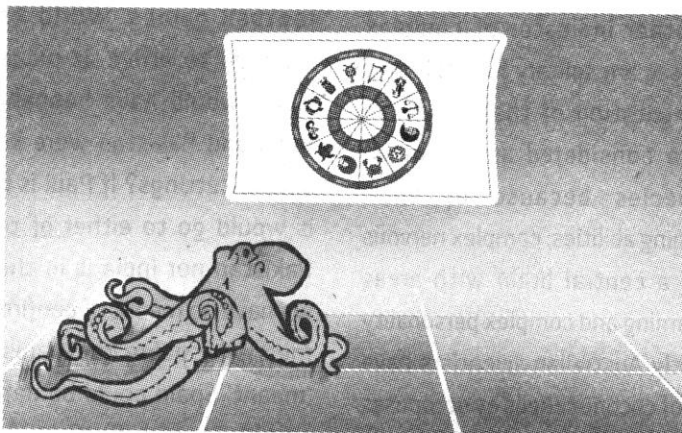


OH PAUL- WHO REALLY COST? GERMANY OR SCIENCE?

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Paul the octopus living in Sea Life aquarium in Oberhausen, Germany became the celebrity all of a sudden, rivalling even fiction characters, through accurately predicting the winner of eight FIFA World Cup Football matches. The octopus made his predictions by choosing between one of two transparent cubes marked with either the German flag or the national flag of their opponent baited with mussel or oyster. The container that Paul chooses



first is interpreted to indicate Paul's prediction for who will win the upcoming game. When all the eight predictions were correct, the octopus became a celebrity, and the prediction was broadcasted live on television! There were reports about the 'psychic' octopus possessing 'sixth sense'. People have been influenced by such superstitions and beliefs since the evolution of mankind.

It was not just the game of football that was overshadowed by Paul, but the very method of science, leaving way for pseudoscience (see box). The use of animals for 'precisely' predicting the future is not new in India either! In this article, we take a close look at Paul's 'predictions' from a scientific point of view. Our object is rather humble and simple. We want to resolve at Paul's predictions using the classical method of science and suggest how the curious

phenomena can and should be analysed. We hope both layman and young researchers would find this article a timely curio to re-trigger their thoughts on the scientific methodology.

We present below several hypothesis about the predictions. All of these are based on the assumption that the Paul's promoters had no undescribed and unfair means by





which a prediction of any human expert was being discretely signalled to Paul.

Hypothesis 1: Octopuses are “intelligent” enough to predict the winners

Octopuses, represented by over 300 species inhabiting primarily tropical waters around the world, are known for their secretive nature, uncanny intelligence and the ability to use tools. The oracle octopus in the present case belongs to the species *Octopus vulgaris* that lives in tropical waters including India, and is one of the best studied octopuses in the world; they are very active, curious and agile species both in natural settings as well as in experimental tanks.

The curiosity shown by these creatures led to speculations about their ‘intelligence’ ever since Aristotle first reported it. Of late, authors also demonstrated the existence of personalities in octopuses another indicator of complex behaviour. Octopuses are solitary invertebrates with little documentation of their response behaviour but are considered an advanced invertebrate species because of their demonstrated learning abilities, complex nervous system including a central brain with areas associated with learning and complex personality behaviours. Recently Australian scientists have reported selection of coconut shells by octopuses in Indonesian waters for shelter and this unusually sophisticated behaviour is the first evidence of tool use in an invertebrate animal.

All these scientific findings prove unequivocally that octopuses are intelligent, with highly developed brain capable of storing and processing complex information. It is easy to come to a conclusion that the “intelligence” confirmed in the above studies are behind



Paul’s prediction. However, “intelligence” is an ambiguous term which psychologists and educational experts struggled to define (The close to common agreement is that intelligence is what intelligent tests attempt to measure!).

Howard Gardner for instance has put forward the theory of multiple intelligence with linguistic, logical-mathematical, visual/spatial, bodily-kinesthetic, interpersonal, intrapersonal, naturalist, spiritual, metaphoric and musical perspectives of intelligence. Apart from such diverse views, intelligence alone is not enough for prediction of outcomes of football games. World knowledge is also required to arrive at plausible conclusions. What would have happened if the flags of India and Pakistan were kept before Paul in similar settings? If Paul is behaving similarly, it would go to either of teams, but neither Pakistan nor India is in the World Cup. Also we have no means of confirming what octopus meant by going to Spanish flag. What if it ‘meant’ Spain could be defeated by covering up the Spanish flag? In this case, all Paul’s predictions were wrong!

