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THE MISSING LINK: A TRANSFORMATIONAL VIEW OF METAPHORS IN ORGANIZATIONAL SCIENCE

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This article outlines the different knowledge functions of metaphors in lay and scientific discourses and proposes a methodology for the development of metaphors to yield deeper organizational scientific knowledge. It argues that the traditional dichotomy between metaphorical and literal languages has led either to an overemphasis or a depreciation of the role of metaphors in organizational science. This dichotomy is unnecessary and unproductive because metaphorical language and literal language are different but not incompatible. Drawing on Beer's suggestions about scientific modeling, this article advances a transformational view of metaphors, which attempts to outline a methodology for the development of metaphorical insights to yield literal identities.

The role of metaphors in theory development has been a controversial issue in organizational science. The debate has predominantly clustered around two poles. On the one hand, it has been argued that organizational scientific discourse does not describe, explain, or intervene in an independent reality, but it essentially draws upon symbolic constructs in helping to bring about such a reality (Astley, 1984; Manning, 1979). According to this view, metaphors encourage different ways of thinking, which enable social scientists and laypeople alike to focus upon, explain, and influence different aspects of complex organizational phenomena (Morgan, 1980, 1983, 1986, 1988a,b, 1989; Weick, 1979).

On the other hand, it has been suggested that organizational theories need to account for independently existing social phenomena. In such a process, metaphors are deemed as initially inevitable but eventually detrimental to theoretical development due, mainly, to their imprecision and low conceptual content. At the more mature phases of a scientific inquiry, researchers should make a conscious effort to dispense with metaphorical language in preference for literal language, namely for formal theories (Bourgeois & Pinder, 1983; Pinder & Bourgeois, 1982).

Proponents of these two views share the common assumption that metaphorical and literal languages are mutually exclusive. Consequently, the

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use of metaphors in organizational scientific discourse is either overemphasized or underplayed. In the former case, unrestrained metaphorical thinking is encouraged, but a methodology that could be used for the examination and evaluation of the knowledge claims of various metaphorical lines of reasoning is not suggested. In the latter case, metaphorical thinking is clearly discouraged; thus, the similarities and analogies manifested in our world (natural and social alike) are disregarded, and, consequently, organizational science is deprived of potentially useful bodies of knowledge accumulated across a variety of scientific fields.

The purpose of this article is to dissolve this "either/or" polarity by proposing a third "yes and" view that attempts to synthesize the two rivals. Simply stated, the use of metaphorical language in organizational science can be encouraged in the pursuit of literal language. Metaphorical and literal languages are not viewed as antagonistic but complementary to each other. In the first section it is shown that metaphors are inevitably used in both lay and scientific discourses, but their knowledge functions are different. In lay discourse, metaphors constitute an economical way of relaying primarily experiential information in a vivid manner, and they can be used as a variety reduction mechanism in situations where experience cannot be segmented and imparted through literal language. In scientific discourse, metaphors can provide significant insights about mechanisms that produce observable phenomena. The identification of these mechanisms is possible only if the literal core of the metaphors is revealed. In the second and final section of the article, the transition from a metaphorical to a literal language is demonstrated through the use of Beer's methodology of scientific modeling.

METAPHORS AND THEIR USE IN LAY AND SCIENTIFIC DISCOURSES

The *continuous* nature of perception of experience by human beings has been emphasized by both philosophers and cognitive psychologists. Yet, even though experience is perceived as a continuous flow, through the conceptual mediation of language, experience is inevitably segmented in order for it to be expressed and reflected upon (Daft & Wiginton, 1979; Ortony, 1975). Such ontological asymmetry between perceptual continuity and conceptual segmentation has two effects. First, it generates a linguistic requisite variety lower than the requisite variety of our experience of the world (cf. Ashby, 1956; Beer, 1985). Second, it causes a partial reification of our experiences (Berger & Luckmann, 1967; Fromm, 1986; Roth & Frisby, 1986).

Unlike other sign systems, language possesses an inherent quality of *reciprocity:* It establishes a "conversation" between thinking and acting. Moreover,

> The process of giving language to experience is more than just sense-making. Naming also directs actions toward the object you have named because it promotes activity consistent with

> the related attribution it carries. To change the name of an object connotes changing your relationship to the object and how one will behave in relationship to it because when we name something, we direct anticipations, expectations, and evaluations toward it. (Srivastva & Barrett, 1988: 34–35)

In other words, language is both descriptive and constitutive of reality (Giddens, 1976; Hayek, 1988; Sayer, 1984; Whitley, 1989). In social scientific discourse, this double function of language finds its ideal equivalent in the form of metaphors, similies, and analogies.

Metaphors

According to *The Oxford English Dictionary* (Simpson & Weiner, 1989, 9: 676), a metaphor is "the figure of speech in which a name or descriptive term is transferred to some object different from, but analogous to, that to which it is properly applicable" (e.g., "my French has gone a bit rusty"). Metaphors involve the transfer of information from a relatively familiar domain (variously referred to as *source* or *base* domain, or *vehicle*) to a new and relatively unknown domain (usually referred to as *target* domain or *topic*) (Johnson-Laird, 1989; Ortony, 1975; Vosniadou & Ortony, 1989). In the previous example, there is a transfer of information from the more known behavior of metals (i.e., the source domain) to the less known phenomenon of retention of linguistic knowledge (i.e., the target domain).

