

Metaphor-Based Values in Scientific Models

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Abstract: Theories of attention in cognitive psychology are based on various metaphoric models that determine how the phenomena of attention are identified, how they are studied experimentally, and how they are explained theoretically. Three of the central models in contemporary research programs are the Attention-Spotlight metaphor, the Attention As Limited Resource metaphor, and the Biased-Competition metaphor. Each of these metaphoric models involves a specific ontology of entities and processes, and each one entails a specific set of values that guide research on attention. These values are largely incompatible across the three different models. I argue that metaphor-based value systems are characteristic of all science and that this is not a lamentable problem, but rather the source of the insight and experimental fruitfulness of scientific models.

1. PAY ATTENTION: METAPHOR-BASED VALUES IN SCIENTIFIC MODELS

Most scientific research is model-based. There is a rapidly growing body of evidence that scientific models are largely metaphoric. Moreover, these model-defining metaphors give rise to crucial values that determine the nature and course of scientific research. I propose to give substance and credibility to these claims by focusing on one interesting field of contemporary metaphor-based science, the cognitive psychology of attention. An examination of the three most important contemporary theories of attention shows how and why the metaphors are indispensable. The first half of the present

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essay draws extensively from published and submitted work I have done with psychologist Diego Fernandez-Duque on the three major attention metaphors that shape research in cognitive psychology and cognitive neuroscience.¹ In the second half of the essay, I examine how the various metaphors specify some of the values embedded within different research programs for studying attention. I conclude with a speculation about the possible grounding of scientific values in our organic, embodied experience.

2. KEY METAPHORS GUIDING ATTENTION RESEARCH

We all think we know what attention is? It's whatever is involved in our "paying attention" to something, right? But precisely what's going on when we "pay attention"? As we'll see, even attention researchers cannot agree on which mental phenomena are properly cases of "attending to something". Even less do they agree about how to explain the phenomena. In fact, depending on which particular metaphoric model of attention researchers are assuming, the alleged phenomena of "attention" get individuated in quite different ways. It is not the case that we start with agreed upon phenomena of attention and then develop alternative explanations of them. Instead, which specific metaphoric model we adopt determines what we'll count as attention, how we'll go about studying it, and what we'll recognize as relevant evidence.

2.1 The Spotlight metaphor

In order to flesh out these claims, let's begin with what is probably the oldest and most used metaphor in the scientific study of attention - the conception of an internal mental "spotlight" that shines on particular perceptual contents or mental representations. What we are attending to is whatever is "illuminated" at the present moment of consciousness. Scientists have argued that "attention may be compared to a beam of light in which the central brilliant part represents the focus surrounded by a less intense fringe. Only the items located in the focus of attention are distinctly perceived whereas we are less aware of the objects located in the fringe of attention" (Hernández-Peón, 1964, cited in Watchel, 1967, p. 418). The Spotlight metaphor consists of the following conceptual mapping.

¹ The analysis of the Spotlight metaphor is taken from Fernandez-Duque and Johnson (1999), and the examination of the Limited Resource and Competition metaphors is taken from Fernandez-Duque and Johnson (forthcoming).

2.2 The attention spotlight metaphor

Source Domain (Spotlight)	Target Domain (Attention)
Spotlight	Orienting System (mechanism of attention)
Agent who controls the spotlight	Executive System
Agent who sees	Awareness System
Seeing	Attending
Potential field of vision	Representational Space
Area illuminated by the spotlight	Attended representations

The conceptual metaphor here is the entire mapping from the entities in the source domain (visual perception and devices of illumination) to constructed entities in the target-domain (attention). The source-to-target mapping allows researchers to use their knowledge of the source domain to construct a parallel knowledge of the target domain. For example, on the basis of how a spotlight works, researchers may reason that attentional “*scanning* [...] is a measure of how much the *beam* moves around the *field*, while the *focusing* [...] refers in some way to the *width* of the *beam*” (Watchel, 1967, p. 418) [italics added]. Such inferences come from the way we use our knowledge of the source-domain structure (a-f below) to construct a parallel knowledge of the target domain of attention (a'-f' below), as follows:

Source-domain knowledge

(a) There is a perceptual field with (b) objects in it. (c) The spotlight sheds (d) light over parts of the field, (e) making it easier to see specific objects. When the spotlight illuminates a target object (f) the target object is seen by the observer.

Target-domain knowledge

(a') There is a mental field with (b') unconscious ideas in it. (c') The attentional system directs (d') attention over the brain areas (or mental field), (e') making representations accessible by our awareness system. When the attentional system focuses on some target idea, (f') that target idea is acquired by the awareness system, and it becomes conscious. (taken, with modifications, from Fernandez-Duque and Johnson, 1999, pp. 93-94).

