Mathematics, Measurement, Metaphor and Metaphysics I

Implications for Method in Postmodern Science

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ABSTRACT. This paper relates philosophy's metaphysical insistence on rigorous figure–meaning independence, and its own distrust of that insistence, to the potential for improved quantitative and qualitative methods in the sciences. Following Wittgenstein's admonition that we pay attention to our nonsense, a kind of Socratic double vision is needed to simultaneously accept (1) that any meaningful discourse necessarily requires a significant degree of signifier–signified coordination, and (2) that an ideal degree of such coordination is never achieved in practice. A metaphysically informed theory of scientific method begins from the mathematical and hermeneutic implications of figure–meaning coordination. This paper explores the mathematical metaphysics of science, critically evaluates the often repeated maxim that fields of study are only as scientific as they are mathematical, and suggests that some forms of quantification are more mathematically astute, metaphysically informed, pragmatic and effective than others. In conclusion, the qualitative and quantitative aspects of three key features of measurement are briefly explored: (1) the deconstructive display and exploration of significant anomaly; (2) the metaphorically and numerically reductive identification, via sufficient reason and sufficient statistics, of new variables; and (3) the constructive application of technologically embodied sign–thing coordinations in research and practice.

KEY WORDS: mathematical thinking, measurement, metaphysics, method, positivism, postmodernism

Scientific researchers continue to increase the attention they pay to the role played by interpretation and influences upon it in every aspect of their studies. The literature is thus replete with efforts focused on formulating post-structuralist and postmodern research approaches in virtually every field. The vast majority of these approaches are qualitatively oriented, and are commonly insensitive to the potentials that exist for an integration of interpretive and quantitative methods, to the point of denying that such integration is possible.

THEORY & PSYCHOLOGY VOL. 13(6): 753–790
[0959-3543(200312)13:6;753–790;039290]

The supporters and detractors of postmodernism vary in the spin they put on this separation of the qualitative and quantitative, but on this, at least, they agree. For instance, one pair of self-proclaimed post-structuralists asserts that ‘One of the ways in which this post-structuralist view of knowledge is incompatible with the necessities of measurement is that interpretations are not assumed to be consistent or similar across time, contexts, or individuals’ (Delandshere & Petrosky, 1994, p. 16). Similarly, the authors of a book that purports to stand up for science and rationality in the face of superstitious nonsense contends that ‘Deconstructionism holds that truly meaningful utterance is impossible, that language is ultimately impotent, as are the mental operations conditioned by linguistic habit’ (Gross & Levitt, 1994, p. 76). Others hold that ‘Psychoanalysis and literary deconstruction, for example, owe some of their appeal to their rejection of objective measuring standards’ (Pyenson & Sheets-Pyenson, 1999, p. 209). In another writer’s opinion, the deconstructionist Jacques ‘Derrida’s attempt to reject the law of contradiction follows from his stress on the indeterminacy of meaning, and makes impossible the assertion of anything’ (Maze, 2001, p. 393). Another writer contends that ‘Derrida destroys the basis of any hope we might have of acquiring any knowledge at all’ (Zuckert, 1996, p. 263). Finally, and most famously, Allan Bloom (1987, p. 387) held that deconstructionism ‘is the last, predictable, stage in the suppression of reason and the denial of the possibility of truth in the name of philosophy.’

These senses of post-structuralism, postmodernism and deconstruction are, however, misinformed. Postmodernism is an awareness of the ambiguities that attend simultaneously deconstructing and asserting meaning, and is in no way anti-realist. Indeed, the thesis that metaphoric (or geometric, numeric or dramatic) figures must be rigorously independent of the meaning they carry has been referred to as philosophy’s only thesis (Derrida, 1982, p. 229). Or, as Mundy (1986) states the thesis, in a context completely removed from postmodernist considerations:

> The hallmark of a meaningless proposition is that its truth-value depends on what scale or coordinate system is employed, whereas meaningful propositions have truth-value independent of the choice of representation, within certain limits. The formal analysis of this distinction leads, in all three areas [measurement theory, geometry and relativity], to a rather involved technical apparatus focusing upon invariance under changes of scale or changes of coordinate system. (p. 392)

The rigorous independence of figure and meaning necessarily has a place as a metaphysical assumption in any discourse (Derrida in Wood & Bernasconi, 1988, pp. 88–89; Gadamer, 1986, pp. 385–390; Hans, 1980; Heidegger, 1982a, pp. 19–23; Hoy, 1978; Kauffmann, 1990, p. 192; Rapp, 1998; Ricoeur, 1977, pp. 300–302), qualitative or quantitative. After all, ‘no philosophical discourse would be possible, not even a discourse of deconstruction, if we ceased to assume what Derrida justly holds to be "the sole thesis of philosophy" ' (Ricoeur, 1977, p. 293).

This fact is often less appreciated than it should be. Derrida's focus on unusual texts in which the direction of signification is undecidable has too often been generalized to apply to any text, as is evident in the preceding interpretations of what post-structuralism is about. As early as 1968, however, Derrida (in Wood & Bernasconi, 1988, p. 88; also see Zimmerman, 1990, p. 261) said, 'I try to place myself at a certain point at which—and this would be the very "content" of what I would like to "signify"—the thing signified is no longer easily separable from the signifier.' Similarly, in a 1981 interview, Derrida remarked that 'it is totally false to suggest that deconstruction is a suspension of reference. . . . I never cease to be surprised by critics who see my work as a declaration that there is nothing beyond language' (Kearney, 1984, p. 123). Maze's (2001) interpretation of Derrida as presenting 'his own idiosyncratic version of classical idealism' (p. 393) is exactly what Hoy (1986, p. 407) characterizes as 'the wrong way' to think of Derrida's claim that there is nothing outside of the text. In his career since 1968, Derrida has been anything but an 'academic renegade and antagonist of philosophy and philosophy programs', acting instead as 'one of philosophy's staunchest advocates', a point made repeatedly during his address to those assembled for the inauguration of a new philosophy program at Villanova University in 1994 (Caputo, 1997, p. 50), as well as in the late 1970s during his activism in support of philosophical research and teaching in France (Derrida, 1983, pp. 47–48).

> Derrida is not trying to bury the idea of 'objectivity' . . . [since] it is not that texts and languages have no 'referents' or 'objectivity' but that the referent and objectivity are not what they pass themselves off to be, a pure transcendental signified. (Caputo, 1997, p. 80; also see Kearney, 1984, pp. 123–124)

So 'it is important to see that the kind of negative conclusion that Derrida would constantly enact does not produce anarchy' (Risser, 1989, p. 184).

On the contrary, the purpose of deconstruction is to identify and appropriate living meaning from within the tradition, so as to open the way to renewed possibilities (Caputo, 1997, p. 73; Wilshire, 1990, p. 157). 'Deconstructive doubt is not a doubt about things but about the unrevisability of established linguistic formulas' (Staten, 1984, p. 156). As Heidegger (1953/1959; see also 1982a, p. 23 and 1962, p. 44) puts it:

> Precisely because we have embarked on the great and long venture of demolishing a world that has grown old and of rebuilding it authentically anew, i.e., historically, we must know the tradition. We must know more—i.e. our knowledge must be stricter and more binding—than all the epochs before us, even the most revolutionary. Only the most radical historical knowledge can make us aware of our extraordinary tasks and preserve us

> from a new wave of mere restoration and uncreative imitation. (1959, pp. 125–126)

The goal, then, of postmodern thought, is to be as faithful as Levi-Strauss was to the double intention of being able 'to preserve as an instrument something whose truth value he criticizes' (Derrida, 1978, p. 284), that instrument being the thesis of philosophy.

Even though the metaphysical requirements relative to the heuristic fiction of rigorous figure–meaning independence are unavoidable and are approximated whenever meaning is shared, that does not mean that these requirements are ever perfectly well met, and no broad claims of such independence should go unchallenged. The goal of completely transparent, univocal, universally translatable communication that was associated with the logical positivists' anti-metaphysical program (Carnap, 1959; Hempel, 1970; Neurath, 1970) no longer remains viable. But the fact that pure objectivity now has to be understood as a heuristic fiction does not mean that we are completely and permanently mired in confusion. On the contrary, it would seem that Wittgenstein's admonition that we pay attention to our nonsense (Wittgenstein, 1980, p. 56; see also Staten, 1984, p. 156) will remain a basic methodological dictum for the foreseeable future. To do this is to be both the Socratic gadfly afflicting those perhaps too comfortable in their assumptions of common unity, as well as the Socratic midwife comforting those afflicted with exclusion from, and welcoming new members into, the community (Bernasconi, 1989; Risser, 1989, p. 184).

Epistemological and ontological structures do not exist in things in any way that has historical effects apart from the extent to which they are infused with meaning from the context in which they appear. Saying this does not deny that structures exist without producing historical effects, since every discovery/invention of a new effect implies its prior unnoticed availability. Sometimes the contexts infusing meaning into things are remarkably wide, as is the case with the technics of the physical sciences, where it is relatively easy to identify reproducible qualitative and/or quantitative effects and to set up the social networks through which these are shared and traced.

