Language and Its Biological Context

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SUMMARY

All reasonably functioning newborn humans learn any native language effortlessly. No other species can learn human language even with effort. Such facts indicate that young humans are similar in ways which match them to properties shared by the set of natural languages. We would expect some similarities to be found in the baby's brain and others in the surrounding environment.

Up to now, the brain has revealed little to help us understand language learning. Studies of abnormal development, however, show that language can be learned in spite of severe deficits. Such data serve to constrain the list of possible cognitive precursors. The role of the environment is no clearer. Deviations have to be extreme before they affect acquisition. The biological system, the interaction between child and environment, seems robust. A possible regulatory mechanism would be the influence of the child on the relevant environment.

1. ACQUISITION AND DISSOLUTION

Acquisition and dissolution approach normal adult language processing from opposite directions, and they illuminate it in different ways. Their relationship, however, is not simple. One view which used to be very popular, and which re-emerges from time to time, was that language breakdown recapitulates language acquisition in reverse (see Caramazza, this volume). Thus, Goldstein (1948) claimed 'We can expect from the study of development of language in childhood to gain some insight into the ways of differentiation of language in aphasia. From the point of view that development is increasing integration and pathology is disintegration, and the assumption that disintegration goes through similar steps (except in reverse) as the increasing organization in children, these studies should prove productive' (pp. 34–35).

The evidence which led to such a theory was based on the assumption that behavioural similarities necessarily have deep significance. An example from phonology is that consonant clusters, like /str/ in straight, are difficult for small children to say and they attract errors in aphasic speech. No matter how many observations of this kind could be mustered, the conceptual problems in drawing parallels between the growth of the phonological system and its breakdown in aphasia are acute. The parallels tell us something about the formal structure of the domain (phonology, syntax, semantics) being studied, but the idea that aphasia is the psychological inverse of development seems impossible to sustain. The reason is that the behaviour being described is created by cognitive processes; the cognitive processes, in turn, are implemented in the brain. At a certain age, A_1, a behaviour pattern, BP_1 is the product of a cognitive state, CS_1, including both the processes which have developed by that time and the relevant accumulated knowledge. A cognitive state is, of course, a description of the function of particular parts of the brain. The cognitive state, CS_1 then, can be said to be equivalent to the brain state, BS_1. At any age (A_n) we can represent the state of development by a set of brain (BS_n)/ cognition (CS_n)/ behaviour (BP_n) triples. The shifts through time driven by normal changes in brain states, are known as maturation. The shifts through time driven by changes in cognitive states involve some form of learning. All shifts in CS will be mapped by a corresponding shift in BS and vice versa, and these shifts will, in some sense, be orderly in relation to each other. Beyond puberty, there would be no relevant changes in BS other than those driven by changes in CS because the BS is steady (more or less) beyond this point. Language dissolution, on the other hand, is driven by a change in BS caused by an aneurism, a tumour, or a degenerative illness. For there to be regression, it would be necessary not just for the behaviour pattern, BP_{n+1} to correspond to an earlier one, BP_n, but for the brain state BS_{n+1} to correspond to the equivalent earlier brain state, BS_n. For this to be possible, the process of dissolution would have to be equivalent to the process of development. Since it is not, regression is impossible on this model.

One kind of model in which regression would in principle be possible is one in which successive configurations of the cognitive systems are stored in temporal order. The order, rather than the content, could have some systematic biological mapping either by virtue of physical location or in terms of, say, chemical processes varying over time. The brain damage, then, could be selective along the dimension of equivalence. Some account such as this is used in accounts of retrograde amnesia (Cermac 1982), but no-one has suggested it for language.

2. CONTINGENCY IN DEVELOPMENT

Biology has a different role to play in development. One of the problems with the classical debate is that it was restricted in the range of explanatory possibilities. So, we were to judge whether language is innate or not; whether language acquisition depended on cognitive abilities or not (Piatelli–Palmerini 1980). It is clear that language acquisition is massively complex, with many interlocking dependencies. The language acquisition literature used to be full of painstaking descriptions of the detailed acquisition of this or that construction. But we really knew that structure does not emerge unprompted from data. Recent progress has depended on well-formulated causal models which have brought to life some of the old descriptive studies.

