

ANIMAL RITUAL AND
HUMAN LANGUAGE

*Ma come d'animal divegna fante
Non vedi tu ancor*

Dante's *Purgatorio*, Canto 25, 61.

Von Frisch's discovery of the methods by which bees communicate is a landmark in human achievement comparable with Champollion's elucidation of hieroglyphics, and Professor Benveniste¹ has performed a service in introducing it to the notice of readers of *Diogenes*. Nevertheless the very importance of the facts discovered makes it desirable to discuss their interpretation from a somewhat different standpoint.

Bees in a hive carry out various movements which evoke responses in other bees. For example a peculiar shivering, which a human observer after an hour or so's observation can distinguish from other movements, evokes grooming movements by other bees which clean areas of the shiverer, for example, under the wings, which she cannot reach with her own jaws or legs. Several 'dances' are performed when plentiful food has been found, or in dry weather when water is brought back.

¹ E. Benveniste. *Diogenes* I, p. 1. I refer readers to his description of the 'dance', but take the opportunity of drawing attention to what would appear to be a slight error. On p. 2 in the fourth and fifth lines from the bottom it is stated that the bee 'flies' in the course of its dance in the hive. In fact it walks or runs on the comb. I would also add that von Frisch has recently given an excellent account of his recent work in *Structure et physiologie des sociétés animales*, published by the Centre National de la Recherche Scientifique, Paris.

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We will confine ourselves to one of these, the dance performed when honey or pollen has been found at a distance exceeding about seventy-five metres. Different races of bees use somewhat different movements in similar situations, but the comparative philology of bee 'languages' is still in an embryonic stage.

If we were to employ the terminology of the logic of Peano and Russell, we should say that the 'dance' was a propositional function with four variables, translated as follows. 'There is a source of food smelling of A, requiring an effort B to reach it, in direction C, of economic value D.' A is indicated by demonstration. Other bees smell the communicatrix, or receive small draughts of scented liquid from her, and then search for food sources with the appropriate scent. B is indicated symbolically by the rhythm of the dance. The number of abdominal oscillations in each straight run of the figure is about three for a flight of 125 metres, and one more oscillation for every additional 75 metres. The rhythm also slows down with the distance. As, however, it slows down when the wind on the outward journey is contrary, when the journey is uphill, or when a detour must be made, B is probably effort or time taken in reaching the food, rather than distance. The direction C of the flight is indicated by the direction of the straight part of the dance on the comb. The vertical direction indicates the direction of the sun. A deviation to the right or left of it indicates a deviation of the same angle to the west or east of the sun. The symbolism may be compared with that of a clock. The angle between the hour hand and the vertical is approximately twice the angle between the direction of the sun and the south. Finally the duration of the dance, which may vary from one second to several minutes, indicates the richness of the food source and therefore the labour force required there. If, however, we wished to use the terminology of human logic, we should have to note that items B, C, and D are quantitative, and not susceptible of a sharp dichotomy into true or false, as a verbal statement may be. The many-valued logic of Tarski and Lukasiewicz would be more appropriate than any of the systems which derive from Aristotle in which the principle of the excluded middle holds. A fuller discussion of the data, both from a statistical and a biological point of view, with a bibliography of von Frisch's and some other work on the subject, is given by Haldane and Spurway.²

Clearly we could equally well translate the dance into an imperative

² J. B. S. Haldane and H. Spurway. 'A Statistical Analysis of Communication in *Apis mellifera*, and a Comparison with Communication in Other Animals.' In the press.

'You D workers are to go to a food source smelling of A, you are to fly for B seconds in direction C.' We shall find reason later to think that this interpretation is a little truer than our first, that the 'dance' refers to the future rather than the past, but that it is not necessarily to be interpreted as a command.

Any translation of the dance into words is an anthropomorphism. But if we are to be anthropomorphic, let us be thoroughly so, first however noting a fundamental fact on which Benveniste laid little stress. The bees which fly out in response to a dance have always followed the dancer in her movements, at least for a short distance. They are not merely observers, but participants. Now if an anthropologist observes that before some important communal activity, such as harvest or war, members of a primitive human community imitate the bodily movements of another member, he will say that he is witnessing a ritual dance. If the participants, when questioned, say that this ritual is essential to the success of their undertaking, he will be tempted to add the word 'magical'. He will not, however, be surprised if, in the course of this ritual, some details regarding the future activity, for example, the direction of the enemy or the method of gathering a crop, are communicated. In Western European cultures he will find the nearest analogues to the dances of bees in country dances, many of which are believed to be vestiges of pre-Christian ritual, and in the close-order drill of soldiers, which is intended to prepare them psychologically for fighting.

