By E. BENVENISTE

ANIMAL COMMUNICATION AND HUMAN LANGUAGE

THE LANGUAGE OF THE BEES

To apply the notion of language to the animal world is admissible only at the price of misusing terms. We know that it has been impossible until now to prove that animals enjoy, even in a rudimentary form, a means of expression endowed with the characteristics and functions of human speech. All serious observations made of animal communities, all attempts to establish or verify, by means of various technical devices, any form of speech comparable to that of man have failed. It does not seem that animals which emit certain kinds of calls are thereby displaying any behaviour from which we may infer that they are conveying 'spoken' messages to one another. The fundamental conditions for a strictly linguistic communication seem to be lacking even in the higher animal world.

The case of the bees, however, is different. At any rate, it has become apparent lately that it may turn out to be different. Everything confirms the belief that the bees possess the means of communicating with one another—a fact which has been observed for a long time. The amazing organisation of their colonies, the differentiation and co-ordination of

https://doi.org/10.1177/039219215300100101 Published online by Cambridge University Press

their activities, their capacity for reacting collectively to unforeseen circumstances, lead us to suppose that they are capable of exchanging real messages. The attention of observers has been drawn particularly to the way in which the bees are informed when one of them has discovered a source of food. Consider, e.g., a foraging bee discovering on its flight a sugar solution, placed at a certain point experimentally in order to attract its attention. It will drink of it, and while it feeds, the experimenter carefully puts a mark on it. Then it flies back to the hive. A few seconds later a flight of bees arrives on the spot, all from the same hive. The bee which discovered the food is not among them. It must have informed the others, and the information must have been quite precise since they are able to reach the spot without any guide, although it often is at a considerable distance from the hive and always out of the bees' sight. There is no error or hesitation in locating it. If the foraging bee has chosen one particular flower among others which could have also attracted it, then the bees arriving on the scene after its return fly to the same flower, neglecting all others. It seems clear that the scouting bee has indicated to its fellow bees the spot whence it has come. But how?

This fascinating problem has baffled observers for a long time. We owe it to Karl von Frisch (Professor of Zoology at the University of Munich) and to the experiments he conducted for some thirty years, that we are now in the possession of principles which enable us to solve the problem. His research has revealed the method of communication among bees. Working with a transparent hive, he has observed the conduct of the bee returning after the discovery of honey. It is immediately surrounded by the others. The excitement in the hive is great. They stretch out their antennae towards it to collect the pollen with which it is laden or they drink the nectar which it disgorges. Then, followed by the others, the scouting bee proceeds to perform dances. This is the critical moment and constitutes the act of communication. The bee performs two different dances, according to the kind of information it intends to convey. In the one dance it traces horizontal circles from right to left, then from left to right, in succession (round dance). In the other dance (wagging-dance) it wags its abdomen continually and cuts what appears to be a figure of eight in the following manner: it flies straight, then makes a full left turn, flies straight again, and begins a full turn to the right, etc. After the dances, one or several bees leave the hive and go straight to the supply spot visited by the first bee. Once they have had their fill they regain the hive, where they, in turn, perform the same dances. This causes fresh departures so

that, after a few comings and goings, some hundreds of bees swarm to the spot where the forager discovered the food.

The round dance and the wagging-dance, then, appear to be the actual message which announces the discovery to the hive. The difference between the two dances still awaited an explanation. Frisch thought that it refers to the nature of the food: the round dance announcing the nectar, the wagging-dance the pollen. These facts and their interpretation, first presented in 1923, have been much publicised, and even popularised, in the meantime.[1] It is easy to appreciate the lively interest which they have aroused. Nevertheless, they do not entitle us to ascribe to the bees a language in the strict sense of the word.