What is less well understood is the extent to which, within the cultural frameworks that pre-interpret much of the world for us, the shared psychosocial meanings of interest to the human sciences *do* exhibit some degree of consistency and similarity across time, contexts and individuals. To be teachable and learnable, and so be mathematical, in the metaphysical sense (as will be explained below), sufficient reason has to play a role in the birth of any object of discourse. Unless the object of a conversation of any kind can separate from the contingencies of its origins and take on a life of its own, even if that separation is never complete, meaning is not shared. Without the ability to posit, entertain and test for sufficient consistency and similarity, there is no basis for asserting that different interpretations are interpretations of the same thing or different things, and there is therefore no way to justify bringing them together for purposes of comparison and contrast.

Any two interpretations that are not identical are different, but perhaps not in any way that has substantive significance. The point for the human sciences is to find out how much of a difference makes a difference. What proportion of differences in interpretation are inconsistencies that have to be expected from people who vary in their special strengths and weaknesses? Do some differences in interpretation in fact exhibit structural consistencies in the way they vary? What is the proportion of consistent structural variation relative to the inconsistent variation? Are there significant amounts of improbable inconsistent variation? How improbable? Can the improbable events be localized in specific question-and-answer exchanges? Do these events constitute fundamental threats to the generalizability and validity of the data? Do they open up new questions that lead further along a reproducible path of inquiry? Even if such inconsistencies are not detected in existing data, is it possible to monitor incoming data routinely for such threats and opportunities? Is it possible to incorporate some small individual differences in data consistency without threatening the generalizability of the overall consistency? Must quantitative measurement effect pure signification, as we typically assume, or can (or even must) numeric figures and the meaning they carry be less than perfectly coordinated? If so, how do we know when they are sufficiently well coordinated?

These are the kinds of questions that must be routinely posed in research that aspires to integrate the qualitative and the quantitative, embodying, living up to and vigilantly questioning the mathematical metaphysics of the academy. The integration of qualitative and quantitative concerns is facilitated when scientific instruments are understood as texts written quantitatively, as ‘readable technologies’ (Heelan, 1983a), which means that, in principle, instruments ought to be the most metaphysically rigorous texts, that is, achieving the greatest degree of figure–meaning convergence and separability in the context of networks through which local particulars can be traced to universal reference standards (Ackermann, 1985; Bud & Cozzens, 1992; Fisher, 2000; Hacking, 1983; Ihde, 1991; Latour, 1987, 1994; Mendelsohn, 1992; O’Connell, 1993; Schaffer, 1992; Shapin, 1989, 1994; Van Helden & Hankins, 1994; Wise, 1995). This paper will first elaborate on the fundamentally mathematical character of metaphysics, and on the way this metaphysics plays out in the context of measurement. Work in progress pursues (1) the implications of mathematical metaphysics for addressing the problems of measurement and metaphoric signification, and (2) the extent to which metaphysically informed measurement is implicitly achieved by metaphor. This latter involves an empirical data study through which the virtual calibration of language as an instrument capable of providing a measure of the weight of meaning is made actual.

Mathematics and Metaphysics

A Wider Sense of the Mathematical

How is metaphysically rigorous figure–meaning convergence and separation, or signifier–signified coordination, mathematical? A broader sense of the mathematical begins to take shape when it is realized that, for the ancient Greeks, 'the name "mathematics" means the same thing as learning' (Descartes, 1961, p. 17). This general sense of the Greek category *ta mathemata* as learning, doctrines or a curriculum of what can be taught and learned is widely recognized in the mainstream of the philosophy and history of mathematics (Bell, 1931, p. 58; Bochner, 1966, p. 255; Dantzig, 1955, p. 25; Heath, 1931, p. 5; Heilbron, 1998, p. 8; Høyrup, 1994, p. 10; Miller, 1921, pp. 78, 17; Wilder, 1965, p. 284), but is rarely pursued at any length.

Heidegger (1967, pp. 67ff.; 1977a, 1977b, pp. 118–120), however, focused his attention on Greek mathematics in order to recover its wider implications for the conduct of science and the meaning of technological humanity. He says that:

> *Ta mathemata* means for the Greeks that which man knows in advance in his observation of whatever is and in his intercourse with things: the corporeality of bodies, the vegetable character of plants, the animality of animals, the humanness of man. Alongside these, belonging also to that which is already-known, i.e., to the mathematical, are numbers. If we come upon three apples on the table, we recognize that there are three of them. But the number three, threeness, we already know. This means that number is something mathematical. Only because numbers represent, as it were, the most striking of always-already-knowns, and thus offer the most familiar instance of the mathematical, is 'mathematical' promptly reserved as a name for the numerical. In no way, however, is the essence of the mathematical defined by numberness. (Heidegger, 1977b, pp. 118–119; also see 1967, pp. 74–75)

In the spirit of the Pythagorean motto that the 'world is number', Copernicus, Galileo, Descartes and others felt so confident about the stability of the nature of knowledge and existence as things that would always be sure in their status as 'always-already-knowns' that they were willing to define the essence of mathematics as only numerical (Burtt, 1954; Husserl, 1970a). Descartes (1961), for instance, remarks that 'arithmetic and geometry . . . deal with an object so pure and simple that nothing need be assumed which experience has rendered uncertain' (p. 8).

Though it is true that Descartes 'undertook to bring all objective evidence back to the primordial evidence of the cogito', he 'was the first to betray himself', remaining 'a prisoner of the evidences of Galileo. . . . As he [Descartes] saw it, the truth of the physical is mathematical, and the whole enterprise of doubt and the cogito served only to reinforce objectivism'

(Ricoeur, 1967, p. 165, commenting on Husserl, 1970a, pp. 78–83). Because of their situation in their particular historical contexts, perhaps Galileo and Descartes could not have thought or acted in any other way. But in the same way that modernism relies upon unexamined assumptions concerning the nature of knowledge and existence, so too does the definition of the mathematical as purely numerical.

Number was not always recognized as quintessentially mathematical. Suppes and Zinnes (1963) remark on how difficult it was in the earliest uses of number to dissociate the operations of arithmetic from the things counted:

> The ancient Egyptians could not think of 2 + 3, but only of 2 bushels of wheat plus 3 bushels of wheat. Intellectually, it is a great step forward to realize that the assertion that 2 bushels of wheat plus 3 bushels of wheat equal 5 bushels of wheat involves the same mathematical considerations as the statement that 2 quarts of milk plus 3 quarts of milk equal 5 quarts of milk. (p. 4)

Of course, Suppes and Zinnes have no evidence as to the full range of what the ancient Egyptians could and could not think of. All we have are texts and artifacts, and these demonstrate conclusively that mathematical practice before the Greeks had no place for fully generalized and abstract mathematical concepts (Ifrah, 1999; Kline, 1953, p. 31; Menninger, 1969). In fact, the historical substance of Plato's insight that names are not the things they stand for (Gadamer, 1980, p. 100; 1989, p. 405) follows from the way that the sign–thing coordination embodied in alphabets and writing itself originated in the business mathematics needed for commercial accounting (Ifrah, 1999).

For instance, the earliest business accounts are based in one-to-one or one-to-many correspondences between various kinds of markers and the things themselves. With numerous images of archeological artifacts to illustrate the story, Ifrah (1999, pp. 101–108) documents how contracts for sheep trading, for instance, initially involved small uniform clay markers matched one-to-one with the actual sheep to be traded. The markers would be sealed in a clay ball that was not opened until the execution of the trade. Given the lack of both written language and counting numbers higher than 3 in the cultures investigated, this kind of a contract was needed to ensure that the trade would involve 'this many' sheep and not any other number of them.

Ifrah suggests that the sealed contracts posed the problem of remembering how many sheep were specified as the time to execute the contract approached. After many contracts were broken in order to re-match the markers with what was to be traded, it occurred to someone to impress on the outside of the clay ball two-dimensional images of the three-dimensional markers in the ball. It then became apparent that the impressions on the outside of the ball served the purpose of the contract, and so writing was born, with the metaphors of sealing and breaking remaining basic parts of business contract language.

Until the Greeks, the extent to which the two-dimensional written symbols became abstract representations of amount alone, and not the amount of something in particular, remained uneven and variable. Similarly, in geometry, for 'the Egyptians, for example, a straight line was quite literally no more than either a stretched rope or a line traced in sand' (Kline 1953: 31; also see Bunt, Jones, & Bedient, 1976, pp. 70–1). Plato's definitions of a line as an indivisible plane, of a point as an indivisible line, and so on (Cajori, 1985, p. 26; Ricoeur, 1965, p. 202), were the geometric equivalents of his distinction between name and concept, and between numbers and particular things counted.

