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Naming and Knowing: Giving Forms to Things Unknown

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Naming and Knowing: Giving Forms to Things Unknown

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UNLESS we believe that we can create a distinct name for every conceivable object, thought, feeling, and action—and persuade everyone else to use the same set of names—we might as well concede from the start that *we are necessarily creatures of metaphor*. For time and time again, we are forced to construct and convey our understanding of things through the use of terms previously reserved for other things, on the basis of some perceived or conjectured similarity between them. And even if we refuse to accept that this sort of cross-naming and knowing-by-comparison is inevitable, we can hardly deny that metaphor does in fact account for a large portion of what we know and think, not to mention what we feel, communicate, and do.

Metaphor, in other words, is no mere grammatical or rhetorical device. It is one of the major means by which we steer our way through life, gaining as much traction as we can on a roadbed of partial similarities. Common experiences—and experiences of commonality—allow us to construct concepts and words that can be used again and again in a wide variety of situations. This potential for multiple reference accounts for the power of metaphor—the power of comparing, comprehending, and communicating; the power of putting our finite resources to virtually infinite use.

I have written about this elsewhere, focusing in particular upon the role of metaphor in the realm of psychology (Leary, 1990), but many others have reached the same basic insights. Aristotle, for instance, recognized that giving names to previously nameless things is our best means of "getting hold of something fresh," and he argued accordingly that "the greatest thing by far is to be a master of metaphor" (Aristotle, ca. 330 B.C./1952a, p. 662; ca. 330 B.C./1952b, p. 694). In more recent times, Isaiah Berlin is but one of many scholars and thinkers who have noted the impossibility of doing without metaphor:

> To think is to generalise, to generalise is to compare. To think of one phenomenon or cluster of phenomena is to think in terms of its resemblances and differences with others. This is by now a hoary platitude. It follows that without parallels and analogies between one sphere and another of thought and action, whether conscious or not, the unity of our experience—our experience itself—would not be possible. All language and thought are, in this sense, necessarily 'metaphorical' (1981, p. 158).

This is as true in the realm of science as in everyday experience. To understand any phenomenon, scientists need to compare it with an established point of reference or some other standard. At some earlier time, *that* reference or standard, in turn, was established in relation to some other object. And so on, and so on.

This might sound neater than it should. There is nothing simple and ineluctable about the ways in which our knowledge, feelings, and actions are constructed, whether in science or in any other domain. The delicious complexity of how it *can* be done is more than half the challenge and fun of how it actually *is* done. Ultimately, the process depends upon what our bodies sense and our minds imagine. Our modern ambivalence about both sensibility (especially "feelings") and cognition (especially "imagination") is well known. Science has tried to legislate this ambivalence out of existence by dictating the acceptable forms of sensibility and by limiting the free play of the imagination. Until the recent downfall of simple-minded positivism, such dictation obscured the actual workings of sensibility and imagination in the realm of science. Ironically, this led to a situation in which the concept of the imagination was "seldom encountered in modern treatments of analogy in science" (Park, Daston, and Galison, 1984, p. 287). However, this situation has been changing as serious reflection upon the roles of "fact, fiction, and forecast" (Goodman, 1954), "personal knowledge" (Polanyi, 1958), "plans" (Miller, Galanter, and Pribram, 1960), "foresight and understanding" (Toulmin, 1961), "the logic of scientific discovery" (Hanson, 1961), "conjectures and refutations" (Popper, 1963), "posits and reality" (Quine, 1966), "paradigms" (Kuhn, 1970), "the thematic imagination in science" (Holton, 1973), "ways of worldmaking" (Goodman, 1978), "the construction of reality" (Arbib and Hesse, 1986), "science as creative perception-communication" (Bohm and Peat, 1987), "constructive realism" (Giere, 1988), and "imagistic and analogical reasoning" (Nersessian, 1990) have come to the fore. There is a clear and emerging realization these days that the scientist, too, has an imagination that "bodies forth the forms of things unknown" and gives to them "a local habitation and a name" (Shakespeare, 1598/1936, p. 406). This is to say that the scientist, too, is a "maker." Indeed, the modern scientist has demonstrated the awesome truth of Ralph Waldo Emerson's conviction that "the whole of nature is a metaphor of the human mind" (1836/1983, p. 24) and Wallace Steven's contention that "the imagination is man's power over nature" (1930–1955/1982, p. 179). These claims assume, of course, that the imagination is stimulated by and nurtured through its embeddedness in nature.

The purpose of this essay is to provide some "forms" and "habitations"—some principles and examples, if you will—of the phenomenon of metaphorical thinking in science. First, I will share some general comments about this phenomenon, and then I will illustrate it with an extended discussion of a recent line of thought, research, and application within behavioral psychology.

Naming

Whenever we are confronted with something that we do not know, we search about for a concept or label—a name—by which we might know it. A simple example would be a word that we do not know: We might ask someone else what it means, or we might look it up in a dictionary. In either case, we will keep asking and searching until the word is defined in terms of *other* words that are better known to us.