In metaphorical utterances, sentence meaning (when a speaker literally means that the object S falls under the concept P [i.e., S is P]) is *different* from utterance meaning (when a speaker means by his or her utterance that the object S falls under the concept R [i.e., S is R]) (Searle, 1979). In other words, in metaphorical utterances, a speaker says S is P (e.g., "my French has gone a bit rusty") but he or she really means that S is R (e.g., "I have forgotten some of my French"). By contrast, in literal utterances, sentence meaning and utterance meaning coincide. A speaker says S is P and he or she means S is P; in other words, in literal utterances P = R (Searle, 1979).

For analytical purposes three types of metaphors can be distinguished (cf. Lakoff & Johnson, 1980; Sanford, 1987).

Live metaphors. First, we use live metaphors knowing that these words are substitutes for literal utterances (e.g., "The production plant is the heart of the firm"). Live metaphors are the focus of this paper because compared to dead or dormant metaphors, they particularly lend themselves to further conceptual development.

Dead metaphors. Second, frozen or dead metaphors have become so familiar and so habitual that we have ceased to be aware of their metaphorical nature and use them as literal terms. Many, if not most, utterances in our language are dead metaphors (Rorty, 1989). The concepts of strategy (from *strategos*, meaning "general" in Greek) and organization (from *organon*, meaning "tool" in Greek) are examples of dead metaphors that are widely used in management. When dead metaphors are used, "the original sentence meaning is bypassed and the sentence acquires a new literal meaning identical with the former metaphorical utterance meaning" (Searle, 1979: 122).

Because dead metaphors are used as literal terms, their meanings usually are discontinuously shifted rather than continuously developed. Such a shift happens through either their associations with live metaphors or their interpretations in different contexts. An instance of the former is Mintzberg's (1987) description of strategy making as a crafting process. Similarly, an example of the latter is Mintzberg's (1978) dynamic redefinition of strategy as a pattern in a stream of important decisions, in opposition to the traditional static definition of strategy as a set of plans and intentions about an important issue. Dead metaphors prefigure the ground to be studied, but by themselves they cannot provide significant insights regarding the study of specific phenomena. For example, although the term *organization* is a (dead) metaphor, it is not very suggestive in the study of *specific* organizational phenomena and processes (e.g., division of labor, motivation, leadership, change). For the latter to be understood and explained the use of live metaphors may be necessary.

Dormant metaphors. Finally, dormant metaphors are quasi-literal terms through which we restrict ourselves to seeing the world in particular ways; however, the metaphorical nature of these terms can be easily exposed (e.g., the term *organization structure*). Dormant metaphors can aid the process of creative problem solving (cf. Proctor, 1989; Rickards, 1988) because by using them individuals can be encouraged to conceive of the topic through a different vehicle. Consider, for instance, Handy's (1989) suggestion to view organization structures not in terms of solid pyramids but rather as shamrocks and federations. In the same vein, Peters (1987) argued that organization structures should be seen as circles rather than as stratified pyramids. Ultimately, dormant metaphors are convertible to either dead or live metaphors.

Similes

A simile is a comparison of one thing with another (e.g., "an organization is *like* an organism"). Like metaphors, similies involve the transfer of information from the source domain to the target domain. Unlike metaphors, similies involve explicit comparisons and assert directly the similarities between the compared items. Every metaphor presupposes a simile, and, provided the source domain is sufficiently different from the target domain, every simile is convertible to a metaphor. However, though literarily different, similies, from a cognitive point of view, can be treated as being identical to metaphors (cf. Ortony, 1975). In this article, the distinction between similies and metaphors is considered of no cognitive importance.

Analogies

An analogy "operationalizes" a metaphor or a simile by focusing on *relationships* between items (Bunge, 1973; Sanford, 1987; Vosniadou & Ortony, 1989). More formally, an analogy is "a name for the fact that the relation borne to any object by some attribute or circumstance corresponds to the relation existing between another object and some attribute or circumstance pertaining to it" (Simpson & Weiner, 1989, 1: 432). For instance, a person might say, "Kuala Lumpur is to Malaysia as London is to Britain," or a feminist might assert, "A woman without a man is like a fish without a bicycle" (Sanford, 1987). The defining characteristic of analogical reasoning is the transfer of an explanatory structure from the source domain to the target domain. Although domain incongruence is necessary in metaphorical reasoning, this is not the case in analogical reasoning (Vosniadou, 1989). A person can employ either within-domain analogies, namely, analogies derived from very similar domains (e.g., "A puppy is to a dog as a kitten is to a cat"), or between-domain analogies, that is, analogies derived from conceptually very different domains (e.g., "Electrons are to the nucleus what planets are to the sun").

The Differences Between Metaphorical and Literal Languages

Metaphors, similies, and analogies, more than literal assertions, do not simply describe an external reality; they also help constitute that reality and *prescribe* how it ought to be viewed and evaluated (Harré, 1984; Keeley, 1980). To characterize metaphorically, for example, a particular capitalist as someone who "sucks the blood of his employees" is to make more than a statement of alleged real processes; it is to evoke certain commonly upheld images (negative in this case) and thus, by implication, to pass implicitly a value judgment and prescribe a mode of behavior.