The way the field is moving, it seems, is in terms of contingencies. These take the form of sufficiency arguments as well as arguments from necessity. The common form of argument can be represented in terms of a contingency model (Morton 1986). The basic ideas are shown in figure 1. This would be read as the ability of a child to acquire a skill X is contingent on the prior existence of factors A, B and C. The horseshoe corresponds to the implication sign in reverse. If X is present, then A, B and C must have been present at some time. In this figure, are illustrated the three types of pre-requisite. A corresponds to a class of input from the environment; B is something which has already been learned and for which there will be other contingencies; C is something given let us call it innate for the moment though there are problems with that term. In all events, with this kind of precursor, by definition, there are no contingencies to trace in the domain of language acquisition, or, indeed, cognition as a whole. The task of the empiricist is to show that any item postulated to be of form C with relation to language, is actually of form B; that is, that it has precursors in the cognitive domain. There will, however, be contingencies for items of the form C in the domains of neurophysiology or genetics. Thus, the most hardened nativist would agree that the functioning of any language acquisition device will depend on the correct migration of cells into particular parts of the cortex which itself will depend on a large number of factors at different levels of biological description.

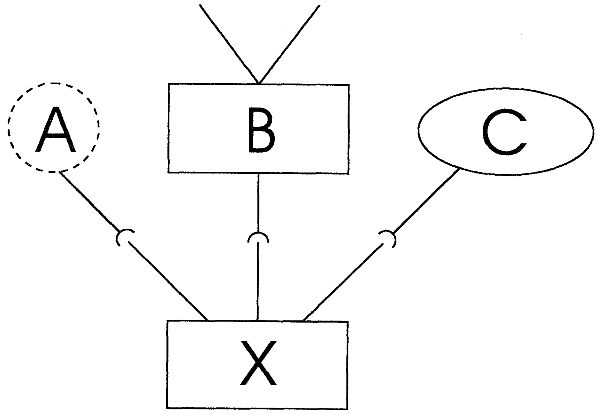

Figure 1. The ability of a child to acquire a skill X is contingent on the prior existence of factors A, B and C. The horseshoe corresponds to the implication sign in reverse. If X is present, then A, B and C must have been present at some time. The three types of pre-requisite are illustrated. A corresponds to a class of input from the environment; B is something which has already been learned and for which there will be other, prior contingencies; C is something given (roughly corresponding to innate).

Returning to the notion of the native endowment, I will draw on previous work (Johnson & Morton 1991). The context was the infant's response to faces, but this relatively simple domain helps us to see the issues more clearly than we can with something as complex and protracted as language acquisition. On the basis of a variety of experiments by ourselves and others, we concluded that the human infant was born with knowledge of the size and structure of the adult face (Morton & Johnson 1991). We called this knowledge Conspec.

It would have been natural to use the term innate with respect to Conspec. But this term is often used in the classical nature/nurture debates to refer purely to the genetic endowment. Following Oyama (1986), we could find no use for terms that are so restricted, since it is clear that one cannot meaningfully separate out the influence of the genome from that of aspects of the internal (biological) environment. It also seemed to us that we could not consider the internal environment alone. Conspec does not specify the human face, but rather anything of the right size with three blobs for eyes and mouth. Johnson and Horn (1988) established a similar fact more firmly for the chick, when they showed that a polecat (stuffed) was as attractive to the day-old chick with no visual experience as a stuffed hen. Such a loose specification of what mother will look like does not seem, in either case, to be an outstanding culmination of all these years of evolution. Yet it is outstandingly successful. Why should that be? The role of Conspec is to attract the infant's attention to faces that are in the periphery of its visual field. The success of the infant in learning about the human face, then, depends on there being lots of face stimulation in the first two months. Given that this can be guaranteed, Conspec does not have to be more precise. At this point we were able to use the concept of the species-typical environment (STE). The idea is that if the environment reliably provides the young of a species with particular information, then this information should be seen as part of the infant's biological heritage. The combination of genetic factors, the infant's internal environment and non-specific STE (such as patterned visual stimulation) constitute what we have called the primal specification. This interacts with the specific STE. Adult human faces are clearly part of the STE, and their presence within the range of the infant's limited visual discrimination is as much a part of the biological endowment with relation to faces as is Conspec.