This simple example can serve as a paradigm for the various ways in which we come to understand "reality." Whenever any aspect of our experience calls for understanding, we begin to look about for what William James called "similar instances" (1890, chaps. 13, 19, and 22). Only when we have found an apt "peg" or "pigeonhole" for this aspect of our experience do we feel the subjective satisfaction that brings our search to an end. The similar instances that, thus, come to serve as our pegs and pigeonholes—as our categories of understanding—are either explicitly or implicitly metaphorical in nature and function. They provide the means by which we manage to *place* and to *label* our experiences of things, thus giving them "a local habitation and a name."

In reflecting upon the many variations of this process, it becomes obvious that *all knowledge is ultimately rooted in metaphorical (or analogical) modes of perception and thought.*[1] By extension, metaphor necessarily plays a fundamental role in every domain of knowledge, including the domain of science. Although this is a very large claim, it has the backing of theorists of markedly different persuasions, including empiricists and pragmatists as well as idealists and intellectual anarchists. The commonality of this view across such a wide spectrum of thinkers has rarely been noted, much less appreciated, perhaps because of the differences in the vocabularies favored by theorists of such varied and even contradictory orientations. Without an appropriate meta-terminology based upon a sufficiently broad meta-theory, the cacophony of their individual voices has made it difficult to hear the persistent theme that underlies their disparate articulations. Still, if we listen carefully and allow for variations in orientation and terminology, we can gather such pertinent and coherent statements as: David Hume: "All arguments from experience are founded on the similarity which we discover among natural objects" (1748/1972, p. 36). Immanuel Kant: "We are justified in combining appearances [in order to arrive at concepts] only according to what is no more than an analogy" (1781/1965, p. 88). Jeremy Bentham: "In the use made of language, fiction. . .becomes a necessary resource" (1841/1962, p. 331). Alexander Bain: "Some discoveries turn upon this [use of the law of similarity] exclusively; and no succession of discoveries can proceed without it" (1855, p. 508). Friedrich Nietzsche: "The drive toward the formation of metaphors is the fundamental human drive"(1873/1979, p. 88). William James: "*A native talent for perceiving analogies* is. . .*the leading fact in genius of every order*" (1890, vol. 1, p. 530). Charles Peirce: "Upon finding himself confronted with a phenomenon unlike what he would have expected. . . , [the reasoner] looks over its features and notices some remarkable character or relation among them, which he at once recognizes as being characteristic of some conception with which his mind is already stored. . . . Presumption [the 'abducting' of similarities] is the only kind of reasoning which supplies new ideas" (ca. 1893/1932, p. 777). Hans Vaihinger: "All cognition is the apperception of one thing through another. In understanding, we are always dealing with an analogy, and we cannot imagine how otherwise experience can be understood. . . .All conception and cognition are based upon analogical apperception" (1911/1924, p. 29). Ernst Cassirer: "Myth and language [which he considered to be the roots of human cognition] may differ, yet the same form of mental conception is operative in both. It is the form which we may denote as *metaphorical thinking*" (1925/1946, p. 84).

We can find the same kinds of statements by those who study the nature and history of language: Max Müller, the great comparative linguist, noted that "no advance was possible in the intellectual life of man without metaphor" (1876, p. 370). Fritz Mauthner, the writer and philosopher, averred that "without exception every word in its individual usage is metaphorical" and that "we have learnt to understand metaphor as the term for the phenomenon which others call the growth or the development of language" (quoted in Gerschenkron, 1974, p. 432). And I.A. Richards argued that "metaphor is the omnipresent principle of language" (1936), and later stated that it is also the fundamental principle of thinking:

> Thinking is radically metaphoric. Linkage by analogy is its constituent law or principle, its causal nexus, since meaning only arises through the causal *contexts* by which a sign stands for (takes the place of) an instance of a sort. To think of anything is to take it *as* of a sort (as a such and such) and that 'as' brings in (openly or in disguise) the analogy, the parallel, the metaphoric grapple or ground or gasp or draw by which alone the mind takes hold. It takes no hold if there is nothing for it to haul from, for its thinking is the haul, the attraction of likes (Richards, 1938, pp. 48–49).

Many recent philosophers of science have built upon such insights. The works of Max Black (1962) and Mary Hesse (1966) are particularly relevant,[2] both for their own sake and because they presage Thomas Kuhn's recent assignment of metaphor to a preeminent role in the process of revolutionary change in science. As Kuhn (1987) has put it, of the three characteristics shared by the major scientific revolutions that he has studied at length, the one that "has been the most difficult. . .for me to see, but now seems the most obvious and probably the most consequential," is the common occurrence of a "central change of model, metaphor, or analogy—a change in one's sense of what is similar to what, and of what is different" (1987, p. 20). The crux of Kuhn's analysis is that the groupings or categorizations of phenomena change radically and holistically in the course of a scientific revolution, so that what once were "natural categories" of perception and understanding no longer are such. Aristotle, as he points out, found it quite natural to assume that "the falling stone was *like* the growing oak, or *like* the person recovering from illness," and, thus, that all three were instances of "motion" (Kuhn, 1987, p. 20). Newton's alignment of like and unlike, however, was completely different. After reviewing this and other instances of scientific change, Kuhn further noted that,

> all these cases display interrelated features familiar to students of metaphor. In each case two objects or situations are juxtaposed and said to be the same or similar. . . .The juxtaposed items are exhibited to a previously uninitiated audience by someone who can already recognize their similarity, and who urges that audience to learn to do the same. . . .Thus, the education of an Aristotelian associates the flight of an arrow with a falling stone and both with the growth of an oak and the return to health. . . .The student [thus] learns what categories of things populate the world, what their salient features are, and something about the behavior that is and is not permitted to them. In much of language learning these two sorts of knowledge—knowledge of words and knowledge of nature—are acquired together, not really two sorts of knowledge at all, but two faces of the single coinage that a language provides (Kuhn, 1987, pp. 20–21).

