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*William Paterson University of New Jersey,
Wayne, New Jersey, U.S.A.*

THE LOGIC OF METAPHOR

Analogous Parts of Possible Worlds



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THE LOGIC OF METAPHOR

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Contents

Acknowledgements	vii
1. Introduction	1
1. Metaphors and Logic.....	1
2. Metaphor and Possible Worlds Semantics	2
3. Analogical Counterparts	5
4. Theory-Constitutive Metaphors.....	8
5. Analyzing Metaphors.....	12
6. Philosophical Application of the Computer.....	18
Appendix 1.1: Sample Metaphorical Texts.....	22
Appendix 1.2: Analogical Inferences to Existence.....	24
2. Language.....	27
1. Introduction.....	27
2. Languages.....	27
3. The Grammar of Metaphor.....	30
4. Propositions.....	36
5. Propositions as Networks	41
6. Conclusion	45
Appendix 2.1: Semantics.....	50
3. Conceptual Structures	59
1. Introduction.....	59
2. The Network of Concepts	59
3. The Taxonomic Hierarchy of Types	60
4. The Mereological Hierarchy of Types.....	61
5. Taxonomic Hierarchy of Processes.....	62
6. Contrastive Structures.....	63
7. Symmetries in Networks	65
8. Rules and Lexical Entailments.....	66
9. Conceptual Fields.....	67
10. Conclusion	70
Appendix 3.1: Sample Descriptions.....	74
4. Analogy	81
1. Introduction.....	81
2. Towards a Formal Theory of Analogy	82
3. The Stages of Analogical Inference	84
4. Analogical Access	84
5. Analog Retrieval by Constraint Satisfaction.....	85
6. The Access Phase in NETMET.....	89
7. Analogical Mapping	93
8. Analogical Mapping by Constraint Satisfaction	95
9. Difficulties with Proportional Analogy.....	99
10. Rules for Analogical Mapping.....	100
11. Conclusion	108

5. Analogical Transference.....	115
1. Introduction.....	115
2. Analogical Transference.....	116
3. Subsymbolic Analogical Transference.....	118
4. An Extended Example of Analogical Transference.....	119
5. Rules for Analogical Transference.....	121
6. Analogical Transference and Induction.....	126
7. Perfect Analogies.....	130
8. Self-Mirroring Universes.....	131
9. Conclusion.....	134
Appendix 5.1: Examples of Analogical Transference.....	137
6. Metaphorical Communication.....	141
1. Introduction.....	141
2. Rules for Generating Metaphors.....	142
3. From Metaphors to Analogies.....	147
4. Conclusion.....	158
7. Analogy and Truth.....	161
1. Introduction.....	161
2. Truth-Conditions for Analogies.....	161
3. Logical Paraphrases for Metaphors.....	164
4. Rules for Assigning Truth-Values to Metaphors.....	167
5. Metaphorical Identity is Relative Indiscernibility.....	174
6. Conclusion.....	178
Appendix 7.1: Intensions for Metaphors.....	180
8. Metaphor and Inference.....	183
1. Introduction.....	183
2. Metaphor and Inference.....	183
3. Metaphor Justification.....	188
4. Metaphor Interpretation.....	196
5. Conclusion.....	207
9. Lexical Meanings.....	209
1. Introduction.....	209
2. Definitions for Metaphorical Predicates.....	209
3. Metaphors Based on Perfect Analogies.....	213
4. Inference to the Best Definition.....	216
5. Informative Truth-Conditions.....	220
6. Metaphors Based on Imperfect Analogies.....	223
7. Conclusion.....	225
10. Conclusion.....	227
References.....	231
Index.....	249

1 INTRODUCTION

1. Metaphors and Logic

Metaphors are among the most vigorous offspring of the creative mind; but their vitality springs from the fact that they are logical organisms in the ecology of language. I aim to use logical techniques to analyze the meanings of metaphors. My goal here is to show how contemporary formal semantics can be extended to handle metaphorical utterances. What distinguishes this work is that it focuses intensely on the logical aspects of metaphors. I stress the role of logic in the generation and interpretation of metaphors. While I don't presuppose any formal training in logic, some familiarity with philosophical logic (the propositional calculus and the predicate calculus) is helpful. Since my theory makes great use of the notion of structure, I refer to it as the *structural theory of metaphor* (STM). STM is a *semantic theory of metaphor*: if STM is correct, then metaphors are cognitively meaningful and are non-trivially logically linked with truth.