Plato's distinction was so apt that, even by the time of Aristotle, the association of the numerical with what is most obviously mathematical in the broad sense of the teachable and learnable had become taken for granted. 'Mathematical' promptly became a name for the domain of number because of the way that the numbers, their arithmetical operations, and their efficacy so strikingly, obviously and familiarly stayed the same across applications to different units and different things. The Pythagorean cult could even be said to have worshiped number, with that reification becoming embedded in the metaphysics of natural science in the form of the assumptions that everything in nature and the universe is inherently numerical in structure, that a field of study is scientific to the extent that it is quantitative, and that non-quantitative modes of expression are necessarily unmathematical.

Measurement's need for an isomorphism between numbers and invariant, additive structures within a developed sociotechnical context was not recognized at the time that the language and methods of natural science were appropriated in the founding of social science. But such isomorphisms are virtually as old as civilization, and had long since been recognized and implemented, in effect, in the business accounting practices that made writing possible, as documented by Ifrah (1999). They similarly played a role in Plato's restriction of the instruments of geometry to the compass and straightedge (Ball, 1919, pp. 43, 35, 28; Bunt et al., 1976, p. 126; Cajori, 1985, pp. 26–27; Courant & Robbins, 1941, p. 59; Ricoeur, 1965, p. 202; Scott, 1960, p. 20), undertaken as the means of respecting the distinction between name and concept. So, had Descartes not been the first to betray his own insights, had he followed through on his enterprise of doubt and the *cogito* to rethink the fundamentals of knowledge and existence, instead of remaining a prisoner of Galileo's willingness to assume rather than demonstrate that the physical universe is mathematical (Husserl, 1970a, pp. 78–83; Ricoeur, 1967, pp. 162–165), he would have been compelled to show the way in which the mathematical 'taking of what we already have from within' proceeds, and to have overtly and deliberately founded science in a way that takes the limits of philosophy's thesis into account. Instead, that is our task.

A Closer Examination of the Mathematical

It is useful in this context to extend Heidegger's example a bit. If someone sees three apples on a table, advance conceptions must be brought to bear concerning the nature of apples, tables, unity (there is only one table) and what it is for one thing to be on another, besides that of threeness. Concentrating only on apples, to see one requires prior knowledge of what an apple is; or, if one sees something on a table but does not know it as a apple, then perhaps it is known as an edible fruit, or only as a small, red, yellow or green sphere-like object. Even these last qualities still demand advance conceptions of size, color and geometry.

It approaches the impossible to imagine what three apples on a table would look like without any advance conceptions of these qualities. It is even pertinent to suggest that, for a person or organism without such foreknowledge and practical experience in its application, it would be impossible to perceive three apples on a table. The apples would not exist for an organism lacking the advance knowledge of what apples are, knowledge that constitutes the perception and conception of what apples are by way of complex patterns of interaction with the things themselves. These interactions (observing, handling, tasting, feeling, eating, etc.) are a process of playful co-agitation that is at the root of cogitation and cognition; anything perceived with the body or conceived in language emerges as a product of a kind of cognition, and is always a recognition. Apples may be recognized as edible, for instance, by animals or insects that have no sense of fruit, nutritional value or the metaphoric stature of the apple vis-à-vis knowledge, flight from the Garden of Eden, teachers or computers. And the same species of fruit can evoke entirely different systems of associated commonplaces in different languages and cultures sometimes connoting quite opposite meanings and imagery.

This is a point at which some postmodern investigations arrive at the self-contradictory claims concerning the impotence of language and inconstancy of meaning with which this essay began. But consider the extent to which, for instance, mathematical learning in both the classroom and scientific laboratories requires deliberate negotiations of meaning and agreement on practical conventions, through interactions among teachers and learners, learners and learners, or between learners and their objects of investigation (Cobb & Bauersfeld, 1995; Latour, 1987; O'Connell, 1993; Voigt, 1996). Individual students and investigators, as learners, work out understandings that emerge through independent interactions with problems, and via interactions with other students, investigators or teachers. Independent researchers struggle to identify and isolate reproducible effects robust enough to be capable of withstanding the deliberately and accidentally posed tests of strength that determine the extent to which an object is real (Ihde, 1991; Latour, 1987). Independent intra-laboratory isolations of a common phenomenon or effect are followed by the inter-laboratory trials that determine the extent to which scientific entities persist in exhibiting consistent quantitative properties across samples, instruments, operators, and so on (Latour, 1987; Mandel, 1977, 1978; O'Connell 1993; Wernimont, 1977, 1978; Wise, 1995).

But such products in the human sciences are still dreams immersed in the process of co-agitation with the things themselves. That is, one can see a thing even if it is not seen for all that it might be for a different person or organism, but insofar as it is seen *as* anything at all, it is seen in terms of something already known that shares structurally analogous characteristics with the object of interest (Heelan, 1983b, 1983c; Merleau-Ponty, 1964; Nicholson, 1984; Stent, 1981). Therefore, the success of the scientific enterprise arises as an outcome of:

1 specifying in advance what is sought, axiomatically, as occurs perceptually, through the senses, conceptually, via the advance work of organization accomplished in language, or overtly mathematically, via calibrated instrumentation;
2 structuring observations so that there is a reasonable chance of realizing those specifications in practical application;
3 comparing, retrospectively, expectations and observations, mathematically, in the assessment of the extent to which abstract, invariant uniformity across samples, instruments, laboratories, and so on, has been realized as an instance of the convergence and separation of figure and meaning, in order
4 to support or modify existing, or devise new, axiomatic specifications for application and dissemination as technologies instrumental to producing the experimental results in routine applications.

Postmodern philosophy of science thus asserts a horizonal or instrumental realism (Heelan, 1983c; Ihde, 1991; Latour, 1987, p. 93) based in the extent to which technoscientific entities resist tests of strength and maintain an identity across changes in media. Postmodern science does not just observe, manipulate or intervene in the manners of ancient, medieval or modern science; rather, it deliberately isolates, combines, systematizes and produces things capable of persistently exhibiting consistent properties across examples, observers, instruments, laboratories, and so on (Ihde, 1991, p. 134), and it does so by systematically undertaking the necessary metrological steps (Pennella, 1997) (intra-laboratory ruggedness tests [Wernimont, 1977, 1978] and inter-laboratory round robin trials [Mandel, 1977, 1978]) necessary for identifying and sharing the products of research (Fisher, 2000).

A metaphysically astute, and so postmodern, human science will deliberately implement a comprehensive program of research along these lines. In contrast with today's haphazard, piecemeal and incomplete approaches, the postmodern research program extends from the initial qualitative identification and exploration of variables potentially involved in a phenomenon, through the initial efforts at quantification, to the calibration of instruments traceable to reference standard metrics, to the deployment of the technology at its relevant point of use in education, health care, human resource management, political science, human capital accounting and economics, and so on, and back again to the qualitative and quantitative maintenance, improvement and interpretation of the reference standard itself. Understanding of this research program and how it differs from today's human sciences requires a yet closer examination of figure–meaning convergence and separation as the fundamental mathematical value of all scholarly inquiry.

Why is the Mathematical Fundamental to Scholarly Inquiry?

Over the entrance to the Academy (Bachelard, 1984, p. 165; Bunt et al., 1976, p. 126; Glazebrook, 2000, p. 60; Heidegger, 1967, pp. 75–76; Kisiel, 1973, p. 119; Kline, 1953, p. 54; Page, 1996, p. 239; Scott, 1960, p. 20; also see Descartes, 1961, p. 15), Plato put these words: 'Let no one who has not grasped the mathematical enter here!' In requiring students to master mathematics, Plato was not demanding a kind of value-free rigor in the thinking of his students, as is often assumed. Instead, he linked philosophy and mathematics throughout his dialogues (Brumbaugh, 1968), and presumably did so in his teaching as well. One reason for this link is that anyone who knows enough to do a geometrical analysis of a circle knows that it is not the circle drawn as an example that is spoken of, but, instead, looks through the drawn circle at the idea of a circle which must stand independent from each individual analytic example (Bunt et al., 1976, pp. 125–126; Gadamer, 1980, p. 101; Plato, *The Republic* 510d, in Hamilton & Cairns, 1961, p. 746). Another reason for linking philosophy and mathematics, as Plato elaborates in the *Meno*, is the sense of the mathematical as learning through what is already known, as a recollection of forgotten knowledge, where something new is added to something old. This is the doctrine of anamnesis, 'the central motif of Platonism' (Gadamer, 1989, p. 114).

These two aspects of mathematics as learning through what is already known, and what is learned in this way, make the mathematical 'the fundamental presupposition of all "academic" work' (Heidegger, 1967, p. 76) and 'of the knowledge of things' (p. 75), and, thus, the conceptual limit of metaphysics. In other words, the very concepts of schooling, research, teaching and learning taken up and assumed in every effort at clear scholarly communication, in every effort aimed at shared understanding, are fundamentally mathematical, even when no overtly mathematical symbols or functions are involved. As was indicated in the start of this article, many self-described postmodernists and deconstructionists implicitly consider Plato's saying over the entrance to the Academy to be irrelevant. Be that as it may, to be an academic is to accept in practice if not in theory 'that we today, after two thousand years, are still not through with this academic work and never will be so long as we take ourselves seriously' (Heidegger, 1967, p. 76).