Another example of the need to consider the relation between the STE and the role of Conspec comes from contrasting two species of monkey. Japanese macaques are raised in troupes that intermingle with other monkey species. In contrast, rhesus macaques are raised in groups isolated from other species. Thus, the STE of the young monkeys differs in a significant way. The rhesus infant can learn about the characteristics of its own species by experience since it will rarely be exposed to any others which are closely related. Thus, it would not need a precise Conspec and would be subject to 'imprinting' by any foster parent. The Japanese macaque, on the other hand, has to be able to discriminate its own species from the others with which it is reared. It is likely that information about the facial characteristics of its own species would be specified in Conspec. This information would need to be sufficiently precise to allow the range of Japanese macaques to be distinguished from all the other species to be found in the community. Without this, the infant Japanese macaque could attach to the wrong species. Fostering studies carried out at the Primate Research Institute in Kyoto indicate, as would be expected from the position put forward here, that rhesus macaques prefer foster species to own species, whereas Japanese macaques attach to their foster species (Perrett, personal communication).

We can now return to the Developmental Contingency Model and show the requirements for the development of what Johnson & Morton (1991) call Conlern. This is the structure which enables a two-month-old infant to respond in a typical way to schematic faces. In figure 2 is summarized the requirements for the STE of faces in the visual field, the primal structure Conspec, which functions to orient the infant towards these faces, and learning mechanisms.

Contingencies are defined in terms of normal development. In some cases they are obligatory, and there is a simple relation between contingency in normal development and cause in abnormal development (Morton & Frith 1995). An example is the need for a particular kind of phonological representation to have developed for the normal establishment of a graphemephoneme mapping system to be possible. If this representation is missing, dyslexia is the result, though compensatory strategies may permit the individual to learn to read.

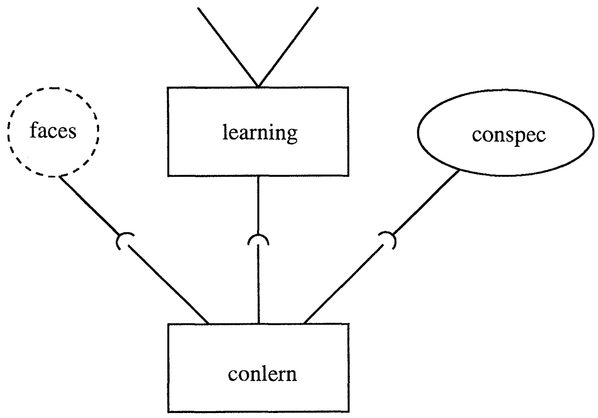

Figure 2. A developmental contingency model for Conlern, the structure which enables a two-month-old infant to respond in a typical way to schematic faces. The three types of contingency are present: environmental (faces), learning, and primal (Conspec).

3. A ROLE FOR THE ENVIRONMENT

Language acquisition has to involve an interaction between the individual and the environment. Even those philosophers who claim that all ideas have to be innate will grant that some input is necessary to reveal the particular set of ideas that are current. If we apply the framework outlined here to language acquisition, we will include the assumption that there is some primal endowment. There are a number of ways of thinking about this. The most extreme is to imagine that there is in some literal sense a gene for language which will specify the tacit knowledge of linguistic structure, corresponding to the Universal Grammar and assumed not to be learnable. This is not a coherent notion, since the things that genes code for are not of the appropriate type. There appears to be a gene whose absence leads to specific linguistic impairments (Gopnik & Crago 1991). But to call this a gene for language is to ignore the many other genes whose absence would have a similar effect. The interaction of these genes with aspects of the internal and external environment constitute the intricate biology of language.

The interaction between the individual and the environment applies to all aspects of language. The acquisition of word meaning is a good example. This involves establishing the relation between a concept and a phonological form. To do this, the concept must be differentiated, in howsoever a rudimentary fashion, from other concepts, and the phonological form must be capable of internalization (see Gleitman, this volume; Snowling & Hulme, this volume). But there is another factor to be considered, and that is the role of the environment. Consider that young children typically learn the meanings of nouns through ostensive definitions. Unfortunately, objects do not usually come along with the names painted on them. Even if they did, there would still be the problem that ostensive definitions under-determine the meaning of words. So, in order to learn the meaning of a word, the child has to know which object is the topic of the discourse and has to make a decision about what aspect of the object is being labelled. It turns out that the solution to the problem is that children only entertain a limited number of hypotheses when acquiring words meaning through ostension. They tend to assume that a word applied to an unfamiliar object refers to: (i) a kind of object rather than to a property, a substance or an individual; (ii) a kind of whole object rather than to a kind of any part of an object; (iii) a basic level kind of whole object rather than to a superordinate or subordinate kind.