I aim to extend possible worlds semantics to handle metaphors. I'll argue that some sentences in natural languages like English have multiple meanings: "Juliet is the sun" has (at least) two meanings: the literal meaning "(Juliet is the sun)_{LIT}" and the metaphorical meaning "(Juliet is the sun)_{MET}". Each meaning is a function from (possible) worlds to truth-values. I deny that these functions are identical; I deny that the metaphorical function is necessarily false or necessarily true. I'll argue that most (but not quite all) metaphors are based on analogies. Analogy is the relative structural indiscernibility of parts of worlds. So: a metaphor is true at a world if and only if certain parts of that world are relatively structurally indiscernible (they are analogous). I'll also argue that metaphors that aren't based on analogies are still based on relative indiscernibilities of parts of worlds. I'll talk about the meanings of metaphors in terms of analogical accessibility and analogical counterparts.

I'll develop all this both informally and formally. Formally: I'll develop an intensional version of the predicate calculus (an extended predicate calculus) that has mechanisms for interpreting English sentences in terms of thematic roles and event-like entities (occurrences). My formal truth conditions for analogies and metaphors are based on the extended predicate calculus and its models. Since truth conditions are sometimes uninformative (even if correct), I'll also talk about confirmation conditions for metaphors. I'll indicate how metaphor is related to abductive inference and explanatory coherence. I'll show how to extend natural deduction systems to handle inferences that (dis)confirm metaphors. Science makes extensive use of theory-constitutive metaphors (e.g. "Light is a wave", "The brain is a spinglass", and "The immune system is the nervous system"). I aim to explain why such ampliative metaphors are scientifically legitimate.

While striving for formal precision, I also strive for empirical generality. One of the most important aspects of my project is its insistence on developing rules for generating and interpreting a wide variety of grammatical classes of metaphor.¹ Most metaphor theories consider only noun-identifications ("Juliet is the sun") or noun-predications ("Socrates is a midwife"); but STM is grammatically general, and is able to handle metaphors involving verbs ("Theaetetus gives birth to an idea"), adjectives ("Sharp minds are intelligent"), and so on. STM is therefore superior to theories able only to handle a few grammatical classes of metaphor. Moreover, by using standard

linguistic and logical notions, such as re-write rules and truth-conditions, STM is syntactically and semantically extendible.

To validate the consistency and empirical adequacy of STM, I built a computational model of it. The result is a working computer program, called NETMET, that realizes the rules I posit for competence regarding metaphors. Using NETMET, you can examine STM yourself. The success of NETMET has methodological consequences: it shows how the computer can be applied to a philosophical problem. NETMET is a very general analogy and metaphor engine serviceable for a variety of philosophical tasks.² In what follows, I attend both to building my theory of metaphor and to my realization of it in NETMET.

2. Metaphor and Possible Worlds Semantics

2.1 Logical Truth-Conditions for Metaphors

According to Davidson (1979), metaphors are supposed to mean just what their words literally mean. So: what does the sentence "Juliet is the sun" literally mean? One answer is that "Juliet is the sun" literally means that (is literally true if and only if) Juliet is the sun. However: there are at least 5 logically distinct senses of "is".³ Each sense involves its own truth-conditions. There is the "is" of numerical-identity: "Cicero is Tully"; the "is" of sortal-predication: "John is human"; the "is" of property-predication "John is white"; the "is" of intertheoretic-reduction: "Temperature is the average kinetic energy of molecules"; the "is" of role-occupancy: "Mel Gibson is Hamlet" (Shapiro, 1997: 83). Syntax alone does not always decide the sense: "Pauline Reage is Dominique Aury" and "Jim Carrey is Andy Kaufmann" are syntactically equivalent but semantically distinct uses of "is".⁴ Which is the literal sense of "is"? It would be better to speak of the *logical senses* of "is".