The comparison of a large group of animal communications to human ritual rather than human language, has been made in great detail by E. A. Armstrong³ (a priest of the Church of England). He has successfully avoided the anthropomorphism of attempting to translate them into human sentences in the indicative mood. *Antiquum documentum novo cedat ritui* could be a maxim for students of animal communication.

If we are to go further we must survey our problem historically, that is to say, from the point of view of evolution, and consider other forms of animal communication, of which the bees' ritual represents one summit, and human language another and higher one. To do so we shall need some definitions.

I say that an activity is carried out for a purpose if it is intended to bring about a future state of affairs which can be imagined or envisaged by its performer, or to prevent such a state of affairs. Whether animals other

³ Edward A. Armstrong, *Bird Display and Behaviour*, London: Lindsay Drummond, 1947.

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than men have purpose is a question which can legitimately be asked. I say that an activity is carried out under the influence of a drive if it is not a mere reflex carried out by a small part of the nervous system, but involves the nervous system as a whole, its details being adapted to the circumstances; and if it would, were it performed by a human being, be accompanied by emotion. Reflex, drive, and purpose, of course, shade into one another in men. Breathing is normally a reflex. If it is seriously impeded, its performance occupies the consciousness and the will to a greater or less degree. The drive becomes compulsive. But it is hardly purposive. We do not breathe, unless perhaps we are physiologists, in order to add oxygen to our blood and remove carbon dioxide from it. We may drink because we are thirsty, because we look forward to enjoying the after-effects of wine, or because we think that a medicine will cure us. In the latter two cases we have a purpose. Purpose implies memory. Even our most sophisticated purposive actions are based on memories. It would be useless to use the fear of hell as a deterrent to a man who had never seen a flame or felt a pain. In making a will, one cannot avoid imagining the legatee using one's property, even if one does not expect to watch this process from another world.

I use the term 'prelude' for a movement, sometimes causing a sound, which is usually or often carried out before another more important movement. This term includes what students of animal behaviour call intention movements, which are often feeble versions of the principal movement. Thus a newt resting on the ground under water commonly raises its head a few seconds before it swims up to the surface for a breath of air. Displacement activities occur as preludes when a drive is frustrated, and a movement usually evoked by another drive is carried out; or when, as the result of a conflict of two drives, a movement originally appropriate to neither of them, but to a third, is carried out. For example, a seagull, under the simultaneous influences of the drives to attack and escape, or, in human terms, of anger and fear, plucks grass as if to build a nest. Tinbergen⁴ has shown the importance of such prelude movements for animal communication, and their tendency to be exaggerated and ritualised so as to serve this purpose.

I shall not discuss here the question of whether a prelude originally learned can become instinctive in the descendants of those who learned it. Hérédia believed so when he wrote, of a Christian peasant pouring a

⁴ N. Tinbergen, 'Derived' Activities, Their Causation, Biological Significance, Origin, and Emancipation during Evolution'. *Quarterly Review of Biology*, 27, pp. 1-32, 1952.

handful of water on the soil before drinking from a fountain, as his ancestors had done in libation to its nymph,

Il a fait, malgré lui, le geste héréditaire.

In man the commonest displacement activities are termed 'fidgeting'. These, with other prelude movements, particularly of the facial muscles, are signs of the emotions. Moreover a characteristic intention movement generates its appropriate emotion, at least in man. It is difficult to smile at a person without feeling at least some affection for him. Shakespeare's King Henry V orders his soldiers, before an attack, to make appropriate intention movements.

*Stiffen the sinews, summon up the blood,
Disguise fair nature with hard-favoured rage;
Then lend the eye a terrible aspect.*

★ ★ ★ ★

*Now set the teeth, and stretch the nostril wide,
Hold hard the breath and bend up every spirit
To his full height.*

A survey of human literature would, I think, show that the description of animal prelude movements was more effective emotionally than that of the actions which they foreshadow. Thus Virgil's Aeneas said of the snakes which devoured Laocoön