Kuhn's relevant conclusion is simply that "the metaphor-like juxtapositions that change at times of scientific revolution are thus central to the processes by which scientific and other language is acquired" (Kuhn, 1987, p. 21).

Of course, with the passage of time, some changes in perception and thought become so typical and familiar that terms and statements that were once obviously "metaphorical" come to be considered "literal." As one scholar of metaphor has put it, even "metaphors that were false seem to become true, and metaphors that were ungrammatical seem to become grammatical, both through usage" (MacCormac, 1985, p. 27). This historical observation suggests what others have argued, namely, that there is no radical distinction between the metaphorical and the literal, as indeed there cannot be if all language is ultimately metaphorical (see Arbib and Hesse, 1986, p. 150). It is not surprising, then, that neither grammarians nor semanticists have been able to provide a definitive demarcation between "the metaphorical" and "the literal." We must rely instead upon pragmatic distinctions based on conventional usage: To the extent that the use of a term is novel or unusual, it is likely to be considered "metaphorical"; to the extent that it is typical and taken for granted, it is likely to be considered "literal."

This issue of literality is important to us because science has so often been presented as being completely "objective" and as utilizing a pristinely "neutral" language. Yet even during the heyday of positivist philosophy of science, there were critics—often literary critics—who saw that matters stood somewhat differently. For instance, Kenneth Burke wrote:

> As the documents of science pile up, are we not coming to see that whole works of scientific research, even entire *schools*, are hardly more than the patient repetition, in all its manifestations, of a fertile metaphor? Thus we have, at different eras in history, considered man as the son of God, as an animal, as a political or economic brick, as a machine, each such metaphor, and a hundred others, serving as the cue for an unending line of data and generalization (1935/1965, p. 95).

And M.H. Abrams wrote:

> Metaphor, whether alive or moribund, is an inseparable element of all discourse, including discourse whose purpose is neither persuasive nor aesthetic, but descriptive and informative. Metaphysical systems in particular are intrinsically metaphorical systems. . . .Even the traditional language of the natural sciences cannot claim to be totally literal, although its key terms often are

> not recognized to be metaphors until, in the course of time, the general adoption of a new analogy yields perspective into the nature of the old. . . . For facts are *facta*, things made as much as things found, and made in part by the analogies through which we look at the world as through a lens (1953, p. 31).

Clearly, Burke's discussion of "fertile metaphors" and Abrams' analysis of "constitutive analogies" foreshadowed Thomas Kuhn's more recent work (1970) on "scientific paradigms." But before them all, the philosopher Stephen Pepper gave a classic statement about the related notion of "root metaphors":

> A man desiring to understand the world looks about for a clue to its comprehension. He pitches upon some area of common-sense fact and tries if he cannot understand other areas in terms of this one. This original idea becomes then his basic analogy or root metaphor. He describes as best he can the characteristics of this area, or, if you will, discriminates its structure. A list of its structural characteristics becomes his basic concepts of explanation and description. We call them a set of categories. In terms of these categories he proceeds to study all other areas of fact whether uncriticized or previously criticized. He undertakes to interpret all facts in terms of these categories (1942, p. 91).

Pepper's line of thinking has proven to be prescient and persuasive and has been carried forward along a variety of trajectories.

What I am trying to show, with generous but very partial reference to the words and works of others, is that many leading scholars have shared the conviction that "metaphor permeates all discourse, ordinary and special" (Goodman, 1976, p. 80). With regard to science in particular, a similarly broad array of scholars have begun to study the ways in which metaphorical thinking has helped to constitute scientific theory and practice.[3] The bottom line is that the overall effect of this widespread scholarly activity has been to confirm the basic insight reached by J.Z. Young, after his review of various metaphors that had been used to understand the functioning of the brain:

> This whole business of making comparisons may seem to you absurd and useless. It is, however, one of our chief aids to exploring the world and hence to getting a living. Indeed, I hope in later lectures to show that it is a tool we have been using in essentially the same way for thousands of years. For many purposes we have no other means of communication. It is not a question of whether or not to make comparisons but of which comparisons to make. We must use the rules—the certainties we have established by past experience. It is by comparison with these that each of us shapes his future. We *must* compare things, because that is the way our brains are constituted (1951, p. 60).

Of course, the "certainties" that we have established, individually and collectively, are relative rather than absolute; but as Young has suggested, they are the bases upon which we continue to bootstrap our understanding of ourselves and the world around us. Metaphor allows us to get a fingerhold, to pull ourselves forward, to reach toward what is now beyond our grasp.