I suggest there is a sixth logical sense of "is": the "is" of *counterpart correspondence*. In this sense, x is y if and only if x in situation T is the counterpart of y in situation S . Here's how Dretske (1991) uses the "is" of counterpart correspondence:

Let this dime on the table be Oscar Robertson, let this nickle (heads up) be Kareem Abdul-Jabbar, and let this nickle (tails uppermost) be the opposing center. These pieces of popcorn are the other players, and this glass is the basket. . . . I can now by moving coins and popcorn around on the table, represent the positions and movements of these players. . . . The coins and the popcorn have been assigned a temporary function, the function of indicating (by their positions and movement) the relative positions and movements of certain players during a particular game. (pp. 52-53)

Dretske uses the "is" of counterpart correspondence when he says "These pieces of popcorn *are* the other players, and this glass *is* the basket." He also uses it in the explicit statements of correspondence: "Let this dime *be* Oscar Robertson, let this nickle (heads up) *be* Kareem Abdul-Jabbar, and let this nickle (tails uppermost) *be* the opposing center". The counterparts are based on a positional analogy. The "is" of (analogical) counterpart correspondence is the metaphorical sense of "is". The metaphorical sense of "is" is one sense of "is" (along with the numerical-identity, sortal and property predication, role-occupancy, and intertheoretic-reduction senses). Each

particular sense has its own logical truth-conditions. I'll argue that the metaphorical sense is logical whether or not it is "literal".

I'll agree that any sentence of the form $(x \text{ is } y)_{\text{LIT}}$ is true at world W if and only if x at W is numerically identical with y at W . So: "(Juliet is the sun)_{LIT}" is true at W if and only if Juliet at W is numerically identical with the sun at W . But that's not the whole story: "Juliet is the sun" is ambiguous. Its other meaning is metaphorical. I will argue that any sentence of the form $(x \text{ is } y)_{\text{MET}}$ is true at world W if and only if there are situations S and T in W such that x in its situation T is the counterpart of y in its situation S . The term "situation" is often linked with the semantic theories of Barwise & Perry (1999). I won't follow Barwise & Perry, but I will use the term situation — it's the best English word for the kinds of structures I want to talk about. Situations are parts of logical space. Any situation contains some individuals with some properties that stand in relations to one another.

For example: "(Juliet is the sun)_{MET}" is true at W if and only if there are situations S and T in W such that Juliet in T is the counterpart of the sun in S . The situations S and T are plain from Shakespeare's text: "(Juliet appears above at a window) ROMEO: But, soft! what light through yonder window breaks? It is the east and Juliet is the sun! Arise, fair sun, and kill the envious moon" (Shakespeare, *Romeo and Juliet*, 1974, Act II Scene II, p. 751). Just as the sun appears in the east, so too Juliet appears at her window.

I assume that literal and metaphorical truth-conditions are both expressed in some logical language — an intensional predicate calculus. I'll use an extended predicate calculus (the XPC) that involves thematic roles and generalized events (occurrences). I do not aim to give literal paraphrases of metaphors; I aim to give *logical paraphrases* of metaphors.⁵ I don't doubt that logical paraphrases miss some of the most exciting aspects of metaphor: the tension, the aesthetic brilliance, the rhetorical force. But I'm interested in truth. I'm interested in the *cognitive meanings* of metaphors.

2.2 Analogical Access and Counterparts

Possible worlds semantics argues that reality in its least restricted form fills a logical space that is divided into parts known as *worlds*. We inhabit one of these worlds: the actual world. Other worlds are possible relative to our world. The other worlds contain the ways things might have been: Bob Dole might have won the election in 1996. So: in some world, Bob Dole does win the election in 1996. But there's a problem: it is hard to see how the Bob Dole who wins the election in that world is numerically identical with the Bob Dole who loses the election in our world. Identicals are supposed to be indiscernible. One way to solve the problem of *trans-world identity* is to deny that one individual inhabits many worlds: Bob Dole in our world has a *counterpart* at some other world who is exactly like our Bob Dole up to the election in 1996. Our Bob Dole loses; his counterpart wins. This is David Lewis's idea.⁶ It is controversial; it is not the only way to deal with the problem of trans-world identity (which may not even really be a problem). Lewis's notion of counterparts won't work for metaphors. Analogical counterpart theory has to allow individuals to have many counterparts in distinct situations in the same world.