Why was a sense of mathematical rigor 'an indispensable preliminary to the study of philosophy' (Scott, 1960, p. 20; see also Gadamer, 1980, p. 101) not only for Plato, but for Husserl as well?

> The mathematical object seems to be the privileged example and most permanent thread guiding Husserl's reflection . . . [on phenomenology] because the mathematical object is *ideal*. Its being is thoroughly transparent and exhausted by its phenomenality. (Derrida, 1989, p. 27)

Accordingly, its 'universality and objectivity make the ideal object into the "absolute model for any object whatsoever" ' (Bernet, 1989, p. 141, quoting Derrida, 1989, p. 66). In other words, numbers are justifiably 'the most striking of always-already-knowns' because they are so thoroughly transparent: 'numerical signs [are coordinated] with particular numbers, and they are the most ideal signs because their position in the order completely exhausts them' (Gadamer, 1989, p. 413). Although clarity in everyday speech necessarily relies on some basic degree of univocal sign–thing coordination, it was numeric figures' rigorous independence from the meaning they carry that became the metaphysical ideal, first in commerce, then for the basic astronomy needed for calendars, then for geometric figures, and then for the figures of any field that took itself to be scientific.

Accordingly, 'modern natural science, modern mathematics, and modern metaphysics sprang from the same root of the mathematical in the wider sense' (Heidegger, 1967, p. 97), making the rigorous independence of figure and meaning the 'unique thesis' of philosophy (Derrida, 1982, p. 229). Over the course of the history of science, it has often been said, in many different ways, that a field of study must be quantitative to be scientific (see Michell, 1999, pp. 33–39, and 1990, pp. 5–9 for verbatim quotations of variations on this theme from historically influential scientists and philosophers). Although numbers are popularly and mistakenly assumed to be inherently mathematical, no matter the application to which they are put, the capacity of numbers to live up to their billing in practice as the most ideal signs depends on their coordination with amounts of the thing they are supposed to represent. Michell's (1990, 1997a, 1997b, 1999, 2000) body of work documents the nearly complete extent to which the mathematical coordination of numerical signs with the amounts they are supposed to represent has been unjustifiably assumed and left unchecked in the human sciences.

The emergence of qualitative methods in the human sciences offers rightful and much needed corrections and alternatives to unthinking quantification. The validity of non-quantitative methods stems from the fact that everyday language often offers much more mathematically astute and metaphysically informed symbol–meaning coordination than is available in many or most numerically oriented research projects in the human sciences. An early foreshadowing of this methodological shift is provided by Aristotle, who pointed out that poetry can sometimes be more scientific than history, as when a metaphor captures the spirit of an age and becomes a touchstone of shared meaning, as opposed to an historical account that offers nothing but details of events with no synthetic organization that instructs one in the management of similar future events (Gadamer, 1989, pp. 115, 579; Ricoeur, 1977, p. 245; 1981, pp. 296, 187).

An overt theory and method of mathematical symbol–meaning coordination was evidently not necessary for the emergence of the natural sciences. It is increasingly apparent, however, that transparent mathematical objects exhausted by their phenomenality, that is, by a rigorous degree of coordination between numerical signs' positions on a quantitatively additive continuum and amounts of the variable in question, are not likely to arrive in the human sciences without deliberate efforts aimed at their construction. Until such efforts are undertaken, quantitative research in many fields will continue to fall short of realizing its potential.

These observations imply two questions. First, how can qualitative methods rooted in phenomenology and hermeneutics be more mathematical than overtly quantitative methods? And second, what kind of quantitative methods would best harmonize with qualitative methods and the wider mathematical metaphysics?

The Mathematical Roots of Phenomenology and Hermeneutics

Much or most of 20th-century philosophy focused on recovering from what Husserl (1970a) called 'science's loss of meaning for life' (p. 5), and which he argued followed from Galileo's 'fateful omission' (p. 29) of the means by which nature became mathematicized. For instance, in a footnote to Heidegger's analysis of a relevant passage from Descartes, the editor (Krell in Heidegger, 1982b, p. 125) suggests that the greatest part of Heidegger's philosophical work was devoted to putting on record basic cultural assumptions of knowledge and existence that Descartes 'thought it needless to enumerate' (Descartes, 1971, p. 184). Gadamer (1989) also addresses the fact that Descartes' 'thoughtful meditations on the compatibility of the mathematical knowledge of nature with metaphysics set a task for an entire age', and that 'the hermeneutics of the human sciences . . . leads us back into the problems of classical metaphysics' (p. 460).

Accordingly, although qualitative researchers in the human sciences rarely, if ever, acknowledge the connection, phenomenology and hermeneutics have quite deep roots in mathematical metaphysics. Husserl, the father of phenomenology, wrote his first book on arithmetic (Husserl, 1970b) and his last on geometry (Husserl, 1970a, Appendix VI). Heidegger's *What is a Thing?* (1967) is almost exclusively a study of mathematical metaphysics and, quite significantly, 'Heidegger never really abandoned his [early] interest in mathematics and the sciences and remained capable enough in the former to serve on doctoral committees for the mathematics faculty' (Krell, 1977, p. 12). Derrida's (1989) first book was on Husserl's *Origin of Geometry*, and mathematical concerns permeate the works of Gadamer, Ricoeur and others documenting the discursive quality of science and technology (Ackerman, 1985; Alderman, 1978; Daston, 1992; Daston & Galison, 1992; Galison, 1999; Gerhart & Russell, 1984; Glazebrook, 2000; Golinski, 1998; Hallyn, 2000; Hankins & Silverman, 1999; Heelan, 1972, 1983a, 1983b, 1983c; Heilbron, 1993; Ihde, 1991; Knorr Cetina, 1995; Kockelmans, 1985; Kockelmans & Kisiel, 1970; Lynch, 1998; Maasen & Weingart, 2001; Marcuse, 1974; Ormiston & Sassower, 1989; Pickering, 1995; Porter, 1999; Rothbart, 1997).

As already noted, the reasons for focusing on the mathematical object stem from its thorough transparency. Transparency implies that phenomena are real and mathematically objective to the extent that they robustly persist in resisting tests of their strength across expression in different media (Ihde, 1991, p. 134; Latour, 1987, p. 93), as an extension of the fundamentally mathematical coordination of sign and thing. It is pertinent to remark on Latour's (1987, p. 93) mistaken etymology of 'resist' as derived from the Latin, *res*, thing. 'Resist' actually derives from the Latin, *resistere*, to withstand, which is in turn related to *stāre*, to stand. Other words also derived from *stāre* include arrest, exist, persist, stable and state. The sense of the real as that which persistently arrests our attention and exists in stable states recalls Aristotle's (*Posterior Analytics*, II, 19, 100a) metaphor of how unified experience emerges from a multiplicity of perceptions. The image is of a retreating army in flight that eventually turns, regroups and comes to a new stand. Despite its shortcomings (Gadamer, 1989, p. 352), this image aptly expresses the way in which 'we grow into the pre-schematization of our future orientation' (Gadamer, 1989, p. 543), in the way that interpretations as well as scientific laws take shape. But in what way could interpretation theory (hermeneutics) ever be considered mathematical?

Hermeneutics is widely perceived to be an alternative to mathematics, but that perception came about as a result of efforts aimed at recovering Galileo's 'fateful omission'. That is, following Husserl and focusing on the ideality of mathematical objects led to the realization that

> . . . lingual experience exercises its mediating function only because the

> interlocutors fade away in face of the things said which, as it were, direct the dialogue. . . . What enables us to communicate at a distance is thus the matter of the text, which belongs neither to its author nor to its reader. (Ricoeur, 1981, p. 62; also see 1974, pp. 258–259 and 1978, p. 160)

Similarly, Gadamer (1989) says that 'what is fixed in writing has detached itself from the contingency of its origin and its author and made itself free for new relationships' (p. 389). The extent to which a tissue of actions, processes, texts and/or things said fuses together and separates from the contingencies of its origins is the extent to which it mathematically achieves its metaphysical destiny. The detachment of the text cannot occur, however, without an associated convergence and belonging together of figure and meaning, sign and sense. The unity of thing and thought within a particular historical, linguistic and cultural context means that

> thought does not start from the concept of a subject that exists in its own right and makes everything else an object. . . . In this thinking there is no question of a self-conscious spirit without world which would have to find its way to worldly being; both belong originally to each other. The relationship is primary. (Gadamer, 1989, p. 459)

Similarly, Ricoeur (1981) holds that 'the first declaration of hermeneutics is to say that the problematic of objectivity presupposes a prior relation of inclusion which encompasses the allegedly autonomous subject and the allegedly adverse object' (p. 105).