Having provided this context for my general theme, namely, that the use of metaphorical or comparative thinking is endemic to the ways in which scientists and non-scientists alike come to comprehend themselves and their world, I want to focus in the remainder of this essay upon an extended illustration of the contention, expressed by W.V.O. Quine, that metaphor is particularly vital "at the growing edges of science" (1979, p. 159). Indeed, it is precisely at the edges of our knowledge that we are most obviously pressed to give forms to things unknown, and I will be particularly interested in what follows to show how new "forms" or "names" are given—and are being given right now—in the ongoing life of what Thomas Kuhn has called "normal science" (1970). For if a set of "forms" or "names" occasionally ends up taking over major portions of a discipline, thus bringing about a large-scale revolutionary "paradigm change," the more typical transformations in the normal day-to-day life of science take place more slowly and less dramatically by means of the cumulative effects of smaller and sometimes more temporary metaphoric changes.

Whether or not the example I shall discuss will become part of a large-scale, more permanent paradigm or remain a smaller and perhaps more evanescent phenomenon, it nonetheless warrants attention because it illustrates a number of things about the power of metaphor in science. First, since its relevance to the field in which it has developed was initially counter-intuitive, and since its deducible, subsequently confirmed theoretical and practical consequences were the *opposite* of widely accepted truth at the time of its articulation, the history of this metaphor demonstrates the significant, nontrivial role that metaphors can play in science. In short, they can make a very substantive difference in the theory and practice of a discipline. Second, since this metaphor has evolved within a scientific tradition that has been vociferously *anti*conceptual and, hence, *anti*metaphoric—a tradition that has eschewed the idea that an *idea* can make any empirical difference in the development of science—there is no way that anyone can claim that the influence of this metaphor has been due to any prejudice *in favor of* metaphorical thinking. Indeed, the fact that it has made its mark within this particular tradition underscores the inherent power of metaphor. Third, the story of this metaphor is not atypical of other ongoing developments on the edges of scientific fields. It does not represent Psychology Writ Large, already known to everyone. Rather, it represents lower-case, restricted-domain psychology, struggling for attention and existence. Developments on this scale and at this level illustrate the way in which the power of metaphor is more typically manifested, not in paradigmatic floods that overwhelm the topography of a discipline in a sudden rush for all to see, but in metaphoric drips that change the landscape much more slowly and less perceptibly. The repeated and varied uses of the metaphor I shall discuss below are precisely the kind of "drips" that are now accumulating into streams which, if sustained, may develop into even larger tributaries. If that happens, the wider domain of psychology is likely to be changed.

Knowing: The Example of Behavioral Momentum

Aristotle was perhaps the first to note that metaphors, to be effective, should be neither far-fetched nor obvious: If they are too unusual, they will be unintelligible to most people; if they are too ordinary, they will simply confirm what is already commonplace understanding (ca. 330 B.C./1952a, pp. 662–663). He also noted that if someone wishes to confer respect upon a topic, it would be wise for that person to take his or her metaphors from a domain held in higher esteem than the topic under consideration (ca. 330 B.C./1952a, p. 655).

These insights have been confirmed and applied over and over in the history of science. In the history of the social and behavioral sciences, in particular, this has often meant that metaphorical comparisons are drawn from the more advanced and prestigious natural sciences, especially from astronomy, chemistry, and physics, but also from biology (especially since Charles Darwin). Not surprisingly, Newtonian science has been a key source of social and behavioral metaphors, ranging from Bishop Berkeley's "social gravitation" (1713/1955) and David Hume's "experimental method of reasoning in moral subjects" (1739–1740/1978) to Sigmund Freud's "dynamic psychology" (1923/1961) and Talcott Parsons' "theory of action" (Parsons, Bales, and Shils, 1953). In fact, it is safe to say that all the talk and texts about the "statics" and "dynamics" of mental and social processes, which have received so much attention since the seventeenth century, have drawn their metaphorical substance from the general "mechanical worldview" of Newton and his contemporaries (see Dijksterhuis, 1969). Although the Darwinian and Einsteinian worldviews have inspired similarly plentiful conceptual offshoots over the past century—and although "chaos theory" is currently generating a host of competing metaphors—the Newtonian tradition remains a powerful source for metaphorical understanding. One particularly interesting instance has been the recent development of a tradition of research, theory, and practice associated with the metaphoric concept of "behavioral momentum." This tradition invites study for a number of reasons, including the fact that it shows how an already well established tradition, based on one family of metaphors, can be modified and enhanced by the translation of its insights and findings into a different metaphoric language. Further, it shows how this kind of translation from one language to another can lead to distinctive implications for clinical and other types of applied work. In these several ways, a review of this tradition will illustrate how a basic metaphoric insight can advance a scientific field, both in theory and practice.

The story begins in the early 1970s within the relatively small but vital group of psychologists whose research was advancing the scientific agenda of B.F. Skinner. This agenda, known as "radical behaviorism," was established some decades earlier in a series of works (especially Skinner, 1938, and Ferster and Skinner, 1957) that drew in significant ways upon the central Darwinian metaphors of variation, selection, and utility. In brief, Skinner proposed and provided some demonstrations suggesting that organisms emit spontaneous *variations* in behavior, some of which are subsequently *selected* (that is, "reinforced") because of their *utility*. This agenda of "selection by consequences" (Skinner, 1981) spawned an experimental tradition that generated a series of "laws of learning," articulated in quantitative terms, that specified the relationship between behaviors and their repercussions, conceptualized as "reinforcements" (for example, food) that are provided according to various kinds of "schedules" (for example, at regular or varying intervals).