Hintikka has often argued that worlds can be small; he calls them scenarios (1983). I follow his lead: situations are small worlds; they are fine-grained parts of logical space. Possible worlds in the traditional sense are just special situations (the

spatio-temporally-causally closed ones, or the maximally consistent ones, or whatever). I refine these ideas later. For now I just want to sketch some links between accessibility, counterparts, and metaphors. If reality in some grand sense consists of a plurality of worlds, then:

We often quantify restrictedly over worlds, limiting our attention to those that somehow resemble ours, and we call this a restriction to "accessible" worlds. And we often quantify restrictedly over possible individuals, limiting our attention to those that somehow resemble some given this-worldly individual, and I call this a restriction to "counterparts" of that individual. (Lewis, 1986: 234).

For metaphors, accessibility is (almost always)⁷ analogy: situation S is accessible from situation T if and only if S is analogous to T. If S is analogous to T, then there is some function f that correlates the individuals (and events and maybe properties) of S with those of T; that function f is usually known as an *analogical mapping function*. More philosophically, it is a counterpart function. If x is in situation S, then $f(x)$ in T is the counterpart of x in S. The counterpart relation was intended to resolve problems of trans-world identity. It looks to me like metaphorical identifications like "Juliet is the sun" are *trans-situation identities* — identifications across small analogous parts of logical space. So I think that some appropriately modified version of counterpart theory that is able to handle situations and analogies is able to provide truth-conditions for metaphors generally.

Possible worlds semantics provides some good resources to deal with metaphors: logical space, situations, worlds, accessibility, counterparts. It is useful for other reasons. For example: some metaphors (as well as similes) involve comparisons with things that don't actually exist: "Tornadoes are vacuum cleaners from the sky" compares tornadoes with things that don't actually exist; so, possible worlds are needed to avoid vacuous reference. Indeed: in Shakespeare's metaphor "Juliet is the sun", Juliet is a fictional character who does not inhabit our world. If that metaphor is true, it is true only in worlds of which Shakespeare's *Romeo and Juliet* is true. Another reason is that Hintikka and Sandu (1994) have sketched a theory of meaning for metaphors using PWS, and their theory in many ways complements Kittay's semantic field theory of metaphor (SFTM). I don't doubt that there are problems with both SFTM and PWS. Both those theories require work. Doubtless their combination is even more troublesome than either theory by itself. Still, an extension of PWS to metaphors brings metaphor into the best semantic theory available today. It also brings metaphor closer to metaphysical issues.

I aim to show that much of the semantic machinery used in PWS for literal statements (e.g. intensions) can be successfully applied to metaphorical statements as well. To do this, it will be necessary to dispel two big myths about the nature of metaphor. First: proponents of PWS, fearful that PWS could not easily accommodate metaphor, have tended to treat it as a matter of pragmatics, a matter of language use. For example: in their recent textbook of PWS, Chierchia & McConnell-Ginet (1991: 161) assign only one sentence to metaphor: "Fresh metaphors and many other figurative uses of language are also to be understood in terms of multiple levels of speaker's meaning". Second: proponents of metaphor have tended to treat metaphor as a counter-example to PWS. Lakoff's (1987) & Johnson's (1987) declamations against PWS (which they refer to as "objectivism") are by now well known. I think that

Kittay, and Hintikka & Sandu, have shown that the conflict between PWS and metaphor is misguided. I aim to show that metaphors have truth-conditions that fit in just fine with logical projects like Chierchia & McConnell-Ginet's.

3. Analogical Counterparts

3.1 Hobbes's Analogy A STATE IS AN ORGANISM

Metaphors involve the comparison of target and source situations. Aspects of the source situation are *systematically correlated* with aspects of the target situation. The correlation is a function from the set of source objects to the set of target objects. Specifically: the correlation is an analogy. To see how source objects are correlated with target objects, it helps to look at a text in which the correlations are explicit. Hobbes (1962) thinks of the state as an artificial human organism:

