Relational Properties in Objective Science

Yaneer Bar-Yam

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A remarkable insight in the study of complex systems is the importance of thinking in terms of dependencies or relationships. This is a key difference from reductionist approaches. Here I will discuss the concept of "relational properties" (properties that exist due to a relationship between something and something else), to distinguish them from properties of a thing. Properly identifying properties that are relational is critical to ensuring valid scientific treatment and logic. Otherwise, properties that are relational could be dismissed as subjective and not part of science. Properly formulating relatedness enables subjective properties to become objective, which then are not mutually exclusive—subjective properties can be objectively defined as relational.

In physics, many properties are relational. Position is relative as are time and velocity. In each case, we need to define a property relative to something else. For example, try to say where Boston is, without saying it in relation to something else. Similarly, velocity is not actually a property of an object: it is a property of the object in relation to the observer. Einstein complicated things by also making differences in distance, in time and in velocity relative (special relativity), and by further having them related to the presence of mass and energy (general relativity). The insight of physical law is that if we properly define these quantities in relative terms, then we have an objective (rather than subjective) description of events.

More than a focus on parts rather than wholes, a focus on things—objects, parts, elements or wholes—causes problems when the properties we are interested in are actually properties of the relationships between things, or the context in which things are found. In the study of networks, the degree of connectivity of a node is a property of the relationships between nodes rather than of a node itself. There are many more examples.

In reductionist thinking, fitness is considered a property of the organism, or better yet of the gene. However, fitness is actually a property of an organism in a particular context. Put the same organism into a different context, and its fitness is different. This may seem obvious when stated this way, but the mathematical formulations of evolution often ignore this. They assign fitness to the organism (or gene) by averaging over the possible contexts. When an organism samples all possible places, and a gene samples all possible genetic combinations it might be part of, then we can talk about its average fitness without regard to context. But this is a strong assumption, and there are important implications for discussions of altruism and other cooperative behaviors when it is not true.

Another example of a relational property is the property of being a key, i.e. a key that opens a door. The property of being able to open a door has to do with a relationship between the structure of the key and the structure of the lock. It is neither a property of the key nor the lock, but rather of the relationship between them. We cannot know that the key opens the door by looking at the key. This is particularly interesting because many of the properties we care about of molecules in biology have to do with how they fit into other molecules. These properties are all relational properties.

The property of being a key is one example of the more general concept of "function"—in this case to open the door. Function is a relationship between a thing and other things. When something is a part of a larger system we often define it in terms of the role it plays relative to some aspect of that larger system. But we can also define the role of the larger system in terms of its impact on the smaller part, and we can define the role of something in terms of other things that are around. For example, the function of a nest, hive, home, chair, table, and so on are all relational.

Consider "meaning." The nature of meaning is a central topic of inquiry in philosophy. We can start to think about this by defining meaning as a relationship between a label and an entity or set of entities. This relational mapping can be established though various means. For example, a computer program may map computer data files onto images, music or movies. Such a program creates a set of relationships that give meaning to the data files. This is an objective definition of meaning in a relational context. If there was only one possible such mapping that would always be used for all labels, then meaning would be a simple idea, but there are many possible relationships and therefore meaning becomes a subtle and important topic to study.

My favorite example of a relational property is the definition of the word "mother" (or "brother," "father," etc.). In some dictionaries [1] it is defined as something like "A woman who gives birth to a child" or "A female parent." There may be a dozen or so other definitions (e.g. Mother superior) but nothing else about the simple notion of the word mother (or its informal variants "mom," "mama"). According to this definition we could walk up to any female parent and call her "mother/mom." More correctly, we might walk up to a female parent and say that she is "a mother" or "a mom," but it would be unusual to call an unrelated woman "mother/mom." What is missing is a definition that says "What a child calls his or her female parent," — i.e. a relational definition. Given that it is easy to say this, why doesn't it appear in the dictionary? It seems the reason is a tendency to assign properties to entities rather than to relationships. Other sources [2, 3] do indicate a relational role though seem more opaque about the difference between "mother" and "a mother" than seems necessary, and there are some quite clear definitions [4].

This type of relatedness is more generally expressed by the possessive words including "my, his, hers, ours, their." In a sense, just as molecular lock/key relationships are central to biology, so possession/ownership is central in society as an essential general purpose relatedness concept.

Herbert Simon [5] and others have made a distinction between "weak" and "strong" emergence. Strong emergence is a property of a system that is not contained in the properties of the parts or their interactions. Simon states that strong emergent properties are not within scientific discourse. However, relational properties are not contained in the properties of the parts, because they also involve properties of another system [6]. As physics has demonstrated, the power of scientific understanding is realized when we can properly formulate the relative nature of quantities we measure. Understanding relative properties is necessary to expanding scientific inquiry to complex systems concepts like function and meaning.

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[1] mother, *The American Heritage Dictionary of the English Language* (2015), `https://ahdictionary.com/word/search.html?q=mother`.

[2] mother, Oxford English Dictionary, Compact ed. (Oxford University, 1971).

[3] Mother, *Wikipedia* (accessed April 22, 2016), `https://en.wikipedia.org/wiki/Mother`.

[4] mother, n.1 (and int.), *Oxford English Dictionary* (2016), `http://www.oed.com/viewdictionaryentry/Entry/122640`.

[5] H. A. Simon, Sciences of the Artificial, MIT Press; 3rd edition (October 1, 1996)

[6] Y. Bar-Yam, A mathematical theory of strong emergence using multiscale variety, Complexity 9.6, 15-24 (2004)