This 'paradox of unity and separation' (Brenneman, Yarian, & Olson, 1982), 'dialectic of belonging and distanciation' (Ricoeur, 1981, pp. 61, 244) or fusion of horizons (Gadamer, 1989, pp. 302–307) is the process through which we continually test a priori suppositions against the things themselves via involvement with them in a common world (Gadamer, 1989, p. 302). As Ladriere (1970) says:

> The life of the concept is that perpetual coming and going between the horizon from which it breaks away, and which invests it with its content, and that supreme objectification in which it cuts itself off from its horizon and empties itself of its content in order to constitute itself as a pure form . . . (p. 484)

Alternating belonging together in a common world with the distanciation through which we evaluate our positions relative to those of others requires that it be possible to follow the 'arrow of meaning' (Ricoeur, 1981, p. 193) delineated by a text or an object of conversation independent, to some degree, of the particulars belonging to a common cultural tradition of who is questioning, who is responding, and the particular words and phrases mediating the exchange.

In fact, we see here an opportunity for reinvigorating the geometrical metaphors of the line of inquiry, the point of an argument, circular logic and methods of triangular exposition. In the same way that we look through the drawn circle at the idea of a circle that is constant across individual figures, and across the tools and persons involved in their production, so, too, does understanding another person 'always involve rising to a higher universality that overcomes not only our own particularity but also that of the other' (Gadamer, 1989, p. 305). Ricoeur (1981) similarly says that 'knowledge of others is possible because life produces forms, externalizes itself in stable configurations; feelings, evaluations and volitions tend to sediment themselves in a *structured acquisition* which is offered to others for deciphering' (p. 50). The structure acquired via interaction with others that is externalized as a stable configuration, that rises to a higher universality, and that overcomes the particulars of who, when and where is both mathematical and hermeneutical in the way new situations are simultaneously recognizable variations on past experience and also identifiable instances of something new in time and space.

Kisiel (1973) addresses directly this overlap of the hermeneutical and mathematical, saying that 'if we interpretively understand what we already implicitly understand, as Heidegger's discussion of the hermeneutic circle suggests, then the hermeneutical parallels the mathematical "learning what we already know" ' (p. 155). Ricoeur (1981) addresses the overlap less directly, but identifies 'the first and most elementary work of interpretation' as a task intended to produce 'a relatively univocal discourse with polysemic words, and to identify this intention of univocity in the reception of messages' (p. 44). Gadamer (1989) adds that 'the more univocally a sign-thing signifies, the more the sign is a pure sign—i.e., it is exhausted in the coordination' (p. 413), suggesting that both interpretive and mathematical clarity are enhanced as signs and things are coordinated.

Because both interpretation and mathematics lay out or project, and then explicitly appropriate, their own always-already constituted pre-understandings, 'the only difference' between hermeneutics and 'the mathematical tradition seems to be the depth at which the "already" is placed' (Kisiel, 1973, p. 115). Kisiel amplifies his sense of this difference, arguing that hermeneutics yields more than mathematics does, by providing a gift of new meanings that emerge in the course of the interpretive process but not in the mathematical process (p. 119).

Indeed, in the same way that metaphors symbolize more than they signify literally (Ricoeur, 1977), interpretation requires an attitude open to the possibility that what is already known might be wrong or incomplete. In fact, the scientific basis of qualitative methods in the human sciences is asserted to be receptivity to the gift of new learning: 'the fruitfulness of scientific questioning is defined in an adequate manner if it is really open to answers in the sense that experience can refuse the anticipated confirmation' (Gadamer, 1981, p. 164). Gadamer could easily be paraphrasing Heidegger's (1962) famous assertion that

> . . . our first, last, and constant task is never to allow our fore-having, fore-sight, and fore-conception to be presented to us by fancies and popular conceptions, but rather to make the scientific theme secure by working out these fore-structures in terms of the things themselves. (p. 195)

Given that scientific questioning and the scientific theme are at stake in interpretation theory, is it the '"gift" character of the hermeneutical that clearly distinguishes it from the mathematical', as Kisiel (1973, p. 119) contends?

Kisiel concurs with Heidegger in so far as he says that he situates the 'surplus of sense' in the things themselves. Joining with Heidegger under the banner of Husserl's phenomenological motto, 'back to the things themselves', would imply a methodical approach to keeping the scientific theme secure by working out the mathematical and hermeneutical fore-structures of knowledge experimentally, since 'modern science is experimental because of the mathematical project' (Heidegger, 1967, p. 93). But instead of making explicit demonstrations of either (1) 'how the latency of the hermeneutical situation is not limited to the latent knowledge already possessed by us' (Kisiel, 1973, p. 119), or (2) how the latency of the mathematical *is* limited to fore-knowledge (or how it is at least more limited than the hermeneutical latency is), Kisiel (1973) locates the source of the gift of new learning in the mystery of Being as an 'unspecifiable totality', and 'an inexhaustible wellspring of the ineffable' (pp. 199–120).

Following in the spirit of Heidegger's 'first, last, and constant task', alternatives to mysticism can be found in (1) Ricoeur's (1976) assertion that the 'surplus of meaning is the residue of the literal interpretation' of a metaphor (p. 55), and in (2) Kuhn's (1977) assertion that the function of measurement in the natural sciences is primarily to 'display significant anomaly' (p. 205), and not, as is commonly assumed, to discover or verify laws. Might it be that the scientific discovery/invention of new phenomena is provoked by a surplus of meaning left over as the residue of a literal interpretation of the measuring instrument, cast by Heelan (1983a, 1983c) as 'readable technology'? Might it be that good science requires good metaphors (Black, 1962; Gerhart & Russell, 1984; Hesse 1970), and that it is fundamentally poetic in its creativity (Hallyn, 2000; Rothbart, 1997; Smith, 2000; Zimmerman 1990)?

The suggestion that Kisiel's distinction between the hermeneutical and the mathematical may not hold up is supported by two other considerations of immediate concern. First, as has already been pointed out, alphabetic symbolization, and, so, the textual objects of hermeneutics, originated in the mathematical applications of commercial accounting practices (Ifrah, 1999). Thus, the clarity of numerical sign–thing coordination is not only metaphysically primary, it is also temporally primary as the historical portal through which less well coordinated sign-things entered human culture as written language. The gift character of hermeneutics is therefore fundamentally mathematical in its historical origins.

Second, Hermes, the original hermeneut, is notable not only for interpreting and carrying the messages of the gods but also for being the inventor of language and speech (Plato, *Cratylus* 407e, in Hamilton & Cairns, 1961, p. 444), the 'God of Commerce and the Market, protector of traders', the inventor of the lyre (Hamilton, 1940, p. 33), the musical instrument so important to the Pythagorean studies of proportion and harmony, and a born thief. Similarly, an Egyptian precursor to Hermes, Thoth, or Theuth, is credited by Plato as the inventor of 'number and calculation, geometry and astronomy, not to speak of draughts and dice, and above all writing' (Plato, *Phaedrus* 274c, in Hamilton & Cairns, 1961, p. 520; see also Derrida, 1981, pp. 84–94). Hermes' and Thoth's roles suggest that the case could be made for construing the gift character of hermeneutics as also fundamentally mathematical in its mythological origins. It is of no little interest furthermore that the status of these gods as notorious thieves also plays into the way in which advances in mathematical symbolization and technology necessarily erase the understanding that went into their production, leading both to events such as Galileo's 'fateful omission' (Husserl, 1970a) and to the ability of persons ignorant of theory nonetheless to employ advanced technical devices.

Finally, it might be countered that existential hermeneutics' expansion of the concept of the text to include any mode of being (Heidegger, 1962) or meaningful action (Ricoeur, 1981) would provide it with an area of application in which its concerns might be considered prior to and more fundamental than the mathematical, since the unwritten, unspoken and non-calculative activities of organisms other than humans, or of the evolving universe of matter, energy and information, could be taken up as its domain. In Heelan's (1972, 1983a, 1983b, 1983c, pp. 212–213) hermeneutically informed scientific realism, however, no such distinction between the hermeneutic and the mathematical is made or seems necessary. Self-conscious subjectivity seems to have emerged into a world already existing in fundamentally hermeneutic and mathematical ways. The perceptual processes of any organism, for instance, are as hermeneutical as they are mathematical (Stent, 1981).

In recovering the wider, metaphysical sense of Academic mathematics, Heidegger provides a context in which qualitative methods based in interpretation theory can be integrated with quantitative methods. Though the proposed mathematical–hermeneutic integration shares hermeneutic psychology's (Martin & Sugarman, 2001) sense of social constructivism as overly anti-realist, it denies any need for an associated distinction between natural and human kinds. Far from being restricted to the human sciences, or a completely novel introduction of new issues, the integration of qualitative and quantitative has deep roots in the history of the natural sciences, as will be taken up in the final section of this paper and in part II (Fisher, 2003).