Thus, Hall (1991) has shown that if the caretaker says of an object 'This is Zav' to a child of two and a half, what the child understood depended upon how familiar the object was. If it was a cat, the child understood that Zav was the proper name; for an unfamiliar blue-furred monster, the children assumed that Zav was the name of the kind of monster, in spite of the syntax of the utterance which any adult would take as signalling a proper name. For the child to learn effortlessly, the environment (i.e. the mother) should not and indeed does not provide proper names before kind terms for unfamiliar objects.

Another question is whether or not the range of the term used to apply to an object is taken to be unrestricted. Examples of restricted terms are passenger and baby which only apply in particular circumstances. In fact, Hall (1993) has shown that young children assume that count nouns, applied to objects in ostensive definitions, carry unrestricted meanings. For unfamiliar objects, this is the case even when specific information is added. Thus, if a three-year-old is taught of a novel creature 'This is a murvil because it is riding in a car', the term murvil is still applied to that creature when it is sitting on a beach. However, the same word provided with the same specific information, but applied to a familiar object, such as a duck, is treated as being restricted in application. This is all very well, but such a unilateral decision on the part of the child will profit it little unless the environment matches the strategy. As it turns out, when they teach the meanings of words, caretakers provide an input that is related to the biases of children. Thus, caretakers typically teach their children unrestricted count nouns through simple ostension ('This is a murvil') and teach restricted count nouns using more complex constructions (Hall 1995). These are not conscious strategies on the part of the caretakers, but it does seem as though they are strategies we use with other adults as well as with children. What we don't know is whether the child learns what the principles are by figuring them out from clear examples or whether some other principle guides the child's understanding.

One primal factor which might contribute to word learning is the ability to share attentional focus with another and represent other people's beliefs. This is one ability missing in autistics, and while this does not preclude autistics from learning about word meanings, Frith & Happé (this volume) will indicate that it slows them down. This is an excellent illustration of the over-determination of much of language learning. It is a classical problem: how does the child know exactly what it is that the caretaker is referring to? With normal children, the facility of joint attention and the ability to compute rapidly and accurately a representation of the beliefs, desires and intentions of the caretaker must clearly play an enormous role in the mapping of utterance onto event, and thence to a learning not just of word meaning but of the role of word order. Indeed, one might want to argue that it is a necessary component of such learning. The absence of these abilities ought, then, to be catastrophic. Instead, we see that autistics, particularly high grade autistics, are merely delayed in their word learning. A final, cautionary note on this topic: we do not, as yet, have a theory of the psychological representation of word meaning sufficiently refined to allow us even to think about, let alone test, the possibility that the autistics' representation of word meaning is very different from the normal child's.

4. LANGUAGE AND HUMANS

We can now turn to the most basic question in the biology of language. One way of expressing it is: 'What are the characteristics of chimp brains that prevent them from learning language?' A more challenging version of the question would add: 'and what would we have to know to be able to predict the outcome without knowing it in advance?' That is, faced with a brain from an unknown alien species, how would we go about determining whether they were language using, or, better, whether they were capable of being language-using?

If we had the answers to these questions, they would only be a part of the answer so far as language use is concerned. Even assuming that we could implant language in some species, it would avail little unless we included some communicative drive, a theory of mind whereby we could understand the contents of other people's minds, and ancillary devices whereby the language ability would be harnessed to evolutionarily-useful ends. A few years ago, I speculated that a successful use of language would also require the cognitive abilities enabling us to talk about the past and the future and not just the present. In other words, to be viable in competition with related species, we must be able to share our experience create a culture and plan the next day's activities. It would not be particularly advantageous, it seemed to me, simply to be able to sit around and exchange well-formed sentences on the state of the surrounding environment (Morton 1970).

