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How Zoological Studies and Semiotic Analysis can form a Symbiotic Relationship via Firefly Flash Pattern in Relation to Cognitive Abilities.

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By Elyse Hickey

This analysis works to further understand the signs used in communication among the *Photinus* genus of fireflies, and discusses some of the implications of this investigation in regard to the cognitive thinking abilities in this species. It will describe why and how this sign communication indicates cognitive abilities. Through this interpretation I will also expand on the ways in which semiotic and zoological studies can work together to supplement areas the other may need expansion or clarification in.

Charles Peirce was a scientist and philosopher who played a key role in the formation of, and expansions on the study of semiosis. He combined scientific, linguistic, and philosophic approaches and methods to his studies of sign use among creatures of all sorts. He did not limit sign usage to human beings and primates as many others of his time did, and I think this is of great importance in the expansion and combination of the zoological and semiotic areas of study. He will point to three parts of a sign, those parts being the *sign* itself, the *object*, and the *interpretant*. In firefly flash communication the sign is the flash pattern, the object is a desire to mate, and the interpreter is the potential mate that the flash is directed toward, or any creature that can recognize the flashes as an indication of this desire. The object determines the sign, in the way that the object of the desire to mate determines the pattern of flashes employed. The sign determines the interpretant in the way that the pattern is recognizable to those who can un-code to flashes to determine its meaning, or object, the desire to mate.

Peirce has a trichotomic division of signs in the way the sign relates to the objects it is signifying. This division consists of signs as *icons*, *indices*, and *symbols*.[1] *Icon* is the term for a sign that shows a likeness to the object being represented. Icons are imitations. In the area of firefly communicative behavior, an example of this could be, if attempting to show a desire to mate, fireflies danced in a way that mimics intercourse or uttered noises that shared a likeness with those made during (or directly prior to) engaging another firefly with the intention to mate. The flashing pattern does not share a likeness with mating as would be indicated by an icon sort of sign, this is because the pattern of flashing doesn't sensually resemble the desire to mate. *Index* is the term for a sign that indicates the object through a physical connection. Fireflies use a flash of light as an index through the way that it indicates the physical distance between a flash emitting male, and the responsive mate. This would refer to the use of the light frequency, or brightness, to determine the physical distance between the two individuals, however the time sequencing, or pattern, of the flash does not indicate physical distance or connection between the fireflies.[2]

Symbol is the term for a sign that derives its meaning from use. This is a conventional understanding, or one that depends upon habit. The flash pattern is symbolic in the way that it relates to the object—a desire to mate—by way of an idea in the mind of the fireflies. The pattern of flashing stands to other fireflies, and stands for the desire to mate. The flashing lights

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[1] Charles S. Peirce, *Essential Peirce: Selected Philosophical Writings, 1893-1913.* ed. Peirce Edition Project Staff (Indiana University Press, 1998). 4-10.

[2] James E. Lloyd, *Studies on the Flash Communication System in Photinus Fireflies.* (Ann Arbor: Museum of Zoology, University of Michigan, 1966)

neither looks like the fireflies intended intercourse, nor does the pattern physically connect the two individuals to initiate intercourse. The pattern is a conventionally determined language, similar to Morse code that humans use. The varying patterns of flashing are specific for each species of firefly, and may be acquired or inborn.

Acquisition of the flash pattern language would indicate adaptation in the individuals of the species, while having this communicative language inborn pre-supposes an evolutionary development of the flash pattern in the species. Zoological research has proven that individual adaptations have been made, which lead to species evolutionary changes.[3] This information would clarify whether fireflies are showing the cognitive ability of learning. This is an area where zoology can help refine the understanding of semiotics, and semiotics would be able to apply information offered by zoology, to further the zoological understandings of, in this case, the firefly species and their ability to communication in relation to the cognition it may point to.

After the breakdown of the type of sign being used and the quandary into the origins of this flash pattern language, there is also some thought to be put towards the division between utterance and interpretation of signs. Utterance is the employment, or use of the sign. It is the intentionality behind the sign. The utterance in this instance would be a female responding with a flash of light that shares the message of her respective location, and the pattern to indicate her desire to mate. Interpretation is the receptivity of the sign, or the ability to understand the intentions of the sign. The interpretation would be a male understanding the light as an indication

[3] James E Lloyd, *Evolution of a Firefly Flash Code.* (The Florida Entomologist, 1984) Vol. 67, No. 2. 228-239

of the distance the female is from him, and the flashes as a message that she is also interested in mating. This is relevant for the purposes of understanding cognitive ability.

The importance here lies most deeply in the use of symbols as signs in flash communication, and the ability of fireflies to utter and interpret these symbols. It is my belief that the ability to both utter and interpret symbols shows cognitive ability to reason, or to use logic to some extent. Cognitive thinking is a term and idea that has few well-defined conditioning factors. Overall, cognitive thinking refers to the use of mental activities and skills to perform tasks such as reasoning, understanding, and remembering, but the extent of these abilities is not explicated in most definitions. The fireflies are displaying all of these qualities to some degree when employing symbol sign usage. Fireflies also display learning capabilities in adaptations regarding flash pattern mimicry of other species[4]. These abilities to communicate intentionally and receive the intention of these signs points to cognitive reasoning abilities. The determining conditions and factors of whether reason and logic usage are verifiable in insects is a topic for further investigation and discussion, in order to clarify the parameters of these cognitive functions, and where fireflies lie in relation to this.

This is an area where a combination of zoology and philosophy, specifically semiotics, would prove to be useful. Each study alone seems to have some areas lacking precision, though zoology and semiotics are clearly interrelated, when it comes to animal communication. Semiotics would benefit from clearer definitions in certain areas, such as the interplay with sign use and cognition. Zoological studies often place a great deal of focus on experiments that will

[4]Albert D. Carlson, et Jonathan Copeland, *Behavioral Plasticity in the Flash Communication Systems of Fireflies*. (American Scientist, 1978) Vol. 66, No. 3. 340-346.

allow scientists to narrow down broad ideas into working definitions to be applied to further studies. Experiments that would be used to more strictly define the place of semiotics in cognitive reasoning skills would prove to be helpful for analyses such as this, and for other analyses of communication in different biotic species. By refining the idea of cognitive ability, we may better determine where firefly communication fits into this. Having a clearer idea of the extent to which flash communication indicates cognitive abilities will allow for a deeper understanding, zoologically, about fireflies and the ethology applicable to this entomology. It will also offer some zoological backing to support claims in semiotics about sign usage in the animal kingdom. The two fields can work together, forming a mutualistic relationship, where they benefit the other and lend help where clarity is needed.