Art goes yet further, imitating that rational and most excellent work of nature, man. For by art is created that greate LEVIATHAN called a COMMONWEALTH, or STATE, in Latin CIVITAS, which is but an artificial man . . . and in which the *sovereignty* is an artificial *soul*, as giving life and motion to the whole body; the *magistrates*, and other *officers* of judicature and execution, artificial *joints*; *reward* and *punishment*, by which fastened to the seat of the sovereignty every joint and member is moved to perform his duty, are the *nerves*, that do the same in the body natural; the *wealth* and *riches* of all the particular members, are the *strength*; *salus populi*, the *people's safety*, its *business*; *counsellors*, by whom all things needful for it to know are suggested unto it, are the *memory*; *equity*, and *laws*, an artificial *reason* and *will*; *concord*, *health*; *sedition*, *sickness*; and *civil war*, *death*. (Introduction, p. 5)

In the Hobbesian text, the target situation is a (generic) state; the source situation is a (generic) man. Table 1 lists counterpart correspondences between the state and man. Hobbes is using the "is" of counterpart correspondence in "the sovereignty *is* an artificial soul" (my italics). He is not using the "is" of sortal-predication. So: "the sovereignty is an artificial soul" doesn't have the same logical form as "the sovereignty is a political institution"; so, it does not have the same kind of truth-conditions. When he writes "reward and punishment . . . *are* the nerves," (my italics) he is using the "is" of counterpart-correspondence. Thus "reward and punishment . . . are the nerves" doesn't have the same logical form as "reward and punishment are moral operations"; so, it does not have the same kind of truth-conditions.

state	→	man	equity	→	reason
sovereignty	→	soul	laws	→	will
magistrates, officers	→	joints	concord	→	health
reward, punishment	→	nerves	sedition	→	sickness
wealth, riches	→	strength	civil war	→	death
counsellors	→	memory			

Table 1. Correlations from state to body.

One interpretation of "the sovereignty *is* an artificial soul," provides it with truth-conditions like this: "the sovereignty *is* an artificial soul," is true if and only if (means that) the functional role of the sovereignty in a commonwealth is the same as the functional role of the soul in an organism. More precisely: "the sovereignty is an artificial soul" is true if and only if there is some role R such that the sovereign plays R in the commonwealth and the soul plays role R in an organism. There is such a role: x plays role R in system y if and only if x rationally orders the activities of y. Likewise: "reward and punishment . . . *are* the nerves" is true if and only if the role of reward and punishment in the commonwealth is the same as the role of the nerves in an organism. If we say: x plays role Q in system y if and only if x enables the controlling center of y to regulate the parts of y by arousing or inhibiting their activity, then we have found a role played both by reward and punishment in the commonwealth and by the nerves in an organism; if that is right, then we have found a role that makes "reward and punishment . . . are the nerves" true. The statements "the sovereignty is an artificial soul" and "reward and punishment are the nerves" are metaphors. They are rather prosaic metaphors; but they are metaphors.⁸

3.2 Swanson's Analogy THE CELL IS A FACTORY

Metaphors are often used to introduce theories. Such pedagogical uses of metaphor are among the most effective techniques for teaching unfamiliar concepts. Metaphors are quite frequently used to teach scientific theories. If metaphors are creatively used falsehoods, any inferences from the metaphor to the content of the theory are accidental; the speaker can hardly be said to have any intentions, and it is truly surprising that such pedagogical uses of metaphor are effective. It is even more surprising (if metaphors are creatively used falsehoods) to find metaphors used to teach scientific concepts. So far from *facilitating* teaching, metaphor ought to *hinder* teaching. Yet it does not.

On my view, such uses are successful (that is, reliably effective) because the inferences from the metaphor to the content of the theory are rule-governed. There are rules for the interpretation of metaphors. Naturally, these rules are like all other linguistic rules: they have exceptions — a fact about natural language that seems to drive philosophers mad. In mathematics, a single counterexample refutes a theorem; in semantics of natural language, a single counterexample is merely an exception. Indeed, there are even classes of counterexamples (such as English verbs that form their past tenses by internal vowel changes). But back to metaphor. I will argue that metaphors are reliable and effective tools for communication because the same idea of truth is at work in both metaphorical and literal language. Here, for example, is a metaphor used to illustrate the operation of the cell (Swanson, 1960: 26 - 41). The cell is thought of in terms of a factory:

