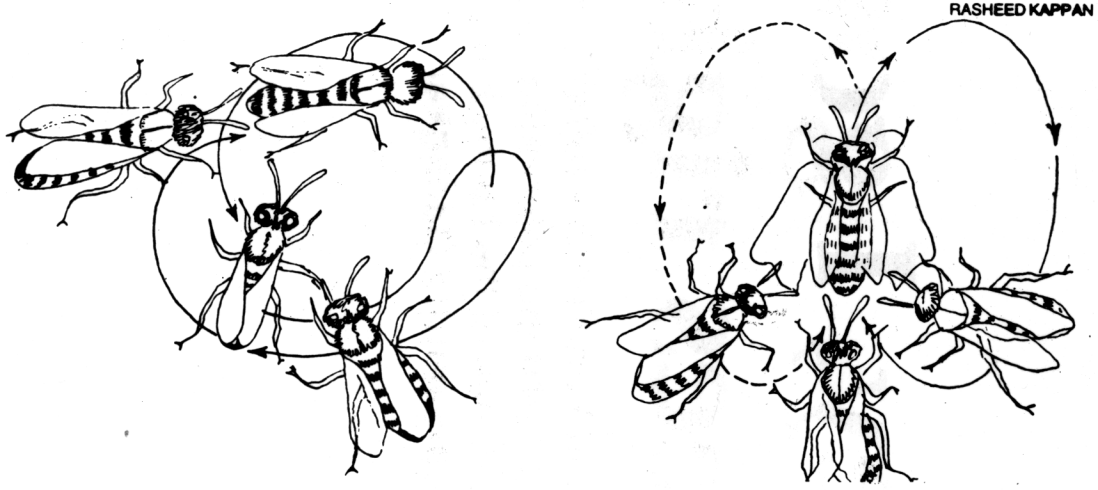
Honey, I got the bees right!

This could well be Karl Von Frisch's refrain. Recent experiments have vindicated the celebrated zoologist's findings on the dance of the honey bees, reports **Raghavendra Gadagkar**

Honey, I got the bees right!

This could well be Karl Von Frisch's refrain. Recent experiments have vindicated the celebrated zoologist's findings on the dance of the honey bees, reports **Raghavendra Gadagkar**

RASHEED KAPPAN



Dancers and their followers: (Left to right) The round dance and the waggle dance.

Humans share 99 per cent of their genetic information with the chimpanzee. What then makes us so incredibly different from chimps? Our language is often credited with being the prime mover in making humans what they are. Noam Chomsky of the Massachusetts Institute of Technology has argued that language is innate and develops spontaneously in children. We are quite unique in our ability to modulate our vocalisations because of the unusual structure of our vocal tract.

Add to the unique structure of our vocal tract our superior brains that permit us to detect virtually infinite variations in sound and associate them with objects or thoughts in an arbitrary and symbolic manner, and you have man's unparalleled ability to communicate and change

phered the honey bee dance language which enables such recruitment.

A successful forager that returns to the colony attraets the attention of her sisters by means of a chemical she releases upon arrival. This usually ensures her an attentive audience to begin her dance. The forager, who alone po sesses information on the location of food, performs either a round dance or a waggle dance. During a round dance, the bee runs in small circles, often alternating between clockwise and counter-clockwise directions. During the waggle dance, the forager waggles her body from side to side about 13 times per second while running in a straight line and then returns to the starting point without waggling her body in a clockwise or counter-clockwise direction, and

dance appears to provide no more information than that there is food close by. But the waggle dance has been shown to convey information on the distance between the colony and the food, the direction in which the food source is located as well as an indication of how much food can be expected. The dancer also smells of the pollen that she has recently encountered and that adds to the knowledge of the potential recruits, during both dances.

The direction of the waggle run contains information about the direction of the food. Most species of honey bees dance on the vertical surface of the nest and so the bees have to transform the angle between the sun (or, to be more precise, the sun's azimuth, meaning it's projection on the horizon), the food and their

run pointing straight up, a direction against the sun with a waggle run pointing downwards, a location of food 60 degrees to the right of the sun with a waggle run direction 60 degrees to the right of the vertical and so on.

Every direction in the outside world can thus be accurately conveyed by the angle of the waggle run except only when the sun is exactly overhead at the equator (when the bees simply rest for a few minutes!) The number of figure eight circuits made per unit time and the duration of each waggle run indicate the distance between the nest and the food source.