Hypothesis 2: Octopuses selected the winners based on colour and patterns of flag

When we analyse the colour and patterns of the flags of the winners selected by Paul octopus, it may be seen that the selections are skewed towards the flags with yellow and red or those with contrasting horizontal lines.

The tricolour flag of Germany, with three equal horizontal bands of black, red and gold, and the flag of Spain, with its broad yellow stripe and two horizontal red stripes were the most frequent choices of Paul. The other winners picked up were those flags with contrasting stripes such as blue and white. Although there are different functional uses, the structure of the cephalopod eye is very similar to the vertebrate eye with only one main difference; the cephalopod retina contains no rods or cones and hence no colour vision is possible. The argument of colour could not be justified simply because the octopuses are almost certainly colour blind while the selection of flags with stripes may be partially correct.

Though colour vision is not possible, individuals would still be able to distinguish brightness as well as an object's size, shape, and orientation. This shows that the octopus could have been choosing boxes systematically on his attraction to the countries' flags or the food items offered inside the box. Octopuses are equipped with sensitive chemo receptors on its tentacles, which are used to taste food and smell the water and they can detect minor chemical differences on the surface of each box. In such cases they could be easily trained to pick up the right box.

Hypothesis 3: Partial preference or related factors such as light intensity helped octopus selecting



the winners

One may argue that spatial preference or related factors such as light intensity might have helped the octopus to select boxes on either side. Out of the total eight predictions, the octopus picked up the winner six times from the right hand side (of camera). On only three out of seven predictions, the German flag was on the right-hand box, with it being the left-hand box for matches with Australia, Serbia, England and Spain - all correctly predicted by Paul, despite Germany winning two and losing two. However, Paul's keepers simply put the first team as officially listed by FIFA in the left-hand box, the second team listed by FIFA in the right-hand box, for all predictions. Polarization vision may provide information similar to that available from colour vision in octopuses and thus serve to enhance the detection and recognition of objects. The lateralization of sensory and motor functions and lateral asymmetry of eye use has demonstrated in octopuses. However, these features in octopuses does not seem to assist their choices of picking the winners, as they moved either way, though the movements are more towards the right.

Hypothesis 4: Simple chances favoured the selection

Is Paul's perfect record in prediction was more a product of randomness than wisdom? Under the hypothesis that Paul was equally



PSEUDOSCIENCE

Pseudoscience is any scheme of assertions, beliefs and methods, wrongly considered as scientific. It differs from antiscience in the non-attendance against real science and the scientific method. Based on pseudoscience, many dishonest beliefs have derived, supposing that the reality relies on one's perception, not on the observation and experimentation matters. A pseudoscience is set of ideas based on theories put forth as scientific when they are not scientific. Scientific theories are characterized by such things as (a) being based on empirical observation rather than the authority of some sacred text; (b) explaining a range of empirical phenomena; (c) being empirically tested in some meaningful way, usually involving testing specific predictions deduced from the theory; (d) being confirmed rather than falsified by empirical tests or with the discovery of new facts; (e) being impersonal and therefore testable by anyone regardless of personal religious or metaphysical beliefs; (f) being dynamic and fecund, leading investigators to new knowledge and understanding of the inter-relatedness of the natural world rather than being static and stagnant leading to no research or development of a better understanding of anything in the natural world; (g) being approached with skepticism rather than gullibility, especially regarding paranormal forces or supernatural powers, and (h) being fallible and put forth tentatively rather than being put forth as infallible or inerrant. Pseudoscience is relatively simple to detect in topics about creationism, astrology, divination, chiromancy, homeopathy, holistic medicine, UFOs, Aliens, etc.

likely to choose the winner or the loser of a match, and neglecting the possibility of a draw, he had a 1/2 chance of predicting a single result, a 1/4 chance of predicting the first two games, a 1/8 chance of predicting all the first three games and a 1/256 chance of predicting eight in a row. Scientific method calls for repeatability of experiments. Theories to explain his behaviour could have been systematically tested if Paul (or for that matter any human oracle) had repeated his selection many times, but he only selected one box per game. According to mathematical probabilities, the predictions of Paul are not so extraordinary. It can be compared with flipping a coin and getting the same result 8 times, which is unusual, but not impossible. However, as the public and media search for something mysterious, the unusual is transformed into miracle! Some do take in the

right stride- as curiosity and fun. Conversely, if it is taken as an oracle or miracle, the scientific temperament of the society suffers.

The pursuit of scientific knowledge usually involves elements of intuition and guesswork. Yet, in science, we should have a broader and holistic vision rather than reductionist approach. When we fail to do so, the pseudoscience takes its dominance, of course in the modern era, with fast growing media support, as in the case of Paul, the 'psychic' octopus.

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