By contrast, to say that "a capitalist extracts surplus value from the labor of his employees" and then to proceed analytically to define the concept of surplus value and demonstrate the processes of surplus value appropriation, is quite a different matter. In the latter case, the speaker uses a *more* literal language in an attempt to hypothesize an empirically falsifiable connection between observable phenomena and theoretical concepts, while refraining from the invocation of possibly familiar, but vague, atheoretical and unnecessarily value-laden images. To be sure, even in this case metaphorical language is not entirely avoided (e.g., consider the verb *extract* and its accompanying images), but at least this is a dead metaphor that has acquired a new literal meaning.

Literal language, best manifested in scientific theories, attempts to redescribe the world in order to establish identities; it is used to lay bare the mechanisms responsible for the observable phenomena we experience (Bhaskar, 1978a,b; Harré, 1984; Sayer, 1984). For instance, water can be redescribed as H_2O molecules, profit as surplus value, a business firm as a profit maximization unit, and so forth. In contrast to metaphorical language, literal redescriptions deny or transcend phenomenological accounts in the name of more profound ontological truth-claims (Davis, 1971; Maki, 1985; Tsoukas, 1989a). As noted previously, in literal utterances, sentence meaning coincides with utterance meaning, whereas in metaphorical utterances, these two types of meaning differ.

Furthermore, metaphors allow "inferences to be made about one of the things, usually that about which we know least, on the basis of what we know about the other" (Harré, 1984: 172). Given that there will always be things about which we know nothing or very little and that there are already other things about which we know something, it is to be expected that metaphors and analogies will always be used in lay as well as in scientific discourse (Weick, 1989). Moreover, given that an unfamiliar object can be corresponded in more than one way to other more familiar objects, it follows that metaphors are inherently partial. Metaphors *must* emphasize certain features at the expense of others (Bunge, 1973; Morgan, 1980, 1986, 1988a).

The preceding remarks are particularly valid for the social sciences because its subject matter (i.e., social reality) has a more vague and less "solid" (although no less real) character than natural reality. In the social sciences, metaphors render social reality more palpable and comprehensible than it would otherwise be (Gharajedaghi & Ackoff, 1984; Sackmann, 1989). The latter remark helps explain why social science metaphors tend to be of a pictorial nature invoking *images* rather than pure constructs or abstract symbols. It is easier to comprehend the concepts of, say, strategy making or organization transformation if more familiar images are invoked (cf. Sackmann, 1989). What these images may be is left up to the imagination, conceptual background, and metaphysical convictions of those involved.

Metaphorical language is a better alternative than literal language for expressing the continuous flow of experience (Ortony, 1975, 1979; Srivastva & Barrett, 1988), but by using it, human beings are less able to detach themselves from experience in order to abstract it and explain it. Although metaphors per se "avoid discretizing the perceived continuity of experience and are thus closer to experience and consequently more vivid and memorable" (Ortony, 1975: 53), they are poor cognitive devices for either specifying mechanisms that produce observable phenomena or revealing the generality of the operation of explanatory mechanisms.

By contrast, literal language has an inherently reductive propensity; it abstracts and segments experience in order to decipher relationships between its constitutive components (Berger, 1987). For example, I cannot use literal language to express my feelings of resentment about my low pay as a university employee. At best, I can use it to analyze and explain the declining salaries of academics in British universities over the last 10 years. By contrast, through metaphors I can say what cannot be said in literal language, thus expressing an emotional reality lying beyond even conscious awareness (Srivastva & Barrett, 1988).

In addition, through metaphors a person attempts to reduce the diverse variety of experience that may be difficult to adequately conceptualize because of the unavailability of literal terms. This idea is colorfully illustrated through the following example provided by Srivastva and Barrett (1988: 36):

> Imagine a child who cannot describe to his mother that his foot is asleep. He has no way of relaying this strange sensation; he doesn't know what is happening to his foot. In frustration, he says to his mother: "It feels like there are stars hitting my foot." Having no available literal terms, the child associates a new unfamiliar experience with one he understands. He has a sparkling, glittering, tingling sensation that seems to impact his foot from somewhat outside his body. At the age of four he is unable to say, "Mother, there is a certain numbness in my foot which is a result of an inadequate supply of blood flow which I inadvertently seemed to have circumvented."

Instances like this example are not symptomatic of lay discourse alone but they extend to scientific discourse too. Thus, in physics, molecules and swarms of molecules have been conceived analogously to particles in motion and gases, respectively. Also, electrical conduction has been explained through the supposition that there are free electrons in the metal, which behave like swarms of molecules (Harré, 1984).

However, what chiefly differentiates lay from scientific discourse (natural and social alike) is the conscious effort of researchers to construct theories that they hope will account for the mechanisms that are really responsible for the facts of experience (Bhaskar, 1978a; Bunge, 1973; Sayer, 1984). As Harré (1984: 178) put it, "This is what prompts that deepest of all scientific questions, 'What is there really in the world? Are those hypothetical mechanisms, which we believe might exist, really there?' " To return to the above-mentioned example, the posing of this sort of question is a corollary of the "coming of age" of the fictitious child: He is now not contented with what his foot *feels like*, but with *what it is* that causes the sensation he experiences.