Recovering from Galileo's 'Fateful Omission': Positivism, Metaphysics, and Mathematical Thinking

We have achieved at this point a sense of what was lost in Galileo's 'fateful omission'. A question, complementary to the previous question concerning hermeneutical mathematics, arises as to how logical positivism's express respect for mathematical logic and symbolism could have failed it. The answer resides in positivism's unwillingness to address fully the mutual implication of subject and object through which a priori understandings are worked out hermeneutically and mathematically. For Descartes, Newton and the modern age, the universe was obviously mathematical in a numerical sense. In his own expression of the mathematical metaphysics of the Academy, Descartes (1961) asserted that 'we should be concerned with nothing about which we cannot have a certainty equal to that of the demonstrations of arithmetic and geometry' (p. 8). Galileo freely capitalized on the mathematical as that which is always already known, considering experience 'useless because before any experience we are already in possession of the knowledge we are seeking for', and which we can obtain via rigorous and imaginative theorizing (Koyré, 1968, p. 13). But Koyré misses the metaphysical importance of Galileo's theorizing, holding that it is the 'research of quantitative precision, of the discovery of exact numerical data . . . that forms the goal, and thus determines the very structure of the experiments of modern science' (p. 91).

Heidegger (1967, pp. 67–8) seems almost to be addressing Koyré directly in saying that we miss what is fundamental to science if we stop at considering it to be factual, experimental and measuring, urging (pp. 90–1, 116) that we focus instead on the extent to which Galileo, for instance, projected an abstract plan and organized an anticipatory framework within which motion could be understood as uniform, and through which that uniformity could be embodied in applications. Koyré, like Descartes, too easily accepts Galileo's own version of events and does not examine the actual process through which mathematization took place. In a manner similar to Kuhn's (1970) contrast of scientific practice with textbook presentations of scientific method, Heidegger (1967) points out that 'that which can already be found in the older philosophers is seen only when one has newly thought it out for himself' (p. 79). Textbooks synthesize experimental practice retrospectively, presenting routines and algorithms for producing predetermined results, erasing the creative process and producing the illusion that science is predominantly factual, experimental and measuring. It is only when a scientist takes up original research and enters into a sustained dialogue with previous researchers that the actual activity of the thing itself encapsulated in the textbook method becomes understood in its own terms.

Thus, the crucial omissions, the nearly pure transparency of the relevant mathematical variables, and the fact, documented by Latour (1987), O'Connell (1993) and Shapin (1989), and others, that the sociotechnical networks supporting the production and reproduction of consistent results were ignored led Newton and many of those who aimed to apply mathematics to physical bodies to explicitly deny a metaphysics of science by making it seem that such a position was required for objectivity. But, Burtt (1954) asks,

> . . . what kind of metaphysics are you likely to cherish when you sturdily suppose yourself to be free of the abomination? Of course . . . in this case your metaphysics will be held uncritically because it is unconscious; moreover, it will be passed on to others far more readily than your other notions inasmuch as it will be propagated by insinuation rather than by direct argument. (p. 229)

In his historical overview of metaphysics in science, Burtt (p. 227) cites Brewster's 1855 *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton* (Vol. II, p. 532) as holding Newton to be 'the first great positivist'. Burtt (pp. 207–302) agrees with this characterization and substantiates it in terms of Newton's rejection of metaphysics and hypotheses, defining positivism as holding that 'it is possible to acquire truths about things without presupposing any theory of their ultimate nature' (p. 227).

The futility of positivism is seen in the fact that 'no discourse can claim to be free of presuppositions for the simple reason that the conceptual operation by which a region of thought is thematized brings operative concepts into play, which cannot themselves be thematized at the same time' (Ricoeur 1977: 257). In other words, 'the attempt to escape metaphysics is no sooner put in the form of a proposition than it is seen to involve highly significant metaphysical postulates' (Burtt, 1954, p. 228). Or again, in other words,

> . . . there is no sense in doing without the concepts of metaphysics in order to shake metaphysics. We have no language—no syntax and no lexicon—which is foreign to this history; we can pronounce not a single destructive proposition which has not already had to slip into the form, the logic, and the implicit postulations of precisely what it seeks to contest. (Derrida, 1978, pp. 280–281)

Accordingly, 'the only way to avoid becoming a metaphysician is to say nothing' (Burtt, 1954, p. 227). The grand success of Newton's scientific achievements led to his unstated and unquestioned metaphysics being thoroughly insinuated into the subsequent works of many important philosophers, from Leibniz to Berkeley and Hume, to the French Encyclopædists, the early Kant and Hegel, to the extent that 'none of them subjects the whole system of categories which had come to its clearest expression in the great *Principia* to a critical analysis' (Burtt, 1954, p. 35; see also pp. 34–35, 229–230).

The positivism of Newton, Durkheim, the Vienna Circle and British empiricism denies any important role for preconceptions, 'prenotions,' pre-understandings, hypotheses, the unconscious, history, tradition, language, culture, or any other fundamental fore-structure of understanding in the constitution of the mathematical object. Though it has deep roots in the Pythagorean sense of the world as number, positivism as a movement became a distinct possibility in Descartes' failure to account for 'the circle in which he was involved when he presupposed . . . the *possibility* of inferences transcending the ego, when this possibility, after all, was supposed to be established only through this proof' (Husserl, 1970a, p. 90). The unrecognized mathematical/hermeneutic simultaneous projection and taking up of the possibility that inferences could transcend the ego was Descartes' brilliantly flawed metaphysical expression of Galileo's similarly 'ambiguous genius [that], in uncovering the world as applied mathematics, covers it over again as a work of consciousness' (Ricoeur, 1967, p. 163; see also Husserl, 1970a, pp. 23–59).

But the father of positivism was Hume. Husserl (1970a, p. 88) explicitly considers him as such, and Ayer (1959) consider's Hume's famous statement as to the worthlessness of works lacking 'abstract reasoning concerning quantity or number' as 'an excellent statement of the positivists' position' (p. 10). Hume's division of all significant propositions into two classes, formal and factual, along with the logical symbolism developed by Frege, Peano and Russell, are fundamental to positivism (p. 10). It is in this context that Carnap (1959, p. 78; Murray, 1978, p. 32), echoing Hume's call to 'commit to the flames' all works of metaphysics (Ayer, 1959, p. 10), asserts that 'the statements of metaphysics are entirely meaningless'. 'The originality of the logical positivists', thus, according to Ayer (1959),

> . . . lay in their making the impossibility of metaphysics depend not upon the nature of what could be known but upon the nature of what could be said. Their charge against the metaphysician was that he breaks the rules which any utterance must satisfy if it is to be literally significant. (p. 11)

Rephrasing and updating Burtt's (1954, originally published in 1924) characterization shows that the positivist program of eliminating metaphysics and metaphor from philosophy combines (1) Russell's (1918–1919; in Vick, 1978, p. 205), Frege's (in Rosen, 1978, pp. 123–130) and Popper's (in Hempel, 1959, p. 113) requirement that, to be true, a statement must in some instances conceivably be false, with (2) the mistaken assumption that statements about Being cannot conceivably be false, as though we cannot speak of Not-being (Vick, 1978, pp. 205–207), as though Being is not bound up in Nothingness (Rosen, 1978, p. 129), and as though metaphor can be avoided in the articulation of new concepts in mathematics learning (Presmeg, 1997, 1998) and the discovery/invention of new phenomena (Black, 1962; Gerhart & Russell, 1984; Hallyn, 2000; Hesse, 1970; Kuhn, 1979; Ricoeur, 1977; Rothbart, 1997).

A recent imaginative and detailed comparison of Carnap's and Heidegger's perspectives on metaphysics holds 'that Heidegger and Carnap are actually in remarkable agreement' (Friedman, 1996, p. 48; 2000, p. 13) as to the issue that divides them. Unfortunately, the alleged agreement is an artifact of an analysis that remains fundamentally positivist, and repeatedly misreads Heidegger, or leaves him unread. The failure is inevitable from the outset of the analysis because it remains at an advanced conceptual level, and never incorporates metaphysical fundamentals into the argument. Carnap and Heidegger are said to agree that the possibility of metaphysics requires 'a prior overthrow of the authority and primacy of logic and the exact sciences' (Friedman, 1996, p. 48; 2000, p. 13), with Carnap resisting this overthrow and Heidegger promoting it. However adequately this encapsulation might serve Carnap's position, it does a major disservice to Heidegger's. Although the analysis appears to give Heidegger a detailed and sympathetic reading, it does not integrate the substance of Heidegger's position into the argument, since this would in fact undermine the basic thesis.

It is quite significant, for instance, that Friedman makes no reference at all to the works in which Heidegger most fully develops his sense of mathematical metaphysics (Heidegger, 1967), and in which Heidegger constructively situates positive science within a metaphysically informed context (Heidegger, 1982a). Similarly absent are references to secondary literature (Murray, 1978) in which not only is the Carnap–Heidegger situation addressed both explicitly (Vick, 1978) and implicitly (Gadamer, 1978, p. 162; Ricoeur, 1978, pp. 156–157; Rosen, 1978), but also Carnap's (1959) key article is reprinted.