What of other species? Do they lack the language mechanisms or simply lack the general cognitive capacity necessary to learn language? The work on faces opens an interesting way of looking at the problem: namely that other species have failed to develop language, not because they lack the necessary neural mechanisms but simply because the Species Typical Environment lacks the language input necessary. This argument might have been interesting 20 years ago but not now. There have been intensive attempts to place chimpanzee and gorilla in a sign-language environment to little avail. The attempt by Penny Patterson at Stanford University is the most interesting because the gorilla in question, Koko, is reported to have an IQ in the low normal range when tested on a standard intelligence test (Stanford Binet). On this test, her score fluctuated between 85 and 95 (Patterson 1978, 1980). What is interesting about Koko is that she has a measured IQ considerably in excess of many human beings who have learned language without apparent effort. The presence of language in the humans is unquestionable but while it seems that Koko displays creativity in use of sign language, there is little evidence that she possesses any syntax. Compare the following from a girl, DH, studied by my late colleague Rick Cromer. 'And how old are you now?'

> '14, nearly 15 and that's a long time when you think about it. I've been here on and off I must admit. Only because my father has a job where he has to move a lot, around a lot. So, that means I've not really been settled in one school. I'm ... I've always been shifted around, which does unsettle a child. The head ... said if you keep on moving her it's going to make her worse instead of better, so they want me to stick here now.'

This passage was spoken in conversation by a hydrocephalic girl with a measured IQ in the low 50s (Cromer 1991, 1994). She would be unable to perform many tasks which Koko would succeed on. People see such an example as an argument against the use of IQ tests, arguing that DH must be intelligent, otherwise she couldn't learn language. Apart from the circularity of such an argument, the problem is that no matter what tests are applied, DH cannot do them. We normally use our intelligence somewhere along the line in learning our native language. But if we have (nearly) no intelligence, we will learn it some other way.

Note that the lack of measurable intelligence in DH does not affect her humanity; what it means, however, is that the lack of general intelligence is insufficient reason for the inability of animals to learn language. Claims that DH is intelligent but that it only gets applied to language, however, effectively accept our argument. The existence of a specific intelligence for language is exactly what we mean by a primal endowment. Some, rote, aspects of language learning are helped by intelligence. Thus, Karmiloff–Smith (1993) has shown that French-speaking Williams Syndrome children, with IQs in the 50s or 60s, are very poor at grammatical gender (learned through general skills) but are proficient on many complex syntactic structures such as the passive, negation and conditionals, which are learned by language-specific mechanisms.

The interesting question is then the nature of the primal endowment for language. A variety of proposals are available, depending on the linguistic theory espoused by the proposer. Two options proposed by Bickerton (1984) are based on Chomsky's Universal Grammar: 'the tacit knowledge of linguistic structure that human beings must be supposed to have prior to experience'. Bickerton approaches this problem from a novel direction: the study of pidgin and creole. Pidgins are auxiliary languages that arise when speakers of several mutually unintelligible languages are in close contact. Bickerton claims that pidgin speakers lack the resources that languages normally employ in expressing complex propositions and have no consistent methods of marking tense or other forms of the verbs, no structure more complex than a single clause and no systematic way of distinguishing case relations. All of these factors distinguish pidgins from normal human languages.

By definition, there are no native speakers of pidgins. A creole then comes into existence when children are brought up in a pidgin-speaking community. Looked at perversely one could say that the children fail to learn the pidgin. In fact, what the children do is to invent the creole, introducing means to overcome all the shortcomings of pidgins referred to in the previous paragraph. Creoles, in fact, look like normal human languages. Bickerton also claims that all creoles are closely similar in structure, these similarities arising from a common substantive grammar. Bickerton calls this the bioprogram grammar.

Where does this grammar come from? In the framework Bickerton is using, Universal Grammar can be defined in terms of a set of parameters corresponding to the various sub-systems into which the language faculty can be divided, each parameter having a small number of possible settings. One example of a parameter is that, in a particular language, a head noun of a proposition either always precedes, or always follows its complements. Various combinations of such settings would yield the core grammars of all possible human languages. Normally the parameters would be set on the basis of relevant input from the language community. The bioprogram grammar would simply constitute the list of preferred settings of the parameters that would arise in the absence of any such input. The trouble with this view is that it virtually eliminates the role of the environment. It is as if the child needs no input whatsoever in order to develop the syntax that arises from the default setting. We know that this is not the case from the findings of Feldman *et al.* (1978) on the kind of signed communication that develops in communities of deaf children which do not have the benefit of signed input. In the communication systems that result, there is not the kind of syntax that typifies natural languages. However, second-generation signers do develop a creole (see Pinker 1994, pp. 36–39).