*Ardentesque oculos suffecti sanguine et igni
Sibila lambebant linguis vibrantibus ora,⁵*

lines far more memorable than the subsequent
miseros morsu depascitur artus

and Milton describes how

Th' old dragon underground

confined more closely as the result of Christ's nativity,

Swindges the scaly horror of his fouled tail.⁵

⁵ Robert Mertens gives a full account of such phenomena in 'Die Warn- und Droh-Reaktionen der Reptilien' (*Abhandlung 471 der Senckenbergischen Naturforschenden Gesellschaft*, 1946). Tail-swinging and tongue movements are common. Lizards of the genus *Phrynosoma* squirt blood from beneath their lower eyelids, while other reptiles bleed from other parts of the head. Of the snake *Tropidophis semicinctus* Mertens writes, 'Während des Blutens verloren die Augen ihre unansehnliche dunkle Färbung und wurden rubinrot.' Virgil's *suffecti sanguine* is thus probably based on observation, though the habit is commoner in American than in Old-world reptiles. Milton's lines may be an echo from Canto 1 of Marini's *La Strage degl' Innocenti*.

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Similarly Thucydides often devoted more space to the speeches before battles than to the battles themselves.

Finally by a communication from animal X to animal Y I mean an action by X involving a moderate expenditure of energy, which evokes a change in the behaviour of Y involving much larger quantities of energy. There is, of course, no sharp line between communication and more intense action. A gentle tap on another man's shoulder is a communication, a violent blow is an assault, even though it communicates to him that I am angry with him.

In many animal communications, X evokes in Y an activity very different from its own. Thus the 'hunger call' and gaping of the mouth by a young bird evokes feeding by a parent, the 'courting' activities of one sex evoke mating activity in the other, whose final stage, at least, is usually different in the two sexes. We shall not be much further concerned with such activities.

On the other hand, in social animals it is often biologically advantageous either that Y should perform an activity simultaneously with X, or that it should perform an activity like that of X though not necessarily simultaneously. Pavlov showed that an originally neutral stimulus, such as the sounding of a particular note, can release an activity (a conditioned reflex) if it is repeatedly presented shortly before, or even simultaneously with, a stimulus such as the giving of food, which releases an unconditioned reflex. If the originally neutral stimulus is given after the principal stimulus, it has no such effect. The conditioned stimulus is only effective if it points forward in time. Thus animals come to recognise intention movements of other members of their species or of men, and to respond to them. The more such intention movements can be ritualised, the more certain will be this response.

The various movements, including movements causing vocalisation, involved in courting, may be regarded as ritualised intention movements for the actual process of mating. They are forward-pointing in time in so far as observable events are concerned, though of course they are determined by the animal's physiological or psychological state in the immediate past. When, however, it is biologically advantageous that Y should carry out a similar activity to X, Y will be brought into the appropriate mood if it imitates X's intention movements or other preludes. True imitation in animals is much rarer than is usually thought, as Tinbergen⁶

⁶ N. Tinbergen, *Social Behaviour in Animals*, London: Methuen, 1953.

points out. A fish can hardly see itself swimming. It keeps its position in a shoal largely by moving so as to keep the visual images of its fellows in a nearly constant position, as it keeps those of weeds when swimming against a current while remaining in the same place. There are two conspicuous exceptions to this generalisation. It is relatively easy to imitate sounds, because a sound made by X produces similar sensations in X to a sound made by Y. We shall return to this later. In the case of bees, if bee Y has already been conditioned to the odour carried by bee X, and more rarely when it has not, it follows X in the dance, and thus automatically imitates it.

Haldane and Spurway (*loc. cit.*) have discussed in some detail the reasons for considering the bee's dance as an intention movement, that is to say, as a prediction of her future movements rather than a description of her past movements. The simplest of these reasons is the following. When a bee which has been wandering about for some time in search of food discovers a rich source, she fills her stomach or the 'baskets' for pollen on her hind legs. She then returns to the hive and dances, indicating the distance and direction of the food. This is not a report of her last outward journey; for if so she would report a much longer flight than is necessary. It is not a report of her last homeward journey; for if the wind has helped her homewards, she dances more slowly, indicating a greater effort, than if the wind has been against her, but will help her on her next outward journey. Her dance is a prediction of her next outward flight, and not a report of any past events. A number of other arguments lead to the same conclusion, that the dance ritual points forward in time, not backward.

We must remember that simple human beings describe a location in terms of imperatives. If I ask 'Where is the Town Hall?' I expect to get such an answer as 'Follow the tram lines, turn right beyond the cathedral, and go on till you see a park on your left', rather than '750 metres to the north-west', or '300 metres north of the cathedral', which would be a more 'objective' answer.