The analysis is also disappointing for not contextualizing the point of putative agreement between Carnap and Heidegger in relation to the metaphysical developments in the works of Descartes and Galileo that Heidegger specifically takes up, and in relation to recent developments in the study of metaphor and the history of science. The analysis should have specifically addressed (1) Descartes' failure to account for the circle in which he was caught up when he presupposed the possibility of inferences transcending the ego; (2) Galileo's simultaneous demonstration of the world as applied mathematics and concealment via symbolization of the process through which that demonstration was accomplished; (3) the role of metaphor in the discovery/invention of scientific entities; and (4) Kuhn's (1977) point that measurement does not lead to the discovery of laws and the development of theories, but, on the contrary, that measures are not possible until lawful regularities and theoretical understandings of them are in hand.

To make his point, Friedman should have shown that these metaphysically primary issues either have no bearing on the matter, that their relevance is inconsequential, or that their resolution leads to the alleged agreement between Carnap and Heidegger. Since none of these demonstrations are made, the only conclusion that can be drawn is that Friedman, like positivism in general, still willingly subscribes to a hidden metaphysics that refuses to articulate an explicit theory of ultimate nature, or to allow an overt place for metaphor in the creation of scientific meaning.

An alternative and more productive critique of Heidegger's position is offered by Ricoeur (1981, pp. 87–95; also see Ricoeur, 1977, pp. 309–313), who quotes Heidegger (1962, p. 195) on making 'the scientific theme secure' and then asks how this work is to be undertaken

> . . . when one declares, immediately afterwards, that 'the ontological presuppositions of historiological knowledge transcend in principle the idea of rigour held in the most exact sciences,' and thereby eludes the question of the rigour proper to the historical sciences themselves? The concern to anchor the circle more deeply than any epistemology prevents the epistemological question from being raised on ontological ground. (Ricoeur, 1981, pp. 88–89; see also 1978, p. 156)

Ricoeur is here addressing exactly the question raised by Friedman (1996, pp. 47–48; 2000, pp. 12–13) concerning the alternative between ontological presuppositions and the rigor of the exact sciences. Ricoeur proceeds in a manner which, in contrast with Friedman, does not disconnect scientific epistemology from the ontological task of deconstructing metaphysics, as though a mutually exclusive choice has to be made. Heidegger himself does not see the matter as one requiring an either/or dichotomy, since he in fact does situate objectivity, positive science and method within a metaphysically informed context (Heidegger, 1982a, pp. 19–23, 320–330). It is undeniable, though, that Heidegger's broader preoccupation with a seemingly interminable mining of the history of metaphysics has provoked many, not just Carnap and Friedman, into concluding that metaphysics necessitates, if not an outright 'overthrow of the authority and primacy of logic and the exact sciences', at least the development of alternatives to that authority and primacy.

Gadamer, for instance, like Ricoeur, quotes the passage from Heidegger (1962, p. 195) regarding 'our first, last, and constant task' relative to making 'the scientific theme secure', and raises the question of 'the consequences for the hermeneutics of the human sciences of the fact that Heidegger derives the circular structure of understanding from the temporality of *Dasein*' (Gadamer, 1978, pp. 161–162; 1989, p. 266). Echoing Friedman's construal of the mutually exclusive alternatives supposedly represented by

Heidegger and Carnap, Gadamer begins to move from ontology to epistemology but is prevented from following through by the lack in his hermeneutics of a critical moment capable of structuring the working out of the fore-structures of understanding in terms of the things themselves (Ricoeur, 1978, pp. 156–160; 1981, pp. 60–62, 89–90). Because of the resulting disjunction between truth and method in Gadamer (1989), Ricoeur (1981, p. 60, see also pp. 90, 131; 1978, p. 157) asks 'to what extent the work deserves to be called *Truth AND Method*, and whether it ought not instead be entitled *Truth OR Method*'. But Ricoeur (1978, p. 159; 1981, pp. 61–62, 91, 131–144) identifies within Gadamer's (1989) sense of the fusion of horizons elements of the dialectic of belonging and distanciation capable of supporting further steps toward a methodological hermeneutics. Approaching the matter from another angle, Larmore (1986, pp. 148, 164–165) similarly concludes that Gadamer sometimes manages to show that 'history and objectivity are far less antagonistic' than he (Gadamer) usually assumes. It is in this spirit that the present work is aimed at exploring the extent to which the metaphysical supposition of sign–thing coordination ubiquitous in the academy might structure an explicit theory of measurement applicable within a broad range of postmodern sciences.

Positivism's overt use of mathematical logic and symbolism was undertaken without having first taken cognizance of the metaphysical context in which these become effective and meaningful. In what many may find to be an ironic development, existentialism's express concern with hermeneutic-mathematical metaphysics provides it with a more rigorous scientific foundation than can be afforded by positivism. After more fully situating measurement in its proper metaphysical context, this speculation could be tested by comparing the extent to which positivistic and hermeneutic-mathematical methods realize their own stated goals. It is probably never stated as such within positivism itself, being an inherently metaphysical proposition, but in valuing abstract, quantitative, experimental reasoning as highly as it does, positivism cannot help but assume that the sense aimed at through its geometrical, numerical, metaphoric and symbolic figures is an essence rigorously independent of those figures.

This assumption, referred to by Derrida (1982, p. 229) as philosophy's unique thesis, also constitutes the mathematical metaphysics assumed in all academic knowledge (Heidegger, 1967, pp. 75–76). Had positivism actually developed methods by which its sign–thing coordinations could be justified and validated, then a recent review of metamathematics would not have concluded that its

> . . . technical results . . . are unimpressive: not only have they resulted in what is generally acknowledged to be a barren and uninformative philosophy of mathematics, but (not independently) they have failed to shed any light whatsoever on mathematics as a signifying practice. (Rotman, 1999, pp. 432–433)

Similarly, if positivism had produced any viable offspring, would quantitative methods in the human sciences, which, in positivist fashion, typically leave behind metaphysics in a quick leap to numeric symbolization, have failed as completely as they have in their efforts to identify and understand amounts of abilities, attitudes, health and behaviors (Cliff, 1989, 1992, 1993; Michell, 1990, 1997a, 1999, 2000; Wilson, 1971; Wright, 1984)? The basic problem of phenomenology, as a qualitative and quantitative mathematical method of testing the fore-structures of understanding against the things themselves, following Heidegger (1982a), is to situate measurement relative to the three basic components of phenomenological method (reduction, construction and deconstruction) in such a way that logic and the exact sciences are not disconnected from and uninformed by their metaphysical presuppositions.

Beyond these issues, future works will attempt (1) to account for Galileo's 'fateful omission' by expressing Michell's (1990, 1997a, 1999, 2000) critique of contemporary psychological measurement and Rasch's (1960, 1977) theory of measurement in terms of hermeneutic-mathematical metaphysics (Fisher, 2003); (2) to redress Descartes' self-betrayal by showing how a simultaneous, conjoint measurement model can be formulated so as to incorporate tacit presuppositions; (3) to examine the topic of the interweaving of Being and Not-being as that which makes discourse possible (see Derrida, 1982, p. 199), as taken up in Plato's *Sophist* (Bruns, 1992, p. 36; Gadamer, 1980, pp. 109–111, 149–150; Vick, 1978), and, concomitantly, in the study of the ubiquitous effects of metaphor in the history of science, en route to (4) providing an example of how the previously opposed disciplines of hermeneutics and mathematics can be integrated in the study of metaphor.

Situating Measurement in the Context of Mathematical-Hermeneutic Metaphysics

Three key features of measurement were ignored by positivism's focus on the facts of sense perception, unwillingness to overtly articulate and accept hermeneutic-mathematical metaphysics, and consequent rigid adherence to unexamined metaphysical presuppositions. The three key features are the openness to the deconstruction of anomaly, the necessity of effecting a metaphorical and/or quantitative reduction of the thing of interest, and the role of metrology in the birth of the common languages structuring the distributed, collective thinking of communities of inquirers. Two of the three key features of measurement were pointed out by Kuhn (1977), and the third by Latour (1987; O'Connell, 1993), and the three of them together comprise the three moments of the phenomenological method (Heidegger, 1982a). The first is that:

> To the extent that measurement and quantitative technique play an especially significant role in scientific discovery, they do so precisely because, by displaying significant anomaly, they tell scientists when and where to look for a new qualitative phenomenon. . . . When measurement departs from theory, it is likely to yield mere numbers, and their very neutrality make them particularly sterile as a source of remedial suggestions. But numbers register the departure from theory with an authority and finesse that no qualitative technique can duplicate, and that departure is often enough to start a search. (Kuhn, 1977, p. 205; also see Wimsatt, 1981)

In accord with Heidegger's sense of mathematical metaphysics, Kuhn holds that the function of measurement in science is not the usually assumed accumulation of evidence that leads to the discovery of laws. That function is instead held to be the way that measurement remains open to unexpected answers and reveals new phenomena inviting investigation, with theoretical expectations projected and embodied mathematically in calibrated instrumentation. As Heidegger (1967, p. 93) says, the form of modern science is not dictated by the requirements of numerical measurement; rather, numerical measurement and the form of modern science are both consequences of the mathematical project.