This metaphor-based knowledge about attention is not merely a folk-model. Rather, this metaphoric model has become the basis of a substantial body of empirical research within cognitive psychology (Cave and Bichot, 1999; Fernandez-Duque and Johnson, 1999). In recent years, the internal structure and logic of the Spotlight metaphor has also influenced research in

cognitive neuroscience. Consider the following examples, in which scientists explored the “physiological correlates of the ‘spotlight’ of visual attention” (Brefczynski and DeYoe, 1999), by measuring hemodynamic and/or electrophysiological response in areas of the visual cortex:

1. Several areas of the visual cortex can create retinotopic maps of perceptual scenes. This means that objects close or adjacent to each other in the world activate brain areas close or adjacent to each other in the visual cortex. If attention “sheds light” over sensory areas, then cueing attention to more central areas of the visual field should activate brain regions that map central locations, whereas cueing attention to a peripheral part of the visual field should increase blood flow in peripheral areas that map that part of the visual field. There is some evidence for this prediction coming from research designed to test these metaphorical entailments (Brefczynski and DeYoe, 1999).
2. Since a spotlight moves in analog fashion, the target domain inference is that attention moves in an analog fashion. Therefore, the electrophysiological enhancement associated with the processing of attended stimuli should also move in an analog fashion, a prediction that has been tested and confirmed in the laboratory (Woodman and Luck, 1999).
3. Since it takes time for a spotlight to move from one location to another, the delay between the onset of a cue and the enhancement of the electrophysiological response at the cued location has been taken to be a measure of how long it takes the attentional spotlight to move to the cued location (Müller, Teder-Sälejärvi, and Hillyard, 1998).
4. In the source-domain, the spotlight is a different entity from whatever it shines on and from the agent who controls it. In the target domain, therefore, one expects to find something like an independent executive system that controls attention and is separate from both the orienting system and from the sensory areas that are attended to. This concept of the executive system as defined by the Spotlight metaphor led researchers to discover a network of cortical areas that participate in attentional control, moving attention from one location to another. Whether a stimulus is displayed at the attended location has no impact on the activation of these controlling areas. In other words, the perceptual systems that benefit from the attentional modulation appear to be separate from the neural system that controls the attentional spotlight and from the spotlight itself (Hopfinger, Buonocore, and Mangun, 2000, Corbetta, Kincade, Ollinger, McAvoy, and Shulman, 2000; Martinez, Anllo-Vento, Sereno, Frank et al., 1999).

What these four examples of attention research show is precisely how the highly articulated internal structure of the source domain of the Spotlight metaphor generates entailments that shape our understanding of the target

domain and gives rise to the ways we reason about attention. The entities in the source domain (such as a spotlight and an independent operator who directs the spotlight) have specific characteristics (e.g., the beam has a particular width at a given moment and moves in an analog fashion from one illuminated location to another) that structure scientists' conceptualization of the phenomena of attention. A different metaphor, with different source-domain entities and knowledge, would obviously give rise to a substantially different conception of attention and a different research program for studying it. As an example of this, let us consider a second major metaphor system in which attention is conceptualized as a valuable limited resource that is allocated for various cognitive tasks.

2.3 The attention as Limited Resource metaphor

One of the chief competitors to the Spotlight metaphor is the metaphor of attention as a Limited Resource that can be allocated by a general-purpose central processor in a graded fashion for the performance of different tasks. Pashler (1998) succinctly characterizes the folk model built upon this metaphor:

Folk psychology postulates a kind of substance or process (attention) that can be devoted (paid) to stimuli or withheld from them. Whether or not attention is allocated to a stimulus is usually thought to depend on a voluntary act of will; in the metaphysics of folk psychology, this ultimately depends on the choice made by the self [...]. The available quantity of attention is assumed to be finite, and this finiteness is supposed to account for capacity limitations; this means having less attention available to pay to other things. Attention, according to folk psychology, can be devoted not only to stimuli, but also to activities, tasks, and behaviors (as in "pay attention to your driving"). Allocating more attention to a given task enhances performance (pp. 2-3).

Scientific versions of Resource models are most eloquently described in Kahneman's influential book *Attention and Effort* (1973) and have been further developed by several researchers, such as Norman and Bobrow (1975), Navon and Gopher (1979), and Hasher and Zacks (1977). Limited resource models are used to explain many psychological phenomena, such as dual task interference (Christie and Klein, 1996), automaticity (Norman and Bobrow, 1975; Schneider and Shiffrin, 1977), priming (Posner and Tudela, 1997), and mental rotation (Carpenter, Just, Keller, Eddy, and Thulborn, 1999).

The internal logic of the Limited Resource metaphor is made evident by the following mapping, in which cognitive operations are conceptualized as distributions of physical resources that are used up in various tasks.



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