It therefore seems best to regard the bees' dances as highly ritualised intention movements before a flight, which lead any bee Y, which imitates X, to perform a similar flight. I believe it to be an unjustifiable anthropomorphism to assume either that X has a purpose of informing Y, or that Y has a purpose to fly to a certain locality. When I yawn, I have not necessarily the purpose to go to sleep. It is much more legitimate to speak of drives in such a connexion.

Some birds are notoriously gifted in imitating sounds, whether made

by other birds, men, or even machines. This capacity is most developed in birds which, at some stage in their life cycle, live in fairly large flocks, such as parrots and starlings. If a particular pattern of sound, whether as the result of learning or otherwise, is habitually produced before a certain activity, its production, whether spontaneous or imitative, will lead to that activity, or at least induce a mood favourable to it. Lorenz points out that geese, when at rest, produce polysyllabic phrases. When moving forward, the number of syllables is reduced. As a preliminary to flight it is reduced still more. In the air the 'honk' is monosyllabic. He remarks that the phrase most commonly used by domestic geese could be translated 'We are not going to fly'! This language may be complex. Promptov and Lukina⁷ can distinguish about twenty different phrases used by the great tit *Parus Major*, most of which have to be learned, and some of which are different in different communities. A single phrase, particularly an alarm call, may be enough to induce communal action in a flock of birds. But preparation for communal flight often involves a good deal of 'conversation' before anything like unanimity is reached. I suggest, then, that the function of vocal mimesis in birds is to bring about unanimity.⁸ In large flocks, for example flocks of several hundred Indian Whistling Ducks, *Dendrocygnus javanicus*, the 'debate' before a communal flight may last for some minutes, during which birds may be seen stretching their wings.

In terms of human grammar, the prelude by itself is a statement in the first person singular of the future, such as 'I shall fly'. By mimesis it becomes a statement in the first person plural of the future, or even the imperative, such as 'Let us fly'.

This interpretation is strongly supported by Lindauer's⁹ observations on the choice of a new home by a bee swarm. Bees which have found possible sites return to the swarm and indicate their directions and distances by the same symbolism as is used for food sources, save that the

⁷ A. N. Promptov and E. V. Lukina, 'Conditioned-Reflexory Differentiation of Calls in *Passeres* and its Biological Value', C. R. (Doklady) Ac. Sci. U.R.S.S. 46, pp. 382-384, 1945.

⁸ This is a development of Promptov and Lukina's statement 'The existence of adequate conditioned reflexory connexions between a definite sound stimulus (call) and the motor reaction permits of a rapid conveyance of a given physiological state from one individual to many others who in turn "broadcast" it to their neighbours'. The notion that the utterance of a cry, usually made before a certain activity, whether this connexion is innate or learned, generates the emotion or physiological state leading up to this activity, does not differ greatly from the Lange-James theory of emotion.

⁹ Martin Lindauer, 'Bientänze in der Schwarmtraube', *Naturwissenschaften* 22, pp. 509-513, 1951.

dance, being a call to the whole swarm, usually lasts for over five minutes, and may continue for an hour. Other bees follow their direction, explore the sites indicated, and may dance on returning to the swarm. At first a dozen different sites may be indicated. Lindauer gives the history of a 'debate' in which bees, to use Lenin's phrase, voted with their feet during five summer days. A site which had at first received only two out of twelve 'votes' gradually gained support. During the penultimate day, the dances favouring it rose from seven out of twenty-two to sixty-one out of sixty-three. On the next day, unanimity was reached, and the swarm set off.

In a bird flock most individuals seem to make cries. But only a few of the bees in a swarm take the trouble to fly out and to dance. Their decision sways the community. But they enjoy none of the economic or other privileges of human oligarchs, though their method of decision seems to be that of the eighteenth-century Polish nobility. Lindauer's discovery, if confirmed, may give us considerably more insight into the origin of human political systems than did Hobbes' theory of *Bellum omnium contra omnes*, or Rousseau's of the *Contrat social*, to mention two only.

It is at least plausible to believe with Engels¹⁰ that human language began in a similar way, as a preparation for communal activity. This evocative, forward-pointing character of human language is still very important.

*Li miei compagni fec'io sì aguti
con questa orazion picciola, al cammino
che apena poscia li avrei ritenuti*¹¹

said Ulisse in the *Divina Commedia*. A dancing bee could not say more if it could speak.