Knowledge generated via this process of "disciplined imagination" (Harré, 1984: 180; Weick, 1989: 516) is of a *stratified* nature. Mechanisms responsible for experienced events are sought at increasingly deeper strata (Bhaskar, 1978a; Harré, 1984, 1988; Harré & Madden, 1975; Keat & Urry, 1982; Outhwaite, 1987; Sayer, 1984; Secord, 1986; Tsoukas, 1989b). In the very beginning of such a "drilling" process of knowledge acquisition, metaphors may provide the initial insights leading to the hypothesis of plausible causal mechanisms. At subsequent strata, however, metaphorical insights and analogical reasoning need to be transformed into a literal language that expresses real mechanisms and identities (Pinder & Bourgeois, 1982). The manner in which this can be done is illustrated in the next section through the use of Beer's methodology of scientific modeling.

FROM SIMILARITIES TO LITERAL IDENTITIES: A TRANSFORMATIONAL VIEW OF METAPHORS

Let us assume that X and Y are members of the set O, which is the universal set of objects, both concrete and conceptual. Let us further assume that X is a live metaphor for Y; for example, "Organizations [Y] are (like) organisms [X], in that . . . ". The question then is to determine the extent to which knowledge about X's nature and behavior (i.e., the source domain) can be transferred to the study of Y's nature and behavior (i.e., the target domain).

It was argued previously that at the merely metaphorical level there is very little help that can be elicited to answer as conclusively as possible the preceding question. Moving from the metaphorical to the analogical level is an improvement, but it is still an inconclusive step because at this level the researcher cannot determine the extent to which all the theoretically significant aspects of Y have been captured by the postulated analogy. There is, however, a third level at which conclusive comparisons can be made, and this is the level of *identity*. As Beer (1966: 112) pointed out, "If two things are literally identical with each other, then conclusions that hold for the one will surely hold for the other under similar conditions." The initial question then is converted to the following: How can both X and Y be conceptually developed so that their deep identities are revealed? In other words, how can the invariances between X and Y be discovered?

Mapping, Transformation, Isomorphism, and Homomorphism

Prior to answering these questions a few basic terms should be defined. The elements of a set A can be corresponded in various ways to elements of a set B. The process of making this correspondence is a *mapping*. The rules underlying a correspondence constitute a *transformation*. For instance, if we correspond the letters of the English alphabet to the numbers 1–26, this would be a mapping; however, we also need to define how this correspondence will be effected (e.g., one number for each letter), and this would be the rule guiding the correspondence (Beer, 1966). To continue with the same example, there is a one-one transformation when there is one different number for each letter, and there is a many-one transformation when each letter is converted to only one number but the numbers are not all different from each other. A mapping that involves a one-one transformation while also preserving operational relations is an *isomorphism*. For example, a map and the town it represents are isomorphic; relationships in the town are depicted in the map too. A photographic negative and a print are also isomorphic for the same reason (Ashby, 1956; Beer, 1966). Isomorphism is the highest form of resemblance: Two systems that are isomorphic are virtually interchangeable.

A *homomorphism* involves a many-one transformation while preserving operational relationships. For instance, a transformation of the infinite set of natural numbers onto a finite set of the numbers 0–4 is homomorphic because it involves a many-one correspondence, while at the same time it preserves basic arithmetic operations (e.g., addition). More formally, this is written as follows: $f(a_1 + a_2) = f(a_1) + f(a_2)$. In a numerical transformation like the preceding example, when this relationship is preserved the mapping is homomorphic (Ashby, 1956; Beer, 1965).