In this tradition, also known as "Skinnerian" or "operant" behaviorism (for its emphasis on the fact that organisms operate proactively in their environments, rather than simply respond retroactively in a "Pavlovian" or "respondent" manner), reinforcement is routinely said to "strengthen" behavior whereas nonreinforcement "weakens" it. However, even before the 1970s, it was clear that "response strength" was a problematic notion which ought not be used, since two of its presumed measures (the rate of response and resistance to extinction) were often uncorrelated. That is, when reinforcement was suspended, different things happened to the speed and the persistence of previously reinforced behavioral responses. This well known but nonetheless neglected anomaly gave rise to a series of experiments by a member of this research tradition, John A. (Tony) Nevin, the first of which was published in 1974.[4] In these studies, it became apparent that while the rate of responding could be described and explained in terms of the traditional operant language of "reinforcement," consonant with the general Darwinian notion of "selection by consequences," the factors involved in resistance to change (or persistence of response) when reinforcement is reduced or eliminated bore further attention.

Five years later, Nevin published a searching and capacious chapter that reviewed the literature and provided additional experimental results on the relationship between reinforcement schedules and response strength. His primary concern was to correct the long-standing bias in the field, according to which "schedule research" focused almost exclusively on "the rates and patterns of responding maintained under constant conditions" (1979, p. 117). His objective, following up on his previous article, was to see if and how resistance to change was affected by altering conditions (that is, altering schedules of reinforcement) rather than holding them constant. In the simplest case, he wondered if and how long an organism would continue responding as it had learned to do when all reinforcement was withdrawn. Would the organism resist changing the behavior it had learned, or would it stop behaving as it had learned to do? This was a crucial question in his attempt to clarify the issues and factors that seemed to be at stake. By the end of his intricate analysis, he was able to conclude that resistance to change seems to be a very fundamental and distinctive aspect of learned behavior. Indeed, contrary to mainstream work in the operant tradition, he showed that response strength is a concept that should be brought back out of the behaviorist's closet and be measured *not* primarily by response rate under stable conditions (the focal concern in most published research in this tradition) but by persistence in response rate when conditions are altered.

As Nevin later admitted, even the old "response strength" language that he was still using (first popularized by Thorndike, 1911) was implicitly metaphorical, since in everyday terms "to reinforce means to make more resistant to attack, by weather or an armed opponent" (personal communication, 17 May 1994); but he was soon to propose a more obvious and specifically Newtonian metaphor, which would provide the framework within which he was able to translate these old metaphors of reinforcement and resistance into a new theoretical language.

His proposal was expressed in the title of an article in 1983, "The Analysis of Behavioral Momentum," which he published with two research associates. (He had, in the meantime, published another relevant article with Mandell and Yarensky in 1981.) He began this article with a summary of his central thesis:

> Learned behavior varies in its resistance to change, depending on the rate of reinforcement. Resistance to change may be characterized as behavioral momentum, which in turn may be analyzed into terms corresponding to mass and velocity in classical physics. Behavioral mass may be inferred from changes in response rate when experimental conditions are altered (Nevin, Mandell, and Atak, 1983, p. 49).

Leaving no doubt about it, he and his co-authors started their explication with a quotation of Newton's first law, and went on to admit that "by analogy" they were suggesting that "performance exhibiting greater resistance to change [should] be construed as having greater mass" (1983, p. 50). In this and in a series of subsequent publications, Nevin and his associates worked out and tested the implications of his new family of metaphors, in which "behavioral momentum," "velocity," and "mass" took the place of "response strength," "response rate," and "resistance to change," respectively.[5] Interestingly, he sometimes submerged his metaphorical language (in Nevin, Smith, and Roberts, 1987, and Nevin, Tota, Torquato, and Shull, 1990), perhaps in response to resistance to change within the operant community; but over all, there was a remarkable, progressive unfolding of his new theoretical language as well as a similarly impressive sharpening of his use of it, leading up to "An Integrated Model for the Study of Behavioral Momentum" (1992b).

Although it will telescope the historical development of this "Newtonian" theory, it might be useful to provide a synopsis of "the metaphor of behavioural momentum," as published by Nevin in a British journal, to demonstrate that this metaphor is anything but a whimsical, purely suggestive analogy:

> The fact that reinforcement increases response rate rapidly, whereas nonreinforcement decreases response rate slowly, suggests that reinforcement endows behaviour with something analogous to the momentum of a physical body. For example, a ball may be set in motion by a single kick, after which it slows gradually. . . .[6]
>
> In classical mechanics, momentum is defined as the product of the velocity and mass of a moving body. Newton's first law states that a body in motion continues to move in the same direction at a constant velocity unless acted upon by an external force. Likewise, responding . . . under maintained conditions of reinforcement continues at a constant rate until some external variable operates to change it. Newton's second law of motion states that the change in motion is directly related to the magnitude of the external force, and inversely related to the mass of the body. Likewise, the change in response rate is directly related to the magnitude of the external variable, and inversely related to the rate of reinforcement that maintained responding before the external variable was applied. Thus, by