As a vocabulary used before different types of activity develops, some phrases must refer to activities only performed in certain situations. It is just these which are most often learned rather than inborn. Promptov and Lukina state that 'young *Paridae*, when brought up without parents, fail to develop such calls as are specifically connected with definite situations and are typical of the species, save for shrieks accompanying fright, fighting, or calls at a large distance'. Nor do they react to such calls by other birds. Here we have the beginning of language. But a phrase

¹⁰ F. Engels, 'The Part Played by Labour in the Transition from Ape to Man', English translation in *Dialectics of Nature*, London: Lawrence and Wishart, 1940.

¹¹ The quotations from Dante follow the *Testo critico della Società dantesca italiana*.

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inciting to eat can only point backwards in time, that is to say, mean 'Food is present', if the birds in question have a memory. We must, I think, distinguish between memory and recognition. Recognition merely implies a specific activity in the presence of a stimulus, and may be quite unconscious in men. In any skilled activity we react to a considerable range of stimuli unconsciously, and indeed an activity such as cycling or typing is not fully skilled until it has largely ceased to be conscious. Memory implies a revival in consciousness of past experience.

The use of a word or any other symbol as a description implies memory. The transition from evocative speech, pointing forward in time, to descriptive speech, pointing backward in time, must have been extremely difficult, and in my belief only man has made it. It seems probable that just as language made coherent, or logical, thought possible, it also made anything like coherent memory possible. Perhaps a mental image of a nut occasionally flits through a small bird's mind. It is even likely that the phrases calling to eat may evoke such images. But to proceed from the recall of such an image to a vocalisation such as 'I saw nuts on that tree last year' was one of man's greatest achievements. In its early stages any attempt to describe the past must often have been actively misleading.

If this view of man's intellectual development is anywhere near correct, the recognition of long-enduring objects, to which names could be given, was a great and difficult step. The reconstruction of an intellectually ordered picture of the past, even if it only extended over events in one's own life-time, was a still greater one. History, palaeontology, and geology seem not only to be some of man's greatest achievements, but his most humanistic.

They are, of course, pragmatically justified because we cannot plan the future without knowledge of the past.

An interest in the past for its own sake is a more human attribute than most of those to which our moral mentors urge us. Many animals are more monogamous than most human beings. Others display a greater degree of altruism, and devote more of their time to securing the welfare of future generations, even if they cannot envisage it in images drawn from the past.

We can perhaps trace the exact point in history at which a human interest in the past for its own sake was first consciously expressed. Kings had recorded their deeds for their own glory. Myths had been created embodying a certain measure of historical truth. It was left for Herodotus in his opening sentence to proclaim the historical ideal

ὡς μήτε τὰ γενόμενα ἐξ ἀνθρώπων τῷ χρόνῳ ἐξίτηλα γένηται, μήτε ἔργα μεγάλα τε καὶ θωμαστά, τὰ μὲν Ἕλλησι, τὰ δὲ βαρβάροισι ἀποδεχθέντα, ἀκλεῖα γένηται.
'So that neither should human happenings be cancelled by time, nor the great and wonderful deeds, both of the Greeks and barbarians, become without fame'.

Dante's Ulisse is perhaps the first literary figure in whom curiosity,

L'ardore

ch'i' ebbi a divenir del mondo esperto

was an obsessive passion. Dante located him in hell, but it is arguable that the lines which he wrote about him are the greatest in literature. For adumbrations of such a character we must look to some of the Norse Sagas rather than to Graeco-Roman or Asiatic writings.

For a brief period including much of the eighteenth century and perhaps all the nineteenth, curiosity and the dissemination of knowledge were almost respectable throughout Western Europe and North America. States are now beginning to exercise the control over these activities which churches did in the past.

The Aryan or Indo-European languages are still somewhat animalistic in that the simplest forms of their verbs are usually the imperative singular. In the Semitic languages the simplest form is the third person singular of the aorist, the most objective of the verb's forms. Perhaps this is one reason why Moses, Jesus, Mohammed, and Spinoza achieved, on certain matters, an appalling clarity of thought, even though Spinoza wrote, and Jesus' words only survive in, an Aryan language. I do not know whether human languages exist in which the simplest form of the verb is the first person singular of the future indicative tense, or the first person plural of the imperative mood. The example of the Marseillaise, which begins with the word *allons*, suggests that the latter is the most effective of all verbal formulæ whose repetition secures human unanimity. If languages exist with this characteristic they are, at least in that respect, closest to animal communication.