The cell . . . can be considered as a chemical factory. It may, of course, be a general-purpose factory, capable of performing all the services and of manufacturing all the products necessary to continue life; this must obviously be true in unicellular organisms. Or it may be a specialty shop, doing only a single job, such as serving as nerve cells for communication or as muscle cells for movement. Regardless of its nature, however, a cell, like a factory,

must possess a certain organization in order to be efficient; it must contain a controlling or directing center, a source of supplies, a source of energy, and the machinery for making its product or performing its service. (p. 26) . . . The cell membrane, therefore, not only provides mechanical support and exterior form for our cellular factory, it also is very much a part of the living machinery of the cell. (p. 28) . . . the nucleus . . . is the controlling center, the board of directors of our cellular factory, for in it are found the chromosomes and the genes which somehow guide and determine the character, activities, and destiny of each individual cell. (p. 31) . . . The cytoplasm . . . is the main assembly line of the cell and its output is either a product . . . or a service . . . or a combination of the two. To do these things, the cytoplasm requires a source of raw materials, a source of power, the machinery necessary to do the job, and mechanisms for distributing its product or service. (p. 35) . . . The "powerhouse" of the cell is . . . another particle in the cytoplasm, the mitochondrion. (p. 37) . . . the highly ordered arrangement of membranes that make up this cellular background, which is called the . . . endoplasmic reticulum. . . we therefore look upon the endoplasmic reticulum as the principle manufacturing portion of our factory. (p. 41) . . . An efficiently operated factory is a planned, not a haphazard affair; its continuous operation requires, as we have pointed out, direction, power, machinery, and raw materials, and the parts must be related to the functions they perform. Nature has constructed cells along the same lines as we have constructed factories. (p. 41)

Table 2 lists the correlations of the cell and its parts with the factory and its parts. These correlations facilitate comprehension of something initially unfamiliar to students — the cell — in terms of something that is likely to be more familiar — the factory.

cell	→	chemical factory
unicellular organism	→	general-purpose factory
nerve cell	→	specialty shop
membrane	→	mechanical support
nucleus	→	board of directors
cytoplasm	→	main assembly line
mitochondrion	→	powerhouse
endoplasmic reticulum	→	manufacturing area

Table 2. Correlations from cell to factory.

In this metaphor, as in the Hobbesian metaphors, the correlations preserve the functional roles of the components in their respective systems. For example: "The nucleus is the board of directors of the cellular factory" is true if and only if (means that) the functional role of the nucleus in the cell is the same as the functional role of the board of directors in a factory (or manufacturing company). So: the nucleus in the cell is the counterpart of the board of directors in a manufacturing company. In what follows, I will bring out some heavy logical machinery to analyze counterpart correspondence for metaphors. I'll analyze it in terms of analogical mapping functions across situations.

4. Theory-Constitutive Metaphors

4.1 Some Different Kinds of Metaphors

There are many different kinds of linguistic metaphor.⁹ I distinguish between *poetic* or literary metaphors and what Boyd (1979) has called *theory-constitutive metaphors*. Theory-constitutive metaphors are used productively in the sciences: "Electricity is a fluid", "Light is a wave", and "The mind is a computer program", are all instances of theory-constitutive metaphors. But theory-constitutive metaphors also occur outside of the sciences: they occur in philosophy ("Memory is a wax tablet"), in theology ("God is light"), in politics ("A nation is a body"), in logic ("The null individual is the null set"), and in other disciplines. Theory-constitutive metaphors occur in engineering as well as in the more abstract disciplines: "A paintbrush is a pump" (Schon, 1979: 257 - 260) is an *ampliative* metaphor in which the theory of paintbrush function is reorganized according to the theory of pumps in order to solve an engineering problem. Theory-constitutive metaphors are *ampliative* — they use creative reasoning by analogy to generate novel and informative hypotheses that are significantly true or false, and that are tested like other theoretical hypotheses. My thoughts on creative reasoning by analogy are guided by Thagard's *Mental Leaps: Analogy in Creative Thought* (1995).