There are good reasons to call this communication systen of the honey bee a language. Firstly, the bee lanquage conveys information about something at great distance and not visible at the time

Prize in 1973 for this discovery though two scientists from California, Adrian Wenner and Patrick Wells challenged it. Their claim was that bees locate food by means of scent left by the discoverer on the way to and at the location of the food. The reason why this argument cannot be dismissed out of hand is that bees have a very well-developed sense of smel and are indeed capable of finding food by means of the scent of the discoverer.

The question is not so much whether bees can ever locate a food source by means of odour cues but whether bees can ever successfully communicate using a symbolic, arbitrary dance language without the need for scent marks of the discoverer along the way to and at the target location. This can only be tested by eliminating the scent marks of the dis-

and were expected to fly 60 degrees to the right of the bright light, instead of going 60 degrees to the right of the real sun. Gould was waiting at th wrong location (60 degrees to the right of the artificial light).

Sure enough, he was rewarded by the arrival of the bees. The bees should have gone to the correct location if they had relied on the scent of the dancers. Even this elegant experiment did not set the controversy at rest.

The main problem is that we cannot claim to know exactly what the dancer is telllng the recruits. What we need is to be able to talk to bees in their own language and restrict communication to only those elements of the language that we have deciphered. Sounds impossible, does it not? Well, not quite. A. Michelson and B.B. Anderson from Denmark and Wolf-

the world. The only sobering fact is that we are not quite alone, at least in our ability to use a symbolic language.

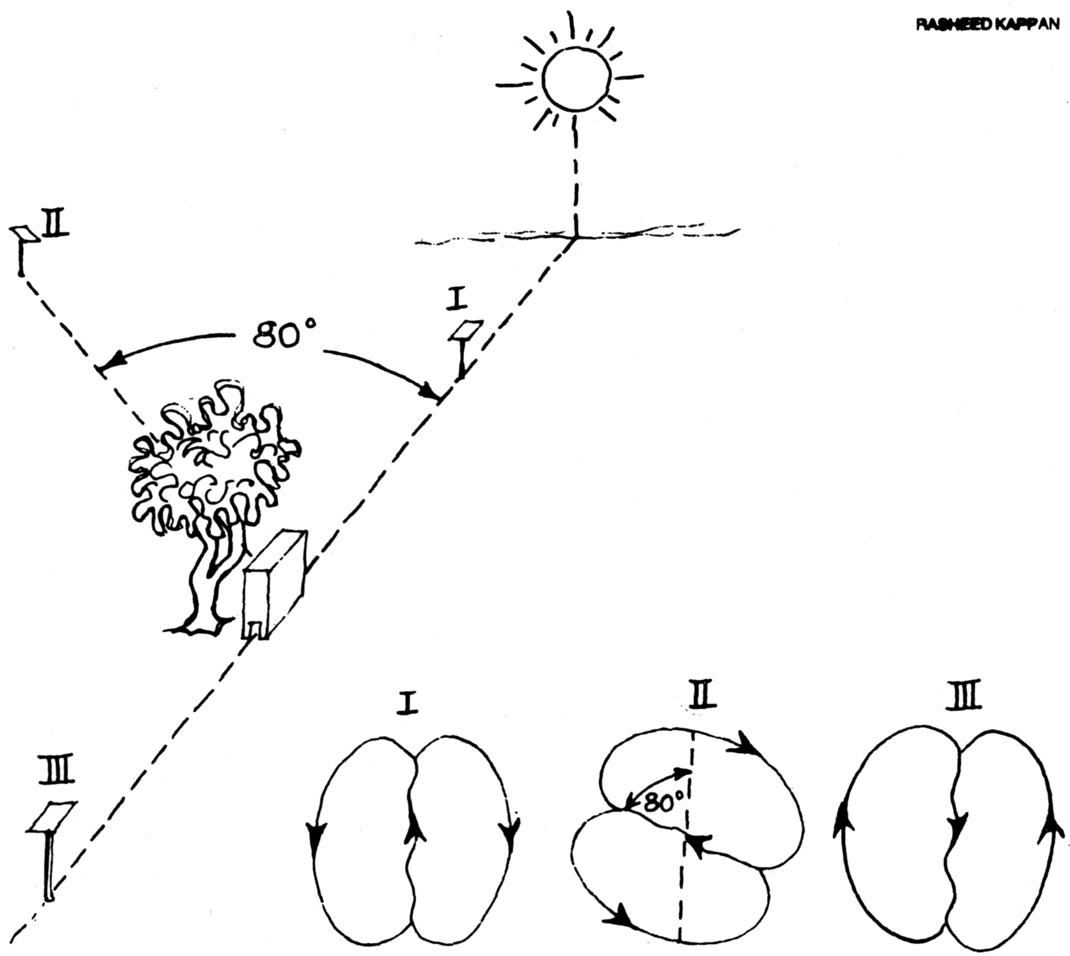
The only other example of a well-developed system of assoeiating environmental stimuli in an arbitrary and symbolic manner with "universally understood meanings" is seen in the dance language of the honey bee. The claim is not that honey bees come anywhere near humans in their communication skills but that no other non-human animal can match even the bee dance language.

