fluent adults (Klima & Bellugi 1979; Wilbur 1979). Where it does operate is in the invention of new signs (Schlesinger & Namir 1978). While this process is in many ways governed by conventional rules (allowable hand configurations, allowable locations in the signing space, etc.), there is also often a clear iconic element.

While the definition, by Pierce and myself, of the symbol specify that it must be related to its referent by purely arbitrary convention, the evidence from Gleitman's deaf children, from Kangobai, from hieroglyphs and pictograms and modern sign languages is that the primary principle of symbol invention is iconicity, a certain kind of non-arbitrariness. However, the point of the stipulation of arbitrary convention in definition of the symbol, by Pierce and everyone else, is not primarily to exclude invented icons but rather to exclude indices that are naturally related to referents in the manner of smoke to fire and a scream to a wound. There is a secondary intent to specify arbitrary convention because only this kind of association allows for an infinite variety of symbols. Iconicity is somewhat limiting but, very much to my present point, it is far less limiting when the organs of response are the hands than when they are the vocal cords and articulators.

Archaeology, palaeoneurology and palaeoanthropology

In the majority of right-handed hearing adults, the left cerebral hemisphere seems to be specialized for language processing. A lesion in Broca's area, just above the Sylvian fissure in the anterior frontal lobe, results in some degree of expressive aphasia, and a lesion in Wernicke's area, at the posterior end of the Sylvian fissure, results in receptive aphasia. If and where sign language skills are localized in the cortex is still not known for the congenitally deaf fluent user of sign language (Kimura 1979). There does seem to be good evidence (Hécaen 1975; Zangwill 1975) that ideomotor apraxia, which entails the inability to create gestural icons that might represent an object, and also ideational apraxia, which entails difficulty in integrating the components of complex motor skills such as are required for the use of some tools and the construction of most, are lateralized and in areas close to and possibly overlapping the speech areas. If we could know when in prehistoric times the hominid brain developed the areas in the left hemisphere that are in man today functionally specific to language, we might hope to know when and in what form language originated. However, the brain is software and does not fossilize. From fossil skulls much can be learned about brain size and shape, but, it was long supposed, nothing at all about the kind of functional organization represented by the two major speech areas.

Until about 10 years ago, it was the prevailing view of neurologists that the functional asymmetries of the human brain could not be correlated with anatomical asymmetries and, indeed, that there were no anatomical asymetries of consequence. It is now clear that there are anatomical differences between the hemispheres, and the most striking and consistently present of these are in the region of the posterior end of the Sylvian fissure (Geschwind & Levitsky 1968; Gallaburda *et al.* 1978). The posterior area of the planum temporale that forms part of Wernicke's area is generally larger on the left side. The gross asymmetry in size of the left and right planum temporale is associated with an asymmetry of cellular organization. A difference on the cytoarchitectonic level suggests that the hemispheral asymmetry in area size may be functionally associated with language processing. Is there any way that this anatomical difference could be detected in fossil skulls?

The pressure of the brain on the inner table of the skull vault during the life of the individual causes an impression to be formed that preserves some of the local variations of contour. For fossil skulls casts have been made of the endocranium, and these endocasts have been studied for indications of anatomical asymmetry of the cerebral hemispheres. Holloway wrote in 1976 that, with the possible exception of the Neanderthal fossil, La Chapelle-aux-Saints, he knew of no hominid brain endocast studied to date that unambiguously demonstrated an asymmetry between the hemispheres in a region regarded as involved in language ability. LeMay (LeMay & Culebras 1972; LeMay 1976) believes that the Sylvian fissures can be seen on the La

Chapelle-aux-Saints skull and that the posterior end is higher on the right as it is in most modern right-handed persons. She believes that there is, less clearly, a hint of the same asymmetry in an endocast of Peking *H. erectus*.

Even if LeMay's observations are correct, it is not possible to infer from Sylvian asymmetries alone anything about functional language areas. From asymmetries of the fissure, asymmetries of hemispheral size do not necessarily follow; nor, of course, do asymmetries of cell architecture. Furthermore, these anatomical differences have not yet been proved to be the structural substrate for language. The great apes have the Sylvian asymmetry but certainly no spoken language, and probably only a rudimentary language capacity of any sort, and they have not been shown to have any definitive functional asymmetries at all (Geschwind 1979). So, as yet, hominid brain endocasts teach us nothing unambiguous about the origin of language, but it has been a fascinating surprise to me that they could come at all close to doing so, and, as Holloway's paper at this meeting testifies, the story is not over.

Stone tools are almost as potent as fossil skulls in attracting speculation about the origin of language. There are reasons to think that the cognitive operations involved in tool construction and in language use are similar. Tools made to standardized forms imply manual dexterity and, it can be argued, a level of social consensus that could only be attained through language (Holloway 1976). Tools and weapons give some evidence of a non-random distribution of handedness as early as Pleistocene *Australopithecus* and from handedness an inference to cerebral dominance and language is often made (Steklis & Harnad 1976). I cannot critically evaluate the many ingenious arguments. What strikes me about stone tools in the context of the other data that I have reviewed is that they are, incidentally, icons, icons that appear long before the carved statuettes and cave paintings of the Upper Palaeolithic (Marshack 1976).

