

From Cognition in Animals to Cognition in Superorganisms

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Research Questions

My research in cognition has not been directed toward animal cognition, *per se*. Rather, I have been intrigued by the apparent inability of modern science, as I understand it, to explain subjective experience. For this discussion I will refer to it as "the problem of mind." While not the same, there is broad overlap between this problem and those of animal cognition.

My research on the problem of mind has been motivated by beliefs, in no way original with me, that:

- Far from consciousness being explained by anyone, I don't think we even know what an adequate explanation would look like, an opinion articulated especially well by Nagel (1986);
- Probably some animals experience subjective feelings in more or less the same way that we do, though there is a gradation;
- At present we don't know how to objectively identify whether or not others, animal or human, experience subjective feelings or what those feelings are like -- more or less for reasons discussed by Erwin Schrödinger (1967) as "objectivation";
- The study of Artificial Intelligence (AI) and robotics have contributed a great deal to our understanding of the problem, but have certainly not solved or "explained" it.

But it did seem to me that:

- While we are not now able to construct an artificial system that can obviously experience subjective feeling, we may still be able to *evolve* systems that do, using techniques that have come to be known as "evolutionary computation" (Mitchell and Taylor 1999).

In recent years, largely as a result of work by Rodney Brooks and his students, much of which is collected in Brooks (1999), I have come to believe further, that

- For purposes of understanding cognition, especially animal cognition, and probably subjective experience, organisms are best viewed as collections of sensors, effectors and processors of limited abilities surrounding -- and studded throughout -- the organism, communicating primarily with other sensors, effectors or processes that are mostly nearby and mostly with limited bandwidth, functioning together as an ensemble.

This means that our cognition and subjective experience are to be understood as the collective behavior of these limited agents, acting as one. If so, then one of the most important challenges facing us, but one we can probably address in concrete terms, will be to understand how such an ensemble will function as some sort of "superorganism".

In the remainder of this essay I will attempt to explain how and why I arrived at this opinion, and at the end, briefly address some of the promises and limitations it offers.

Past Research

Initially I approached the problem of mind by looking at animals that could reasonably be assumed to experience rudimentary subjectivity. We used mutant strains of *Drosophila melanogaster*, exploring how learning or memory-retention mutations affected habitat selection (Taylor 1987). These were chosen because much is known about their biology and because they are easy to grow and evolve. I soon abandoned this because it seemed difficult for me to relate to their sensory experiences; they were setting the boundary conditions on this, not I. It was too difficult to broach the subjective-objective problem mentioned above.

Artificial systems, however, can be made more or less complex, as desired. At that time there was enthusiasm that the "traditional" approach to artificial intelligence would provide insights to the problems of cognition. By "traditional" I mean the approach exemplified by Newell and Simon (1972) in their General Problem Solver (GPS) program, for example. Very simply, a