I am mainly interested in theory-constitutive metaphors. They are usually more extensively elaborated than literary metaphors, and the discourses in which they occur already privilege truth over non-cognitive values such as aesthetic merit. My focus on theory-constitutive metaphors is not meant to exclude literary metaphors. I think the methods I develop to analyze theory-constitutive metaphors apply just as well to poetic metaphors. For instance, Kittay's (1987: 287-8) analysis of the "bees of England" metaphor in Shelley's "Song to the Men of England" uses the same techniques I use for more prosaic metaphors. Poetic metaphors also depend on counterpart-correlations in analogical situations.

Boyd (1979: 359-60) distinguishes theory-constitutive metaphors from pedagogical or exegetical metaphors. Pedagogical metaphors play a role in teaching theories already well-understood. For instance, a physics teacher might say "The atom is a miniature solar system" to introduce the notion of the atom to students already familiar with the solar system. The description of the solar-system in terms of the atom is dispensable once the theory of the atom is learned. But theory-constitutive metaphors are "those in which metaphorical expressions constitute, at least for a time, an irreplaceable part of the linguistic machinery of a scientific theory" (p. 360). Boyd offers the computer metaphor for the mind as an example of a theory-constitutive metaphor.

Boyd lists further distinctive characteristics of theory-constitutive metaphors:

1. if successful, a theory-constitutive metaphor becomes "the property of the entire scientific community, and variations on [it] are explored by hundreds of scientific authors without [its] interactive quality being lost" (p. 361);
2. there is no reason to doubt that complete explication of theory-constitutive metaphors is possible, nor to doubt that "complete explications are often the eventual result of the attempts at explication which are central to scientific theory" (p. 362);

3. theory-constitutive metaphors display a kind of "inductive open-endedness" (p. 363); they suggest "strategies for future research" (p. 363) and have a power to programmatically orient research. Indeed, one can even view theory-constitutive metaphors as *discipline-constitutive*. For instance, the computer metaphor for the mind orients and drives the discipline of cognitive science.

4.2 Explication of Theory-Constitutive Metaphors

A theory-constitutive metaphor for some target consists of a metaphorical re-description of the target along with an analogy on the basis of which the target was metaphorically redescribed. Such a metaphorical re-description directs research concerning the target by assigning to it the task of interpreting all the metaphorical concepts and propositions in the metaphorical re-description of the target. Research into the target consequently involves the *production of a series of ever better logical approximations to the meaning of the metaphor*. Each of these logical approximations is a theory of the target that better approximates its metaphorical re-description. Each successive member of this series more precisely fixes the references or extensions of metaphorical concepts and provides more accurate truth-conditions for metaphorical propositions. The limit of this series is a theory in which all metaphorical concepts have fully fixed references or extensions, and all metaphorical propositions have perfectly accurate logical truth-conditions. In principle, it is possible for this series to converge towards this limit without ever reaching it. In practice, there is usually some point at which the productivity of the metaphor is exhausted.

For instance, the LIGHT IS A WAVE metaphor constitutes a theory of light by directing optical research at the production of a series of ever better logical approximations to the metaphorical concepts and propositions analogically transferred from the domain of waves to that of light. Particularly, a logical approximation is better if it more precisely fixes the reference of the concept "luminiferous ether", and so provides more accurate logical truth-conditions for the proposition "Light travels through the luminiferous ether".

The construction of better logical approximations is often difficult, indirect, and fortuitous. Very accurate logical approximations to the meaning of the MEMORY IS A WAX TABLET metaphor are provided by thermodynamic theories of memory (Smolensky, 1986). Surprisingly, such theories, based on scientific understandings of information in terms of entropy, provide logical definitions for concepts like *computational temperature*, and so provide highly accurate logical truth-conditions for metaphors like "Heat melts memory" and "Memory freezes as it gets colder."

4.3 Examples of Theory-Constitutive Metaphors

Theory-constitutive metaphors are alive and well in recent scientific research (Thagard, 1995: ch. 8). Three theory-constitutive metaphors deserve further philosophical study: (1) the metaphorical interpretation of neural networks in terms of logical switching circuits; (2) the metaphorical interpretation of neural networks in terms of spin glasses; and (3) the metaphorical interpretation of the immune system in terms of the nervous system. All these metaphors are controversial; the fact that they are controversial is good — it means that they are (or have been) actively debated; but