A tool is in part conventional but in part, of course, suited to a purpose and so able to suggest that purpose as well as a way of life in which that purpose has a place. At any rate, we today, or the archaeologists and palaeoanthropologists among us, treat tools as icons, as not entirely conventional symbols, as chips from a very remote referent, which, surviving into the present, are able to convey a kind of report. In their own time, when transported from one context into another, they may also have functioned in this way.

Perhaps the iconic principle that appears so clearly in the invention of manual signs today first operated incidentally and unintentionally when stones were shaped to fit a function. Perhaps what will eventually seem to us most consequential in the experiments on language-like behaviour in the great apes will not be the accomplishments of Nim, Washoe and the other users of sign language, but an observation made by Premack (1976), who has used arbitrary plastic tokens in most of his work, a brief observation, preliminary to the work with arbitrary tokens. Premack found that icons resembling various fruit referents were learned more easily and better retained than were arbitrary tokens. The ability to detect resemblance where man detects it and to benefit from such resemblance in associating a symbol with a referent could be the ability most directly relevant to the origin of language.

References (Brown)

Ashbrook, E. 1977 Development of semantic relations in the acquisition of American Sign Language. Manuscript, Salk Institute for Biological Studies, La Jolla, California.

Bellugi, U. & Klima, E. 1972 The roots of language in the sign talk of the deaf. *Psychology Today* **76**, 61–64.

Bloom, L. 1970 *Language development: form and function in emerging grammars*. Cambridge, Massachusetts: M.I.T. Press.

Blount, B. G. 1969 Acquisition of language by Luo children. Ph.D. thesis, University of California, Berkeley.

Bowerman, M. 1973 *Early syntactic development: a cross-linguistic study with special reference to Finnish.* Cambridge University Press.

Brown, R. 1970 The first sentences of child and chimpanzee. In *Psycholinguistics* (ed. R. Brown), pp. 208–231. New York: The Free Press.

Brown, R. 1973 *A first language.* Cambridge, Massachusetts: Harvard University Press.

Brown, R. 1978 Why are signed languages easier to learn than spoken languages? II. *Bull. Am. Acad. Arts Sci.* **32**, 25–44.

Feldman, H., Goldin-Meadow, S. & Gleitman, L. 1978 Beyond Herodotus: the creation of language by linguistically deprived deaf children. In *Action, gesture, and symbol* (ed. A. Lock), pp. 351–414. London: Academic Press.

Fouts, R. S. 1973 Acquisition and testing of gestural signs in four young chimpanzees. *Science, N.Y.* **180**, 978–980.

Gallaburda, A. M., LeMay, M., Kemper, T. L. & Geschwind, N. 1978 Right–left asymmetries in the brain *Science, N.Y.* **199**, 852–856.

Gardner, B. T. & Gardner, R. A. 1971 Two-way communication with an infant chimpanzee. In *Behavior of nonhuman primates* (ed. A. Schrier & F. Stollnitz), vol. 4. New York: Academic Press.

Gardner, R. A. & Gardner, B. T. 1978 Comparative psychology and language acquisition. In Psychology: the state of the art (ed. K. Salzinger & F. Denmark). *Ann. N.Y. Acad. Sci.* **309**, 37–76.

Geschwind, N. 1979 Specializations of the human brain. *Scient. Am.* **241**, 180–199.

Geschwind, N. & Levitsky, W. 1968 Human brain: left–right asymmetries in temporal speech region. *Science, N.Y.* **161**, 186–187.

Greenfield, P. M. & Smith, J. H. 1976 *The structure of communication in early language development.* New York: Academic Press.

Hayes, K. H. & Hayes, C. 1951 Intellectual development of a home-raised chimpanzee. *Proc. Am. phil. Soc.* **95**, 105.

Hécaen, H. 1975 The relationship between aphasia and disturbances of gesture and perception. In *Foundations of language development* (ed. E. H. Lenneberg & E. Lenneberg), pp. 117–133. New York: Academic Press.

Hoffmeister, R. 1977 The acquisition of American Sign Language by deaf children of deaf parents: the development of the demonstrative pronouns, locatives, and personal pronouns. Ph.D. thesis, University of Minnesota, Minneapolis.

Holloway, R. L. 1976 Paleoneurological evidence for language origins. In Origins and evolution of language and speech (ed. S. R. Harnad, H. D. Steklis & J. Lancaster). *Ann. N.Y. Acad. Sci.* **280**, 330–348.

Kellogg, W. N. & Kellogg, L. A. 1933 *The ape and the child.* New York: McGraw-Hill.

Kimura, D. 1979 Cases of 'aphasia' in the deaf. *Recent developments in language and cognition: sign language research.* Copenhagen: NATO Advanced Study Institute.