So, no input will not serve; but in the pidgin there appears to be no relevant input. Do we have to accept Bickerton's solution of default parameters? An alternative view is that in turning a pidgin input into a creole, the young child can be regarded as a function, f_l, which transforms a set of input strings into a representation (and thence into a set of output strings). But, if this function operates in one case, why should it not operate in all cases? This would mean that a natural language would be definable in terms of passing through the function, f_l, unchanged. The difference between this and the more usual account of language learning can be captured by the phrase, 'butterfly in, butterfly out'. One doesn't build a butterfly bit by bit from the input. Rather, some massive transformations are accomplished by the learning function. A few years ago, Karmiloff–Smith (1979) put forward ideas that could be fitted into this framework. She noted apparent reversals in learning in French children of five or six years whereby they start to use forms such as une de voiture to mean one car, in contrast to une voiture to mean a car.

Karmiloff–Smith proposed that this regression in performance was a transitional stage during which the child was converting her language knowledge from a set of isolated form-function pairs into a relational network. This is the kind of caterpillar-to-butterfly transformation that would serve our purposes.

This way of looking at language learning helps towards solving the problem that it does not seem to make any difference to language development whether or not caretakers use motherese in addressing their children (Newport *et al.* 1977). The suggestion is that the relation between a natural language and the derived motherese can be described in terms of the inverse function, f_l^{-1}. Furthermore, the reason that motherese is much the same world-wide, is that its creation is part of the same bioprogram. Marshall (1984) has made a similar suggestion, that motherese can be seen as a kind of natural pidgin. This is not quite accurate, however, since motherese does have the linguistic resources missing in pidgins, such as a consistent way of marking verb forms.

5. SPEECH AND SIGN

One thing that has become clear over the last decade is that natural language is not tied to speech. There is ample evidence that sign language has the characteristics of natural languages. Thus, whatever the primal endowment of the infant in respect of language, it must be expressed in a sufficiently abstract form to allow either the auraloral and the visualmanual mode to be acquired apparently with identical facility. Pettito (1993) writes:

> ‘The most striking finding is that deaf children acquiring signed languages from birth do so without any modification, loss or delay to the timing, sequence, content and maturational course associated with reaching all linguistic milestones observed in spoken language.’

This equivalence includes the syllabic babbling stage, jargon babbling, the first word stage, the two-word stage and morphological and syntactic developments. It had been thought that the first signs occurred earlier than the first words, but Pettito presents arguments against this. Pettito and her colleagues also carried out a study of hearing children, aged 7–24 months, in bilingual, bimodal homes. These children were exposed to signed and spoken language from birth. Apparently, the children achieved all linguistic milestones in the two modalities at the same time. The existence of manual babbling is particularly interesting. Pettito observes that manual babbling possesses syllabic organization, and is very different from infants’ rhythmic, non-linguistic manual activity. Pettito hypothesizes that infants may be born with a structure recognition mechanism, sensitive to units of a particular size with particular distributional patterns in the input. This would be an amodal mechanism, and would respond particularly to input structures that correspond to the rhythmic, timing and stress patterns common to natural language prosody and to input structures that correspond to the maximally-contrasting, rhythmically-alternating patterns common to the level of the syllable in natural language.

Pettito has a particularly interesting observation in the light of the previous discussion on learning the meaning of words. Young children exposed to signed languages from birth, produce their first signs to refer to kinds, as do speaking children. There is a contrast in these children between signs and symbolic gestures. These are gestures that stand for referents: such as making a brushing motion at the hair to stand for a hairbrush. Although occurring at the same time as signs, symbolic gestures are used both within and across kind boundaries. For example, the same gesture would often be used to a location, an event and an object (in a broad associative manner) rather than to one category or kind. On the other hand, signs never cross such boundaries in their application. This illustrates vividly the distinction between language and communication. Language is restricted in form and, at all levels, obeys constraints that derive from what Johnson & Morton (1991) call the primal endowment, a specific biological contribution. Communication only relies on non-specific learning ability, and is completely free in structure apart from social constraints.

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