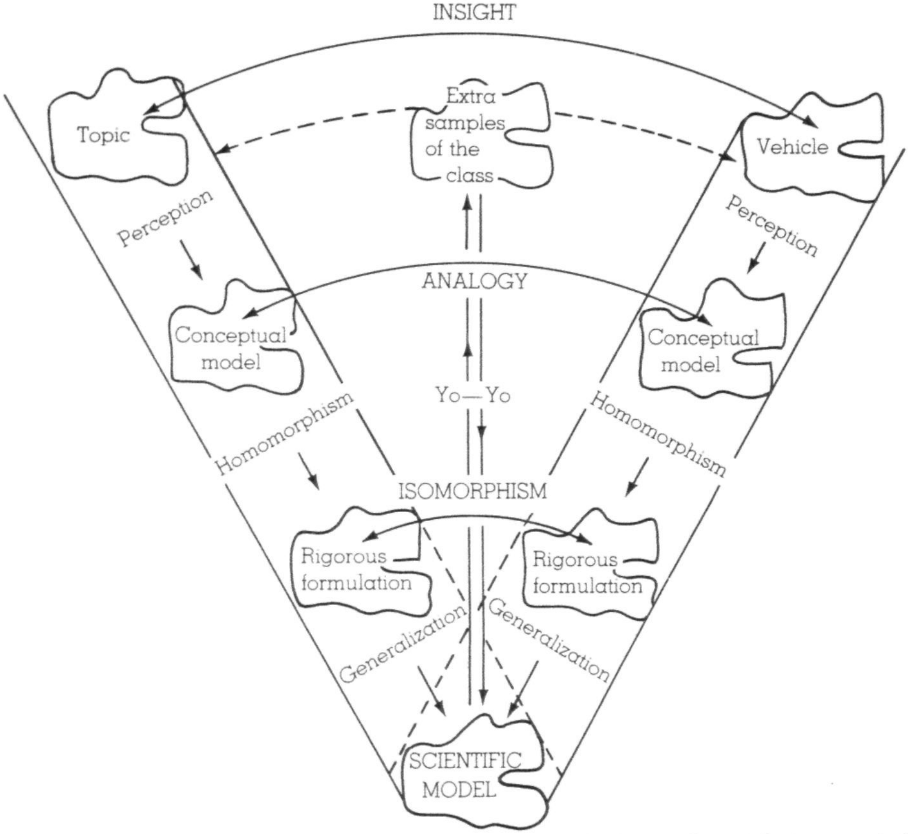
Similarly, in nonnumerical homomorphic transformations there is a simplification (i.e., a many-one transformation) *and* a preservation of important structural information. The guiding principle for the latter is the principle of *systematicity:* Higher order semantic relations (i.e., relations between relations) are preserved at the expense of lower order relations or mere isolated properties (Collins & Burstein, 1989; Gentner, 1983, 1989; Johnson-Laird, 1989). For example, in mapping the structure of the atom onto the solar system, a person can develop a homomorphic model of the latter by dropping the lower order properties of the sun (e.g., its yellowness), while preserving higher order relations such as, "The sun's attraction of the planets *causes* them to revolve around it" (Gentner, 1983; Johnson-Laird, 1989). According to Gentner (1989: 201) it is preferable to "map connected *systems of relations* governed by higher order relations with inferential import, rather than isolated predicates." As illustrated in the previous example, very often the higher order constraining relation "cause" leads to the preservation of both itself and the attached relational structure (e.g., "the sun's attraction of the planets"). Whether or not a nonnumerical homomorphic transformation has been achieved cannot be known ex ante (in opposition to what happens with numerical transformations); it can only be known ex post through an examination of the explanatory and/or predictive potency of the scientific model.

A homomorphism has fewer elements than its inverse image, which is to say that "many elements in the system that is conceptually modelled will map onto one element in a rigorous model" (Beer, 1984: 8). This remark carries enormous implications for it is cognitively impossible to include all the knowable features of a system into its model, and invariably we do resort to many-one transformations. In this respect, our conceptual models, even language itself, are actually homomorphisms of the reality they refer to (Beer, 1959, 1965, 1966, 1984).

From Metaphorical Insights to Literal Identities: An Outline of a Method

In the light of this terminological digression, the initial question regarding the refinement of X and Y so that they are made to reveal their deep identities can be reformulated as follows. We start with the insight that X can give us into Y at the metaphorical level. Next, we proceed to form a conceptual model in which the explicit analogies between X and Y are noted. Both stages, it was argued previously, give inconclusive results regarding the extent to which knowledge about X can be productively utilized to study Y. At this stage, the problem is how to "establish a mapping between the two conceptual models, under some transformation which [we] would like to be isomorphic" (Beer, 1966: 112). Isomorphism will allow us to reach the identity we are looking for, but the conceptual models, as they stand, cannot be made directly isomorphic because they are far too heterogeneous. To reduce this heterogeneity both conceptual models are transformed by many-one correspondences to "produce two deeper-level homomorphic models—*and these may well be isomorphic with each other*" (Beer, 1966: 113). In this way, we can achieve an identity between X and Y. The final

FIGURE 1
The Transformation of Metaphorical Insights Into Scientific Models[a,b]



[a] The *topic* is the object/phenomenon under study of which something is being asserted. The *vehicle* is the term metaphorically used to throw light on the *topic*. For example, "organizations (topic) are like organisms (vehicle)."

[b] From "The Viable System Model: Its Provenance, Development, Methodology and Pathology by S. Beer, 1984, *Journal of Operational Research Society*, 35(1), p. 9. Copyright 1984 by the *Journal of Operational Research Society*. Adapted by permission.

outcome of this process of refinement is a scientific model of high generalization (see Figure 1).

Two points need to be clarified here. First, the preceding process of concept transformation need not be an isolated top-down movement, but rather, it can be an oscillatory movement (or, as Beer graphically called it a *yo-yo movement*) (see Figure 1). Thus, if we follow the downward path (see the right-hand branch in Figure 1), knowledge about a certain phenomenon or object has accumulated and a scientific model has become available; this scientific model can be the starting point for an upward movement (see the middle of Figure 1), and we will be able to construct successively a homomorphic model and a conceptual model of the new phenomenon or object under study. The same process can be repeated as many times as there are new situations that need to be tested against the scientific model. More than one metaphor can be used to draw inferences about the phenomenon under investigation, and they can be evaluated following the previously described methodology. One important qualification, however, is that the pertinent range of activity over which a particular metaphor and the phenomenon under study are considered identical must be well specified. In other words, the limits of a metaphorical insight that is used must be clearly spelled out (e.g., traffic flow along a road can be considered analogous to fluid flow through a channel only in large systems, such as arterial roads).