This position, however, was changed completely as a result of further experiments by Karl von Frisch, extending and correcting his first observations. He announced his findings in 1948 in technical journals and summarised them in 1950 in a small volume presenting a series of lectures he had delivered in the United States.[2] After conducting, literally, thousands of experiments with truly admirable patience and ingenuity, he succeeded in determining the real meaning of the dances. The essential new information which he provided is that the dances indicate the distance from the hive to the food and not, as he thought at first, the nature of the food. The round dance announces that the food site must be sought close by within the radius of approximately a hundred metres from the hive. The bees fly out hovering not far from the hive until they have found the spot. The other dance performed by the foraging bee, in which it wags its abdomen and cuts figures of eight, indicates that the point is at a greater distance, between a hundred metres and six kilometres. This message contains two distinct pieces of information, one about the distance, the other about the direction. The distance is indicated by the number of figures traced in a given time. It varies always in inverse proportion to their frequency. For example, the bee describes nine to ten complete cycles of the dance in fifteen seconds when the distance is a hundred metres, seven for two hundred metres, four and a half for one kilometre, and only two for six kilometres. The greater the distance, the slower the dance. As for the direction

[1] Cf., among others, Maurice Mathis, *Le peuple des abeilles*, p. 70: 'Dr. K. von Frisch had discovered . . . the behaviour of the baited bee on its return to the hive. According to the nature of the food to be exploited, honey or pollen, this bee performs a regular exhibition dance on the wax combs, turning in a circle for a sweet substance or in figures of eight for the pollen.'

[2] Karl von Frisch, *Bees, Their Vision, Chemical Senses, and Language*. Ithaca, N.Y.: Cornell University Press, 1950.

in which the food is to be sought, this is indicated by the axis of the figure of eight and its relation to the sun. According to its inclination right or left this axis gives the angle which the site forms with the sun. By virtue of their particular sensitiveness to polarised light the bees are capable of finding their bearings even when the sky is overcast. In practice there exist slight variations, in measuring the distance, between one bee and another or between one hive and another, but the variations do not affect the choice of the dance. This interpretation is the result of approximately four thousand experiments which other zoologists, at first inclined to be sceptical, have repeated and confirmed in Europe and in the United States.[3] We now have the means of ascertaining that it is in fact the dance with its two variations which the bees use to inform their fellow bees about a discovery and to guide them to the spot by giving information about direction and distance. The nature of the food, furthermore, is disclosed to the other bees by the scent on the scouting bee or by the nectar which it has drunk and which they now absorb from it. Then they take wing and infallibly reach the spot. The experimenter thus can predict the behaviour of the hive and verify the information given, according to the type and rhythm of the dance.

The importance of these discoveries for the study of animal psychology need not be stressed. We should like to dwell here on a less obvious aspect of the problem, which Frisch, intent on describing objectively his experiments, has not touched on. We are, for the first time, in a position to ascertain with precision the methods of communication used in an insect colony. We can, likewise, for the first time envisage the working of an animal 'language'. It may be well to examine briefly if and in what sense it can or cannot be called a language and how these observations on the bees could help us to find, by contrast or resemblance, a definition of human speech.

The bees appear to be capable of giving and receiving real messages which contain several data. They can register reports concerning the position and distance of a certain object. They can store these data in some kind of 'memory'. They can, furthermore, communicate them by means of symbols, using different somatic movements. Indeed, the most remarkable thing is that they show an aptitude for symbolising: there is undoubtedly a 'conventional' relation between their behaviour and the facts it conveys. This relation is perceived by the other bees in the terms in which it is transmitted to them and becomes an actuating force.

[3] Cf. Frisch, *op. cit.*, p. vii (Foreword by Donald R. Griffin).

So far we find among bees the very conditions without which no language is possible, viz., the capacity for formulating and interpreting a 'sign' which refers to a certain 'reality', the memory of an experience undergone, and the ability to decompose the remembered experience.

The message passed on contains three items of information; or, more precisely, only three have been identified until now: the existence of a source of food, its distance, and its direction. These elements could be arranged in a somewhat different way. The round dance indicates simply the presence of food and merely implies the fact that it is not far away. It is based on the mechanical principle of 'all or nothing'. The other dance conveys a real communication. The existence of food, this time, is implicit in two data (distance and direction) which are explicitly announced. There are thus several points of resemblance with human language. An effective, though rudimentary, symbolism is brought into play. Through it objective data are turned into formalised gestures conveying variable elements and an invariable 'meaning'. We are faced here with a language in the strict sense of the term, considering not only the way it functions but also the medium in which it takes place: the system is operative within a given community, and each member of the community is capable of using and of understanding it.