It is noteworthy that conquerors, when learning a language, first learn the imperative forms of the verbs in the language of the conquered, and may then use these as stems which are subsequently inflected. Thus the British soldiers in India learned the second person plural of the imperative of Urdu verbs, which ends in *-o* and is generally used, rather than the singular form, which is the naked verbal stem, as in Latin and French. They then provided it with English inflexions, as 'He pukkerod', from the imperative *pakro*, 'catch', rather than learn the periphrasis which does duty for

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an active past in Urdu. It may be that the coincidence of the imperative with the verb stem in Indo-European languages reflects the conquests of the 'Battle axe' peoples, while the Arabs have never been conquered.

The discovery of the past has immense practical advantages in that it enables us to plan the future. But we can only plan the future on the hypothesis that it will resemble the past in most respects. If this is so, we can hope to change a few of them.

If my thesis is correct, man differs very greatly from all other animals in his relation to time; and communications between men, which include all the arts, must be judged, among other things, by their relationship to time. A large fraction of human communication is purely evocative. It incites its recipients to certain activities, whether it is advertising, religious ritual, political oratory, or martial music. Such communications are not specifically human. Others are mere catalogues of past events. The greatest passages in literature could be said to be eddies in the stream of time. Sometimes this temporal ambiguity was deliberate, as when Hector in the *Iliad* was made to say

Ἔσσεσθαι ἡμᾶρ ὄτ' ἄν ποτ' ἄλλωλῃ Ἴλιος ἱρή

or when Sophocles' Oedipus and Jocasta spoke in ignorance of the facts known to Tiresias and to the audience.

St. Thomas Aquinas' great sacramental hymn displays an extreme subtlety with time. Beginning with *Pange lingua*, an imperative to one of the speaker's own organs, that is to say, an intention movement, or at least a prelude as defined above, it narrates certain events of Christ's life, at first in the past tense, as when the words *effudit* and *clausit* are used. But at the climax, *se dat suis manibus*, the past becomes the present, as in the ritual, and is later followed by the evocative first person plural *veneremur*. St. Thomas had already led up to the second person plural in the phrase *Nobis datus, nobis natus*. I choose this particular example just because St. Thomas undoubtedly chose his words with more scruple as to their exact meanings than most poets.

Even more remarkable are the cases where passages have gained in their emotional effect because the poets described future events. I will not write of Virgil's Messianic Eclogue, or of the fact that Dante's Ulysses anticipated Diaz. The notions that

Iam nova progenies caelo demittitur alto,

and that of the possibility of crossing the equator were certainly in other human minds when they wrote.

I prefer to quote just three of the descriptions of aerial warfare by the great poets; Virgil's of a bomb burst,

*Hic ubi coniectas moles, avulsaque saxis
Saxa vides, mixtoque undantem pulvere fumum,*

Milton's of the end of an aerial combat, where the vanquished is

*Hurl'd headlong flaming from th' ethereal skie
With hideous ruin and combustion down,*

and finally Shelley's of the sound of a rapidly moving aeroplane

*Hark ye the thunder of his fiery wheels
Grinding the winds.*

These lines mean more to us than they can have meant to any past generation. No doubt the poets, from their store of memory, were able to construct visual and auditory images of an intensity beyond anything found in the external world in their times. This is one of the functions of a great poet. But perhaps a biologist should refrain from literary criticism.

The dances of bees are philosophically important just because of their temporal ambiguity. They are at once prophecies and histories. Or shall we say that they are prophecies on their way to becoming histories? It is conceivable that in a bee's consciousness the specious present, which in a man occupies a second or less, extends over five or ten minutes. If so the dance and the flight are simultaneously present to its consciousness, as the whole of a linguistic or musical phrase is simultaneously present to a human mind. A bee's eyes and other sense organs convey so much less information per second than our own that this greater temporal extension would not imply an experience as rich as ours. Such a speculation can certainly not be verified at present. Perhaps it can never be verified.

In spite of von Frisch's magnificent work, almost everything remains to be discovered about the communication of bees. I believe that this discovery, and similar discoveries in other fields, will have very considerable effects on human thought and on human emotion. But, if my thesis is correct, they will reveal differences between men and other animals quite as striking as the similarities. They will also perhaps throw some doubt on Benveniste's statement that everything can be said in human language. The mystics at least have denied this. It seems possible that an analysis of animal communication may show that language and ritual are to some extent complementary in Bohr's sense, that we cannot, in many cases, describe what we perform, or perform what we describe. However that may be, our successors, in so far as they know more about animals, will know more about themselves.