Second, there is no a priori guarantee that this process of metaphor-inspired theory building will always reach the bottom of Figure 1, namely, that it will yield a scientific model applicable to *both* the source domain and the target domain. But if and when this happens, scientific generalization will have been achieved, which usually calls for a conceptual reclassification of both the source and the target domains (e.g., when sound and light are reconceptualized as waves) (Collins & Burstein, 1989).

Alternatively, it might be that at some point in the process toward the generation of a scientific model the metaphor breaks down, usually when it is not possible to create an isomorphic mapping between the two homomorphic models (see Figure 1). In this case, there is no generalization across fields, although the metaphor itself has been insightful. For instance, it could be hypothetically argued that although the Darwinian theory of natural selection is applicable in biology, a Lamarckian theory (postulating the inheritance of acquired characters) might be applicable for organizational populations. In this case, the initial metaphorical insight (i.e., organizational populations are like biological populations) would not have yielded a cross-fields general scientific model, but rather would have resulted in a field-specific theory of organizational populations.

Commenting on the above-described process of theory development, Beer (1966: 113) remarked that

> a scientific model is a homomorphism onto which two different situations are mapped, and which actually defines the extent to which they are structurally identical. What is dissimilar about the original situations is not reflected in the mapping, because the transformation rules have not specified an image in the set the model constitutes for irrelevant elements in the conceptual sets. If the transformation has ignored as irrelevant elements which are in fact relevant, then the model will lose in utility, but it *cannot* lose in validity.

Beer's remark points to a crucial feature of all nondeterministic systems, namely, that unlike homomorphic transformations pertaining to machines or numerical sets, there can be no a priori guarantees that a transformation has indeed been homomorphic or not. This can be ascertained only through a comparison of the homomorphic model with real situations. Such a comparison may refute the proclaimed homomorphism and, thus, render the model useless, but it cannot make the model invalid, for a refutation leaves intact the *process* through which such a model was constructed. Simply stated, any object can be mapped onto anything else under some transformation, but whether it is a useful mapping or not will have to be settled empirically.

It is also important to explain the proper level of application of the transformational view of metaphors. The preceding methodology applies to what Palmer (1989) called the *informational constraints* level. According to Palmer (1989: 333), "The objective at this level is to capture only the input-output mapping of people's analogical thought processes without regard to just *how* they might be accomplished in more specific terms." In that respect, the transformational view of metaphors deals neither with the behavioral constraints level nor with the hardware constraints level of analysis (cf. Palmer, 1989). At the level of behavioral constraints, the preoccupation is with how people *actually* process metaphors and analogies; namely, why and when one metaphor is more amenable to processing than another, why some situations give rise to certain metaphors and others do not, and what the actual sequence of steps is for different individuals who go through the process of refining a particular metaphor. Finally, at the level of hardware constraints, the concern is with how people access metaphors; that is, how the retrieval process of between-domain or within-domain analogies is neurologically accomplished (Johnson-Laird, 1989; Palmer, 1989).

The preceding methodology cannot offer ex ante criteria of how to make an initial choice between various metaphors; however, it can provide a heuristic for developing particular metaphors so that the effective transfer of knowledge from the source domain to the target domain may be possible. A theory of metaphorical reasoning must provide answers to questions posed at all three levels of analysis just mentioned, and it must specify the links between those levels.

In conclusion, the transformational view of metaphors advocated here is a process in which the initial metaphorical insight is progressively disposed of its literary variety through a set of homomorphic transformations, until, it is hoped, an invariance is revealed in the form of a scientific model. This process is illustrated through the following examples.

Three Examples

1. Learning as a function of experience. First, an example outlined by Beer (1966) (see also Bunge, 1973) regarding the learning process taking place in a new industrial plant is considered. It can be said that the learning of people in a new plant is a function of experience: As time goes by, experience accumulates and the people at the plant learn their jobs better; that is, the plant's output is improved. The question is: How might an estimate of its output be produced?

The very idea of the people at a plant learning their jobs implies an organismic view of the problem. The people at the plant can, for instance, be likened to a rat running a maze, and the chances of the rat using the correct exit, under conditions of reward or punishment for doing or failing to do so, respectively, improve over successive trials. The rat, being a source model for the people at the plant, offers a metaphorical insight, which may help us to answer the initial question.

If we follow Figure 1, we would set up a conceptual model at the analogical level, whereby explicit attention is paid to the analogies between the learning processes of a rat and the learning processes of the people at the plant. As mentioned previously, such an analogy is the learning development occurring in both a rat and the people at the plant: As the learning process of a rat improves over time, so does the learning process of the people at the plant.

If we proceed further down the Figure 1 and draw on animal psychology, we can construct a chart showing a concave curve linking trials and probability of failure. The latter decreases as the number of trials increases. This curve is simply a homomorphic model of the rat's learning process. This homomorphic model is a many-one transformation of the conceptual model: According to the principle of systematicity, the isolated properties of the rat (e.g., color, size, specific noises) have been dropped in favor of higher order relations (i.e., the learning capability of the rat—namely, that conditions of reward and punishment *cause* the rat to learn to use the correct exit).

This homomorphic model of the rat's learning process can be isomorphically used to construct a homomorphic model of the people's learning process. The question then is, "Could the people at the plant exhibit such a learning behavior as that described by the rat's learning curve?" A series of experiments would probably answer this question affirmatively: A variety of sanctions and rewards causes people to progressively improve their performance, and, thus, the output of the plant increases over time.