> analogy, behaviour may be construed as having a mass-like dimension that is directly related to the rate of reinforcement maintaining it.
>
> In the momentum metaphor, velocity and mass are independent dimensions of a moving body. Likewise, response rate and resistance to change are both conceptually and empirically independent aspects of operant behaviour, being determined by separate processes that are normally confounded. . . .
>
> Together with the results of earlier research. . . , these findings suggest several conclusions: (a) When conditions are altered, resistance to change (mass) is independent of response rate (velocity) established during baseline training; (b) response rate depends on the response-reinforcer relation during baseline training; and (c) the resistance to change of that response rate depends on the stimulus-reinforcer relation during baseline training (1993a, pp. 163–164).

The formal language about "response-reinforcer relation" and "stimulus-reinforcer relation" in the conclusion of this long quotation points out one of the unexpected developments within this line of research, namely, that one of the measures of behavioral momentum depends upon operant or Skinnerian principles of learning and the other depends upon so-called "classical" or Pavlovian principles. Specifically, response rate is determined by the association of responses with reinforcements, and resistance to change is determined by the association of concurrent and nearly concurrent environmental features with reinforcements. This finding, first reported in Nevin (1984), represents a significant empirical breakthrough, and suggests that the momentum metaphor provides a closer match—that it is more analogous and less dysanalogous—than one might have expected.

It is natural to wonder what came first: Did Nevin's metaphoric conjecture help him isolate the Pavlovian dimension of what was previously called "response strength," or did a preliminary sense of the possibility of non-operant processes lead him to suggest the momentum-velocity-mass metaphor? Nevin's own reports are instructive in this regard:

> In the late 1970's, I collected a data set that was designed to

> quantify the relationship between resistance to change of key-pecking rates [response rates in pigeons] and the previously maintained rate of food presentation [reinforcement]. I played with the data for two years, casting about for the simplest and most compelling treatment, and began toying with physical analogs—the elasticity of a spring, for example. While flipping through a physics text, I got caught by the section on momentum of a physical body, figured out a way to superimpose the trajectories of behavior through time (or against resistance) in a general way, and published the 1983 paper with Charlotte Mandell and Jean Atak (now Roberts). The idea was to distinguish two aspects of behavior—response rate under constant conditions, and the persistence of that response rate when conditions were changed—by analogy to velocity and mass.
>
> In 1984, I recognized that some data I had collected for other reasons suggested that the mass-like aspect of behavior was essentially Pavlovian: That is, it depended on the relations between environmental stimuli and reinforcers rather than the relation between responses and reinforcers. In 1987, Larry Smith, Jean Roberts, and I replicated Nevin 1984 and showed that mass was independent of the response-reinforcer contingency, whereas velocity depended on the response-reinforcer contingency. In 1990, Tota, Torquato, and I did two experiments that made the separation clear. . . .Since then I have been going around with a new version of two-factor theory: velocity is Skinnerian, and mass is Pavlovian (personal communication, 17 May 1994).

In response to a further question, Nevin wrote:

> Did the momentum metaphor describe something I already knew about, or did it help to reach the new formulation? The answer is, both, in a sort of feedback way. In 1983, the idea of behavioral momentum was descriptive of a set of ordinal or qualitative relations that I had known about since 1974; but the quantification of the mass-like term in the 1983 paper with Mandell and Atak would not have occurred without the metaphor. Also, since velocity and mass are physically independent, the metaphor suggested that behavioral velocity (response rate) and mass (resistance to change) might also be independent and arise from different processes; this led to the analyses and arguments from 1984 to 1992 suggesting that velocity is Skinnerian and mass is Pavlovian (personal communication, 3 June 1994).

The behavior momentum metaphor, then, seems to have been at least partially constitutive and was probably largely so. It directed attention and energy toward particular aspects of the learning and performance process. Of course, it was not entirely by chance that Nevin came to it: Not everyone, not even every behavioral psychologist, spends time "flipping through a physics textbook." And, indeed, in response to another inquiry, Nevin replied: "As for the question of whether a physical-science metaphor has special power: I think it does for me, because of my background as a mechanical engineer. For others, it may have an adverse effect" (personal communication, 3 June 1994). However, even granting a predisposition toward physical-science metaphors, it should be noted that the successful articulation and corroboration of this metaphorically grounded theory did not come about without a great deal of careful, even painstaking thinking, experimental design, data gathering, and analysis:

> I had always known that it was possible to interpret Herrnstein's [1970] single-factor quantitative law of effect in a way that would encompass my resistance-to-change data, which if true would obviate the velocity-mass distinction. So I derived a sharp test, ran the experiment, and showed that Herrnstein's approach predicted the opposite of my data, whereas a Pavlovian approach predicted them fairly well. . . .After I submitted that paper [Nevin, 1992a], I saw (while riding a bus at midnight) a way to quantify and unify the Pavlovian factors that were responsible for behavioral mass, and published an integrative model [Nevin, 1992b]. . . .More recent empirical work has been relatively minor—refinements around the edges, so to speak (personal communication, 17 May 1994).