Klima, E. S. & Bellugi, U. 1979 *The signs of language.* Cambridge, Massachusetts: Harvard University Press.

Konstantareas, M., Oxman, J. & Webster, C. 1978 Iconicity: effects on the acquisition of sign language by autistic and other severely dysfunctional children. In *Understanding language through sign language research* (ed. P. Siple) pp. 213–237. New York: Academic Press.

Kuschel, R. 1973 The silent inventor: the creation of a sign language by the only deaf-mute on a Polynesian island. *Sign Lang. Stud.* **3**, 1–28.

Lacy, R. 1972*a* Development of Pola's questions. Manuscript, Salk Institute for Biological Studies, La Jolla, California.

Lacy, R. 1972*b* Development of Sonia's negations. Manuscript, Salk Institute for Biological Studies, La Jolla, California.

LeMay, M. 1976 Morphological cerebral asymmetries of modern man, fossil man, and nonhuman primate. In Origins and evolution of language and speech (ed. S. R. Harnad, H. D. Steklis & J. Lancaster). *Ann. N.Y. Acad. Sci.* **280**, 349–366.

LeMay, M. & Culebras, A. 1972 Human brain morphologic differences in the hemispheres demonstrable by carotid angiography. *New Engl. J. Med.* **287**, 168–170.

McIntire, M. 1977 The acquisition of American Sign Language hand configurations. *Sign Lang. Stud.* **16**, 247–266.

Mandel, M. 1977 Iconic devices in American Sign Language. In *On the other hand: new perspectives in American Sign Language* (ed. L. Friedman), pp. 57–107. New York: Academic Press.

Marcus, J. 1980 Zapotec writing. *Scient. Am.* **242**, 50–64.

Marshack, A. 1976 Some implications of the Paleolithic symbolic evidence for the origin of language. In Origins and evolution of language and speech (ed. S. R. Harnad, H. D. Steklis & J. Lancaster). *Ann. N.Y. Acad. Sci.* **280**, 330–348.

Myers, R. E. 1976 Comparative neurology of vocalization and speech: proof of a dichotomy. In Origins and evolution of language and speech (ed. S. R. Harnad, H. D. Steklis & J. Lancaster). *Ann. N.Y. Acad. Sci.* **280**, 745–757.

Patterson, F. G. 1978 The gestures of a gorilla: sign language acquisition in another pongid species. *Brain Lang.* **5**, 72–97.

Premack, D. 1976 *Intelligence in ape and man*. Hillsdale, New Jersey: Erlbaum.
Schlesinger, I. M. & Namir, L. (eds) 1978 *Sign language of the deaf*. New York: Academic Press.
Steklis, H. D. & Harnad, S. R. 1976 From hand to mouth: some critical stages in the evolution of language. In Origins and evolution of language and speech (ed. S. R. Harnad, H. D. Steklis & J. Lancaster). *Ann. N.Y. Acad. Sci.* **280**, 445–455.
Terrace, H. S. 1979 *Nim*. New York: Knopf.
Terrace, H. S., Petitto, L. A., Sanders, R. G. & Bever, T. G. 1979 Can an ape create a sentence? *Science, N.Y.* **206**, 891–902.
Tolbert, M. K. 1978 The acquisition of grammatical morphemes: a cross-linguistic study with reference to Mayan (Cakchiquel) and Spanish. Ph.D. thesis, Harvard University.
Wilbur, R. B. 1979 *American Sign Language and sign systems*. Baltimore: University Park Press.
Zangwill, O. L. 1975 The relation of nonverbal cognitive functions to aphasia. In *Foundations of language development* (ed. E. H. Lenneberg & E. Lenneberg), pp. 95–106. New York: Academic Press.

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I should like to say how much I admired Professor Brown's critical exposition of a subject that has usually been dealt with in a theatrical manner. I have followed most of the work of recent years on the capacity of chimpanzees to learn American Sign Language, and have been privileged to be kept informed by H. S. Terrace of his progress in the disproof of the idea that, in using or stringing, apes are demonstrating a syntactic and semantic capacity. I was surprised, however, that R. Brown made no reference to the recent work showing that pigeons can do much of what the ape is supposed to do.

Terrace's work has re-emphasized the part that cues play in experiments of the kind that Brown has described. Some recent writings almost take us back to the days of Clever Hans, the horse that could tap out the cube root of sequences of, I believe, nine numbers. I have experience of the speed with which monkeys can learn tricks, and I am very aware of the artificial circumstances out of which far-reaching conclusions are drawn. We heard (this symposium) of chimpanzees using twigs to winkle ants from a hole. Forty years ago a chimpanzee called Sally manicured my nails with a straw almost every second day. But I did not draw the conclusion that this was normal behaviour. We had a chimpanzee that painted abstracts during the period that D. Morris was our curator of mammals. Soon after, a chimpanzee in Baltimore started doing the same. I have one of his works. But since Dr Morris left the Zoo no further ape Rembrandts have turned up in our colony.

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