The end of this reasoning process is a scientific model of high generality, which expresses an identity relationship between rats and people concerning the development of their learning processes. From the point of view of a scientific model, rats and people are *identical* over a specified area of activity; their identity is manifested by the learning curve and the accompanying mathematical expression along with relevant statistical information.

2. Failures in sociotechnical systems. Second, in the field of organizational safety, Reason (1990a,b) suggested a medical metaphor in order to explain failures in sociotechnical systems. The following example explains the use of this medical metaphor.

If we follow Figure 1, at the level of metaphorical insight, we can liken sociotechnical systems to human organisms. Furthermore, there are some explicit analogies between sociotechnical systems and human organisms that are captured by the following conceptual model. Sociotechnical systems can occasionally deviate significantly from their normal operations and break down, causing "the unintended release of mass and energy in the presence of victims" (Reason, 1990b: 2). Similarly, human organisms can suffer various multiple-cause illnesses, thus deviating from a normal healthy life. In addition, there are interesting analogies between the etiologies of multiple-cause diseases suffered by humans and the catastrophic breakdown of complex sociotechnical installations. Both seem to require the breaching of a system's defenses, namely, either the breaching of the autoimmune system in the case of the human body or the thwarting of safety measures in the case of organizations (Reason, 1990a).

In line with Figure 1, if we pursue these analogies one step further, we can set up a homomorphic model of the preceding conceptual model of multiple-cause illnesses. In such a model isolated attributes of human beings (e.g., color, weight, height) are not taken into account, but higher order relations are preserved (the principle of systematicity). At this point in the example, before such a higher order relation is named, the concept of resident pathogens should be defined. In the field of medicine, *resident pathogens* are agents in the human body that have the capacity to cause diseases (e.g., cancer) if they are combined with a set of usually unforeseen external circumstances. At any one time certain pathogens exist in the human body prior to the manifestation of an illness, but it is their combination with local triggers (e.g., stress, diet, toxic chemicals) that activates them to cause a certain illness. In this case, the higher order relation to be preserved is, "When adverse local circumstances are combined with resident pathogens in a human organism, then an illness is *caused*." This relation is preserved because it constitutes a mappable system of higher order relations (i.e., "local circumstances are combined with resident pathogens") governed by the higher order relation "cause."

Similarly, if the insights of the previous homomorphic model are carried over from the source domain to the target domain, a homomorphic mapping of the conceptual model of organizational accidents will preserve the concept of latent failures in bringing about accidents. *Latent failures* are potentially fallible decisions made by designers and managers. Such a decision manifests itself in line-management deficiencies, which, in turn, give rise to certain psychological preconditions that are conducive to unsafe acts. These unsafe acts are active failures that, when combined with certain local events, find "windows of opportunit[y]" (Reason, 1990a: 147) to pass through the defenses of a system and cause an accident.

So far this analogy has offered ex post explanations of organizational accidents and given prescriptive advice to managers, but it has stopped short of offering a scientific model of high generality that would be pertinent to both classes of phenomena. Further development of this analogy could perhaps lead to such a scientific model, which would specify why, how, and when fatal disruptions of biological and organizational routines arise.

3. Biological metaphors in organizational science. Next, an example from organizational science is considered. The population ecology perspective (Aldrich, 1979; Hannan & Freeman, 1977; McKelvey & Aldrich, 1983; Staber & Aldrich, 1987) is an illustrative case in which the use of biological metaphors has yielded a significant amount of scientific output regarding the explanation of organizational variety and the relation of organizations to their environments. It is suggested here that the methodology of the population ecology perspective can be reconstructed to conform with the requirements of the transformational view of metaphors advocated in this article.

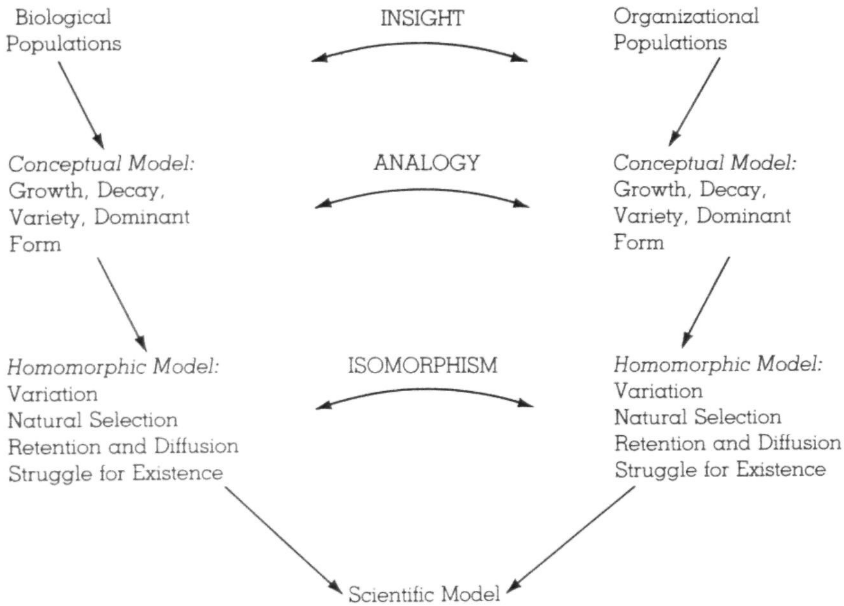
Again, if we follow the steps delineated in Figure 1, at the metaphorical level, we can note the insight that organizations can be seen as organisms; consequently, organizational populations can be described as similar to biological populations. Next, at the analogical level, we can set up a conceptual model, whereby some explicit analogies between organisms and organizations can be noticed. For example, both organisms and organizations go through processes of growth and decay; although there is quite a variety of organizational forms as well as of biological species, there tends to be a dominant form in both the organizational and biological populations.