When projected quantitative expectations are refuted by the evidence, the researcher enters a deconstructive phase in the phenomenological method, effectively disassembling the experimental process in an effort to reveal what happened. When unexpected results are understood for their positive effects, the hardened rubber left on the hot stove is understood as evidence of vulcanization, the dead culture in the petri dish is seen as an effect of penicillin, and the misplaced lead plate is understood as blocking x-rays. More often, refutations stem from clerical or processual errors, and even when they do not, researchers' fixations on obtaining the expected results quite often cause them to be unable to recognize the value of what was accidentally produced (Margolis, 1993).

What is essential, however, is that departures from theory registered with such finesse by numbers provoke reconsideration of the possible questions to which the unexpected results are an answer. In other words, the question is: what is the question to which the anomaly is an answer? Recovery of such a question implies the destruction of the original research question and a 'historical recursion to the tradition' (Heidegger, 1982a, p. 23) of questions raised in the relevant context. This deconstructive recursion 'is not a negation of the tradition or a condemnation of it as worthless; quite the reverse, it signifies precisely a positive appropriation of tradition' (Heidegger, 1982a, p. 23; also see Ricoeur, 1981, pp. 182–193). Caputo (1997) accordingly contends that a deconstruction of natural science would have the effect of keeping 'the laws of science in a self-revising, self-questioning mode of openness to the "other," which here would mean scientific "anomaly," the thing that defies or transgresses the law' (p. 73).

Qualitative techniques are then essential for exploring departures from theory, but because they most purely embody sign–thing coordinations, numbers most clearly provide the gifts of surplus meaning that suggest the need for further investigation. Kuhn (1977) elaborates on this theme, saying that

> . . . new laws of nature are so very seldom discovered simply by inspecting the results of measurements made without advance knowledge of those laws. Because most scientific laws have so few quantitative points of contact with nature, because investigations of those contact points usually demand such laborious instrumentation and approximation, and because nature itself needs to be forced to yield the appropriate results, the route from theory to law to measurement can almost never be traveled backward. Numbers gathered without some knowledge of the regularity to be expected almost never speak for themselves. Almost certainly they remain just numbers. (pp. 197–198)

In contrast with positivism, post-positivist philosophy generally focuses, in one form or another, on the hermeneutic priority of the question, or what Kuhn and others consider in terms of the theoretical constitution of observation and measurement. Both ways of addressing the matter stress that, in order to not ignore the dialectical involvement of theory and practice, it is vital that the question not just be asked, but that its openness to answers be evaluated along with the quality of the responses. In Heidegger's (1982a) terms, numbers gathered with knowledge of the regularity to be expected are a constructive application of a previously accomplished reduction, or figure–meaning coordination, as one might expect to be achieved in the process of instrument calibration.

Reduction, the second key feature of measurement elucidated by Kuhn, sets the stage for the discovery of anomalies. Research is qualitative not only when measurement anomalies provoke new investigations, but also when the measurability of a variable has not yet been determined because the relevant coordinations of numeric signs and amounts of the variable have not been experimentally assessed. Kuhn (1977) thus further observes that 'Many of the early experiments involving thermometers read like investigations *of* that new instrument rather than investigations *with* it. How could anything else have been the case during a period when it was totally unclear what the thermometer measured?' (p. 218). Roche's (1998) historical study of the mathematics of measurement, and Heilbron's (1993) on the quantification of the six imponderables of 1800, provide many examples of this kind of qualitative investigation in 19th-century physics. Michell (1990, 1999) similarly supports the validity and necessity of qualitative research both as an alternative to, and as a preparation for, quantitative research. And, as is explored in greater detail in part II of this paper (Fisher, 2003), virtually the entire field of Rasch measurement applications (Bond & Fox, 2001; Fisher & Wright, 1994; Wright, 1977; Wright & Masters, 1982) is engaged in investigations of sign–thing convergence and separation evaluating what the tests, surveys and performance assessments of the human sciences measure. What these works suggest is something of a hermeneutic-mathematical continuum along which the apprehension of what is already known becomes increasingly clarified, with the possibility, but not the necessity, that the coordination of figure and meaning may reach the point of numerical expression.

What is fundamental is that ‘to discover quantitative regularity one must normally know what regularity one is seeking *and one’s instruments must be designed accordingly*’ (Kuhn, 1977, p. 219, emphasis added). Michell (1994) offers independent support for Kuhn’s order of events, asserting that:

> The practice of measurement, in which an instrument or procedure is used to estimate ratios (or intervals within which ratios fall), cannot then be devised independently of a commitment to a specific additive relation between elements of the quantity involved. Hence, it is unlikely that measurement of some quantity can sensibly proceed *from* the development of the instruments *to* the identification of additive relations. (p. 404)

In retrospect, it is difficult to see how the practice of measurement could ever have been otherwise conceived, since, to be meaningful, any reduction, quantitative or metaphoric, must consistently represent a reproducible effect, one born from the coordination of figure and meaning. On the other hand, again retrospectively, it is easy to see that (1) the most valuable insights are those gained last of all, and those are the insights of method (Heidegger, 1971, p. 74; Nietzsche, 1967, p. 469); and (2) the striking successes of the sciences led to the hasty positivist infatuation with method and its distaste for metaphysics, to the point that science has made less use of method than method has made use of science (Heidegger, 1971, p. 74; Nietzsche, 1967, p. 466).

The third key feature of measurement is implied in the first two, and that is its embodiment of mathematical sign–thing coordinations in a quantitative language shared by all members of a research culture. Anomalies are most effectively revealed by unexpected numbers, but numbers cannot be unexpected until the properties of the phenomenon are understood well enough for its range of effects to be reliably divisible into additive magnitudes. Understanding of the phenomenon’s range of effects, in turn, requires extensive experimental efforts aimed at the consistent coordination of figure and meaning, that is, tests of the hypothesis that the variable is quantitative, and the careful craft of instrument calibration, together achieved as the reductive moment in the phenomenological method (Heidegger, 1982a, p. 23).

The achievement of such coordination within a single laboratory (Wernimont, 1977, 1978) remains insufficient for the emergence of a mathematical language since no one outside of that lab has cultivated experience with the variable's behavior. Should the phenomenon persist across labs, samples, operators, experimental conditions, and so on, and robustly stand up to the relevant tests of strength (Ihde, 1991; Latour, 1987, 1994; Mandel, 1977, 1978; Pennella, 1997; Wimsatt 1981), then it would still remain for the researchers interested in the study and commercialization of the effect to devise arbitrary conventions for its expression and control, to facilitate the distributed cognition made possible by a widely accepted language (Latour, 1987, 1995; Mendelsohn, 1992; O'Connell, 1993; Schaffer, 1992; Wise, 1995).

Concluding Comments

Selective attention to various facets of the historical development of the natural sciences allowed past generations the (blissfully ignorant) luxury of the illusion that mathematical objects were neither metaphorically, hermeneutically, nor socially constituted. Acceptance of roles for these factors in the constitution of mathematical objects does not diminish but greatly enhances our ability to make realistic assessments of the potential of the human sciences for correcting the imbalance between our moral and technical capacities. Ihde (1991) and Latour (1987) explicitly characterize postmodern science as the science actively engaged in the overt, deliberate and metaphysically informed production, dissemination and application of technologically embodied sign–thing coordinations. In contrast, modern science has succeeded in these coordinations only haphazardly, unevenly, and by employing metaphoric, hermeneutic and social devices inconsistently, and against the assertions of its own philosophy. Because those devices appear essential to the effective unfolding of the history of science and to any effective realist philosophy, Latour (1993) correctly asserts that we have never been modern.

What, then, are the most important features to be included in the design of metaphysically competent instruments, ones that effectively reveal anomalies, embody expected quantitative regularities and provide a mathematical language shared by a community of researchers? Each of these will be taken up, in reverse order, in the second paper in this series (Fisher, 2003), after setting the stage with a recapitulation of Michell's (1990, 1997a, 1999, 2000) critique of what passes for measurement in psychology today.

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ACKNOWLEDGEMENTS. Portions of this paper have been presented at various conferences over several years, including the Midwest Objective Measurement Seminar at the University of Chicago in 1989; the African Studies Association annual meeting in Baltimore, in 1990; the Eighth International Objective Measurement Workshops held at the University of California, Berkeley, in April 1995; and the American Psychological Association annual meeting in Boston, in 1999. Thanks to Benjamin Wright for his provocative dialogue; Mark Wilson, Willis Overton and Theo Dawson for their critical comments; Nathan Markward for numerous challenging conversations; Henderikus Stam, Graham Richards, Joel Michell and an anonymous reviewer for their constructive suggestions; and to Richard Harvey, Robert Marier, Bronya Keats, Elizabeth Fontham and Jack Stenner for their support of this work.

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