The refinements to which Nevin refers are further experimental housekeeping chores with regard to the details and nuances of his basic two-factor theory, but beyond this, a great deal of research has been extending his theory (which is based on experimental work with animals) to the study of human learning and applying it in the modification of behavior. This started with the publication of "Behavioral Momentum in the

Treatment of Noncompliance" (Mace, Hock, Lalli, West, Belfiore, Pinter, and Brown, 1988), continued with "The Momentum of Human Behavior in a Natural Setting" (Mace, Lalli, Shea, Lalli, West, Roberts, and Nevin, 1990), and is now a fairly vital "going concern." Nevin himself, besides publishing a number of papers with others, has extended his model of learned behavior to clinical practice (1993a), performance management (1993b), and educational technology (1993c) and has begun considering its applicability to the understanding of interstate warfare, addiction, and alcoholism. Beyond that, other research psychologists and many applied psychologists have been using the behavioral momentum model in their work. It is now cited fairly frequently in the literature, and entire sessions are devoted to it at professional conferences.[7]

An important thing to point out is that the implications of behavioral momentum theory are non-trivial. That is, they are both *substantive* and *different* from the implications of prior operant theory, which has guided behavioral modification strategies for many years. For example, the theory suggests—and research corroborates—that while alternative reinforcement will help bring about the institution of desired behaviors (increasing their "behavioral velocity"), changing the environmental setting will increase their persistence (adding to their "behavioral mass"). Working on both fronts, thus, will increase overall "behavioral momentum" (Nevin, 1993a). While still conjectural, the theory also allows the prediction that in business and industry, people will persevere despite adversity in direct proportion to how they were reinforced in particular work settings in the past (Nevin, 1993b). And in terms of learning in schools, the theory suggests to Nevin (1993c) not only that one should distinguish, but also *what one can do about the distinction* between the ability to respond in school (a measure of response rate) and the ability to apply what is learned outside the classroom (a measure of resistance to change). The point here is that by clarifying which particular factors influence each type of learning, the behavioral momentum model provides both understanding and means by which the acquisition and performance of learned behaviors can be enhanced.

Although it is too soon to be excessively critical about the fact that behavioral momentum theory does not yet appear in psychology textbooks, or even textbooks on learning, it is interesting to note that such books continue to repeat some of the outdated suppositions based on the simple-minded and demonstrably incomplete "response strength" concept. For instance, the famous (or infamous) partial reinforcement extinction effect, according to which behaviors learned under partial reinforcement are more resistant to extinction than behaviors learned under continuous reinforcement, is limited primarily to rats in discrete-trial runway studies (Nevin, 1988). Still, this "principle" gets repeated in many printed sources as well as in many classrooms each year, perhaps because it has been endorsed (that is, reinforced) in many powerful settings and, hence, is resistant to change. Its perpetuation is nonetheless reminiscent of the many inaccurate accounts of John B. Watson's case of "Little Albert," which Benjamin Harris (1979) has shown to be classic instances of people (including estimable scholars) remembering and reporting, over and over, what they *wished* had been the case. Behavior momentum may be up against a similar hobbyhorse. In its favor, however, are the kinds of physical intuitions that have been nurtured in our culture since the time of Newton. If these can be highlighted by the proponents of behavioral momentum, without simultaneously stimulating the Cartesian notion that humans are somehow exempted from the clockwork universe that Newton portrayed, Nevin's metaphoric insight may some day be taken for granted as an objective, literal description of the way things actually are.

Of course, if this happens, the history of science suggests that, sooner or later, some other metaphor will make things seem a little less obvious.

Conclusion

I began this essay with the claim that we humans are necessarily creatures of metaphor and extended this claim to cover science as well as non-science. As suggested by the scholars to whom I referred, metaphor often serves to give forms to things unknown by providing "names" by which they can be identified. The concept of behavioral momentum, as proposed and developed by Tony Nevin, is a powerful instance of this phenomenon. It can now take its place, in psychology, among the metaphors of telecommunications, control systems engineering, computer science, holography, and parallel distributed processing that have oriented theory in the neuropsychology; among the metaphors of feelings, responses, diseases, forces, and roles that have guided the conceptualization of the emotions; among the metaphors of pawns, agents, organisms, and machines that have characterized motivational theory; among the metaphors of hardware and software, vigilance and defense, access skeletons and signal detection devices that have reformed the fields of perception and cognition; and so on (Leary, 1990). All of these metaphors, as Nevin acknowledged with regard to behavioral momentum, have served a constitutive and directive function as well as a rhetorical function. They have not been merely descriptive, though they have often been accompanied, as has Nevin's central metaphor, by additional, second-order, descriptive, or elaborative metaphors.