Honey bees live in extremely populous colonies and maintain organisation. Every colony has a single queen, a few hundred drones and tens of thousands of workers. The queen is an egg-laying machine and a chemical factory. She is responsible for all eggs laid in the colony and she manipulates the behaviour of the workers through various pheromones that she releases from time to time. The workers take on the responsibilities of nest construction and maintenance, brood care and foraging for nectar and pollen from the environment. The drones do nothing for the colony itself and are chased away (often with limited success) during times of food scarcity.

The ability of honey bees to maintain such large colonies can be attributed to their ability to efficiently harvest large but ephemeral sources of pollen and nectar from flowers in their neighbourhood. This, in turn, depends crucially on the unique ability of a succcessful forager bee to quickly recruit large numbers of naive workers from its colony to a newly found food source. After decades of painstaking observations and many false starts, Austrian zoologist Karl Von Frisch discovered and deci- repeats the waggle run, thus inscribinq a figure of eight. The round dance is performed if the food is within 100 metres or so of the colony and the waggle dance is performed if the food is located beyond that. The round nest, into an angle with respect to the vertical surface of their nest. This is where the arbitrariness comes in. The symbolic representation that all bees seem to have "agreed" upon is to represent the direction of the sun with a waggle of communication. The notations are arbitrary, 'up' means in the direction of the sun because that is what the bees seem to have 'agreed' to; 'down' means the opposite direction.

Karl Von Frisch won the Nobel

RASHEED KAPPAN



The waggle dance orientations for three different positions of the food source. When the food is in the direction of the sun as in I, the run is upwards and when the food source is in the direction opposite to the sun, it is downwards. When the food is 80 degrees to the sun's left, the waggle run is 80 degrees to the left of the vertical

coverer and retaining only the information provided by the dancer. This was accomplished in an ingenious way by James L. Gould of Princeton University. He made the bees 'lie' and proved the existence of a true language!

If a bee nest is removed from its normally dark cavity, the dancers need no longer use 'up' to mean in the direction of the sun; they can as well aim their waggle runs in the direction of the food source using the sun directly as a reference point. Th waggle runs can now be in the direction of the sun, away from the direction of the sun or 60 degrees to the right of the sun, depending on where the food is located. A useful trick is to place a powerful source of artificial light close to the nest; the bees will ignore the sun and take this light for the sun. In other words they will orient their dances with reference to this artificial sun. Now if you place the light in a position very different from that of the real sun, bees will use the real sun while foraging, and the artificial sun wile dancing and thus communicate completely wrong information. In addition to their two compound eyes, honeybees have three simple eyes called ocelli on the back of their head. Ocelli are used to sense the intensity of light and help bees to decide when to start/stop foraging.

The ingenuity of Gould's experiment lay in painting the ocelli of the dancers so that they could not see the bright light. They therefore reverted to using gravity for conveying orientation and, say, indicated 60 degrees to the right of 'up' because the food was located 60 degrees to the right of the real sun. However, the recruits (the dance followers) had normal unpainted ocelli and mistook the bright light to be the sun gang Kirchner and Martin Lindauer from Germany have structed a mechanical 'robot' bee that talks to the real bees through a computer programmed by the scientists, based on their idea of the bee dance language and the bees do understand! The robot bee was made of brass and was about the size of a real bee. It was coated with a thin layer of wax and made to sit in the nest among the real bees for about 12 hours and thus came to smell like them. it had wings made of razor blades which when vibrated produced acoustic signals similar to those produeed by real dancing bees. Two rods attached to the robot bee helped control its movements through a computer programme. Most importantly, a plastic tube near the model's head delivered a drop of sugar solution from time to time. This was essential to avoid attacks by the real bees towards the model. Now, by making the robot bee perform a waggle dance with a particular orientation of the waggle run, Michelson and Co. thought that they could make the bees go wherever they wished them to go and, sure enough, they were right. This gives us confidence that our understanding of the bee dance language is sufficient to make the bees understand the true meaning of a message. This should lay the controversy to rest and vindicate Frisch's theory but knowing human nature, Wenner and Adrian are not going to be convinced.

That won't be so bad really, because it will motivate someone to do an even more ingenious experiment.

(The author is the chairman of the Centre for Ecological Sciences, Indian Institute of Science, Bangalore)