If we pursue these analogies even further, we can construct a homomorphic model of the previous conceptual model of organisms along the lines of the theory of natural selection. This theory, which is based on the principle of variation, the principle of natural selection, the principle of retention and diffusion, and the principle for the struggle for existence, specifies what the mechanism of biological evolution is and how different species come into existence in particular environments. Again, this homomorphic model is a many-one transformation of the earlier conceptual model: Isolated predicates about individual organisms have not been included. In line with the principle of systematicity, what have been preserved are the higher order relations that account for the evolution of biological species. These are higher order relations between organisms and their environments, and they are part of a relational structure governed by the even higher order relation "cause." In other words, according to this homomorphic model, "the operation of the above mentioned four principles *causes* the evolution of biological species."

At this point, the insights of this homomorphic model can be applied to the target domain of organizational populations, where a homomorphic model describing the mechanism of organizational evolution should be delineated. The same principles pertaining to the theory of natural selection are applied to organizational populations and form the basis for a research program. Similar to the second example, the end of this process of thinking in parallel about organisms and organizations (i.e., grafting biological knowledge to the administrative field) will result in a scientific model of high generality that is pertinent to both organisms *and* organizations for a precisely defined area of activity (i.e., the forms of biological and organizational populations; how these forms evolved; and whether or not the forms will decline, grow, or remain stable). (See McKelvey & Aldrich, 1983 and Figure 2.)

Eventually, the transformational view of metaphors highlights the underlying mechanisms that account for the phenomena under study. Be-

FIGURE 2
A Transformational Reconstruction of the Methodology of the Population Ecology Perspective



cause such mechanisms are unknown, they must be hypothesized, and this must be done within a framework that endows them with existential plausibility. Metaphors serve the role of this framework so that the hypothesized mechanisms can be taken seriously into account for further research (Harré, 1988). As pointed out previously, metaphors cannot directly reveal these mechanisms. Thus, the methodology outlined above provides a procedure for the transformation of metaphors so that their literary variety is disposed of in order to yield their potential literal identities.

CONCLUSIONS

This article has suggested a way in which the "either/or" thinking that has traditionally characterized the debate about the utility of metaphors in theory development in organizational science can be overcome. Instead, a "yes and" view has been offered to bridge the gap between metaphorical and literal languages. The "yes" component has been the acknowledgment that metaphorical and literal discourses have indeed different, though not mutually exclusive, knowledge functions. Metaphors are better "sensors" than literal terms for capturing and expressing the continuous flow of experience. They allow the transfer of concrete bands of experiences, whereas literal discourse segments experiences. Although three types of metaphors were distinguished, it has been argued that only live metaphors lend themselves to further conceptual development.

However, metaphors are not as adequate as literal terms when human beings want to explain their experiences, predict new experiences from previous experiences, or judge the generality of their experiences. Metaphors tend to be used as substitutes for deeper knowledge, and they tend to be constitutive of, and prescriptive in relation to, the social phenomena they are connected with. By contrast, literal redescriptions of social phenomena tend to be more detached, more precise, and certainly more testable, accounting for the mechanisms (and the generality of their operation) that are really responsible for any experienced events.

Writers of scientific discourse aspire to use literal language, but at the same time they could benefit from metaphorical insights, whenever this is possible. Although the ideal of a purely literal scientific discourse is unattainable, for researchers to neglect metaphors and analogies is both uneconomical and unjudicious. The question therefore is not whether either metaphors or literal terms ought to be used in theory development in organizational science, but rather how can metaphorical language be used in such a way as to contribute to the development of literal language.

The "and" component advocated here is the provision of the link missing between the live metaphorical and literal languages (or between figurative and scientific discourses); it has been suggested that this link is the transformational perspective of live metaphors that acknowledges the importance of both parts of these pairs and attempts to connect them. Beer's methodology has been a particularly useful link. Using this methodology, researchers can gradually refine the metaphorical insights through the construction of conceptual and homomorphic models, so that while unnecessary variety is disposed of, crucial relationships are preserved. These crucial relationships ideally represent identity relationships between the two metaphorically linked objects of study, which are expressed in the form of a scientific model of high generality that pertains to a well-specified area of activity.

In other words, the theorist who uses a transformational view of live metaphors pays attention to both metaphorical and literal languages and suggests a way in which the former can transcend its mere literary status in order to be developed into the latter. To put it more graphically, the seed of literal language may exist within metaphorical language, but in order for it to grow and develop (i.e., in an optimal way to reach the stage in which it can yield its fruits), the nurture and care of the scientist are required.

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