But the differences between the bee language and human language are considerable, and they help us to understand the truly distinctive characteristics of the latter. It should be noted, above all, that the bee's message consists entirely of physical motion, a dance, without the intervention of any 'vocal' organ, whereas there can be no real language without the exercise of voice. This leads us to another difference of a physical nature. Effectuated as it is without the exercise of voice, by means of gestures only, communication between bees necessarily occurs under conditions which permit visual perception, i.e., in daylight. It cannot be made effective in darkness. Human language is not subject to this limitation.

A very important difference exists, furthermore, with regard to the circumstances in which the communication is made. The bee's message does not call for any reply from those to whom it is addressed, except that it evokes a particular behaviour which is not strictly an answer. This means that the language of the bees lacks the dialogue which is distinctive of human speech. We speak to others who speak to us: such is the nature of human intercourse. This reveals yet another contrast. Because the bees are incapable of dialogue, the communication concerns only a certain objective fact. No 'linguistic' information is involved, there being no

reply. For a reply is a linguistic reaction to a linguistic manifestation. Moreover, the bee's message cannot be reproduced by another bee which has not seen for itself what the first bee has announced. There is no indication, for example, that a bee goes off to another hive with the message it has received in its own hive. This would constitute a kind of transmission or relay. Human language is different; for in the dialogue the reference to the objective experience and the reaction to its linguistic manifestation mix freely and without limitation. The bee does not construe a message from another message. Each bee, once advised by the scouting bee's dance, flies out and feeds at the spot indicated, reproducing the same information on its return, not with reference to the first message but with reference to the fact it has just verified itself. Now the characteristic of language is to produce a substitute for experience which can be passed on *ad infinitum* in time and space. This is the nature of our symbolism and the basis of linguistic tradition.

If we now consider the content of the message it is easy to see that it always concerns only one fact, viz., food, and that the only variations of this theme concern the question of space. The contrast with the boundless possibilities of human language is obvious. Furthermore, the behaviour which expresses the bee's message is a special form of symbolism. It consists in tracing off an objective situation of fact, the only situation which can be translated into a message, without any possibility of variation or transposition. In human language, on the contrary, the symbol as such does not trace out the facts of experience in the sense that there is no necessary relationship between the objective reference and the linguistic form.

Many more distinctions could be made here from the standpoint of human symbolism, the nature and function of which have as yet been little studied. But the difference is already sufficiently indicated.

Finally, one more feature of the communication among bees should be mentioned which distinguishes it sharply from human language. The bee's message cannot be analysed. We can see in it only an overall reference to a total content; the only possible differentiation pertains to the spatial position of the reported object. But it is impossible to resolve this content into its constituent 'morphemes' and to make each morpheme correspond to an element of what has been enounced. This is precisely where the distinctive character of human speech manifests itself. Each enunciation made by man can be reduced to elements which combine easily and freely according to definite laws so that a small number of morphemes admits

of a great number of combinations. Hence proceeds the variety of human language—which has the capacity of expressing everything. A more searching analysis of language reveals that this restricted number of morphemes, or elements of meaning, can be reduced to even less numerous 'phonemes', or elements of articulation, devoid of meaning. It is the selective and distinctive grouping of these elements of articulation which produces the sense units. These 'empty' phonemes, organised in systems, constitute the basis of every language. It is evident that no such constituent parts can be isolated in the language of the bees. It cannot be reduced to identifiable and distinctive elements.[4]

All these observations bring out the essential difference between the method of communication discovered among bees and our human language. This difference can be stated summarily in one phrase which seems to give the most appropriate definition of the manner of communication used by the bees: it is not a language but a signal code. All the characteristics of a code are present: the fixity of the subject matter, the invariability of the message, the relation to a single set of circumstances, the impossibility of separating the components of the message, and its unilateral transmission. Nevertheless, it is significant that this code, the only form of language found so far among animals, is the property of insects which live in a society. Society is likewise the condition of human language. One of the most interesting aspects of the discoveries of Karl von Frisch is that, apart from the insights into the life of the insect world, he has indirectly enlightened us as to the conditions of human language and its underlying symbolism. It is likely that further progress of this research will bring a further penetration of the possibilities and nuances of this form of communication. But the mere discovery of its existence, its nature, and its way of functioning is a contribution towards a better understanding of the origins of language and the definition of man.

[4] Since these pages were written, a review of Frisch's book by F. Lotz, published in *Word* (1951), VII, 66, has already called the attention of the linguists to this problem and offered some of the remarks presented here.