As regards the rhetorical function of constitutive metaphors, it is important to remember, as Karin Knorr Cetina has said, that "the process of research production and reproduction is more complex than the equation of metaphor and innovation suggests" (1981, p. 66). In addition to the unpredictable ideas that occur to idiosyncratic individuals, scientific workplaces are suffused with inherited traditions, social norms, institutional structures, practical routines, and the values and constructs of their surrounding cultures. Any of these can provide inspiration for a particular metaphoric insight. Indeed, if a particular insight is to reverberate throughout a research community, it must tap into one of these social dimensions of science. As Emile Durkheim said long ago:

> It is not at all true that concepts, even when constructed according to the rules of science, get their authority uniquely from their objective value. It is not enough that they be true to be believed. If they are not in harmony with the other beliefs and opinions, or, in a word, with the mass of other collective representations [the concepts taken for granted by most people in a given time and place], they will be denied; minds will be closed to them; consequently it will be as though they did not exist (1912/1965, p. 486).

Behavioral momentum, because it is related to some central cultural assumptions, *does* exist presently as a viable concept within one particular tradition in the scientific community, but its long-term existence is far from guaranteed. To the extent that it comes to make a difference, or promises to make a difference, in some significant practical regards, it will be that much more likely to persist and prosper. Metaphors shape insights, and rhetorical factors help to disseminate them, but practical concerns will largely determine which will find a more permanent home.

If the purpose of a scientific work is "to persuade the reader of the validity of the thoughts which it presents," as even the logical empiricist Rudolf Carnap has admitted (1928/1967, p. xv), the ultimate purpose of the practical application of these thoughts is the improvement of the human condition. In the end, giving forms to things unknown may be less important *per se* than the priorities by which we select the things that *ought* to be given "a local habitation and a name."

Notes

[1] See Lanham (1991) for a review of analogy, metonymy, simile, and synecdoche as but alternative instances of the broader category of metaphor.

[2] See also Black (1979) and Arbib and Hesse (1986).

[3] See, for example, Arbib and Hesse (1986), Barbour (1974), Black (1962, 1979), Bohm and Peat (1987), Boyd (1979), Farber (1950), Gerschenkron (1974), Gould (1977a,b, 1983), Hesse (1955, 1966, 1980), Hoffman (1980, 1984), Jones (1982), Kuhn (1979), Leary (1987, 1988, 1990, 1992), Leatherdale (1974), MacCormac (1976, 1985), Martin and Harré (1982), Nisbet (1976), North (1980), Oppenheimer (1956), and Temkin (1977).

[4] Tony Nevin received his Ph.D. in psychology from Columbia University in 1963, taught at Swarthmore College, then returned to Columbia, where he served as department chairperson. In 1972, he moved to the University of New Hampshire, where he also served as department chairperson and where he has been since that time. Along the way, he has been the editor of the *Journal of the Experimental Analysis of Behavior* and the Executive Director of the Cambridge Center for Behavioral Studies. A recent publication of the American Psychological Association's Division of the Experimental Analysis of Behavior described him as being "among the most distinguished of behavioral psychologists" who "helped to establish and popularize the quantitative analysis of operant behavior, and has done extensive research on behavioral momentum and the mechanisms of learning" (Mulick, 1995). In the spring of this year, he retired from full time teaching, but he plans to continue to supervise research, consult, give talks, and write. I thank him for his assistance in the composition of this essay.

[5] The subsequent publications, in chronological order, include Nevin (1984), Nevin, Smith, and Roberts (1987), Nevin (1988), Nevin, Tota, Torquato, and Shull (1990), Mace, Lalli, Shea, Lalli, West, Roberts, and Nevin (1990), Nevin (1992a,b), Mace, Lalli, Shea, and Nevin (1992), and Nevin (1993a,b,c).

[6] As his reference to a ball being kicked suggests, Nevin is particularly effective in the use of what might be called secondary, descriptive, or elaborative metaphors—metaphors that are primarily communicative rather than constitutive, in the sense proposed by Abrams (1953). In a personal communication, he reported that he often uses such second-order metaphors for their rhetorical function:

> I think the arguments for the independence of behavioral velocity and mass are more powerful because they tie in with everyday physical intuitions as well as the formal apparatus of physical science. For example, when talking to social- and health-science

audiences, I introduce the distinction by asking them to imagine two trucks going at identical speeds on a highway, one of which is heavily loaded and the other lightly loaded. How do you find out which is more heavily loaded? You can't tell from current speed alone, but you can tell by asking the drivers simultaneously to shift into neutral and coast to a stop—the truck that coasts farther is heavier (personal communication, 3 June 1994).

Of course, the truck's speed is analogous to response rate, shifting into neutral is analogous to initiating nonreinforcement, and coasting farther represents greater resistance to change, or persistence of response.

[7] One delightful application can be found in Mace, Lalli, Shea, and Nevin's analysis of "Behavioral Momentum in College Basketball" (1992). Yes, there is something to the popular concept of "momentum" in sports as well as to the reality and importance of "teamwork"! Requesting publication lists on "behavioral momentum" through appropriate electronic data bases will produce a good many references on such topics as the behavioral momentum of compliance and non-compliance among preschool children and among those with behavior disorders, and it will reveal that behavioral momentum is now considered a topic worthy of doctoral dissertations. Basic research is also being conducted in the United States by Stephen Cohen (for example, Cohen, Riley, and Weigle, 1993) and in New Zealand by Anthony McLean (for example, Harper and McLean, 1992), and the annual meetings of the Association of Behavior Analysis have featured symposia on the application of behavior momentum theory for some years now.

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