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Scientist versus Philosopher on the Mind/Brain Issue and Induction

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Introduction

Sir Karl Popper, what a delight it has been to read the essays in this volume, essays prepared as a tribute to your influence. The theme that recurs is a sense of liberation from the shackles of preconceptions, the constraints of popular or then-current ways of approaching problems. Reformulate the questions, and the answers become preshaped, as the nineteenth-century Würtzburg school of psychology demonstrated so clearly. But you have added another dimension. The questions must be made more precise, not just different. Thus, answers that at first seem at odds may in fact be shown to be compatible. Not that all answers become possibly correct. Far from that. Some answers can be shown to be *wrong* and eliminated. The compatible remain as complementary views until once more the questions are reformulated, the kaleidoscope is turned, and new complementarities eliminate a few more of the earlier misconceptions.

For me, your procedural philosophy has had direct applications in two critical problem areas in which you yourself have had a good deal to say: the mind/brain issue and the issue of induction in science. With regard to the mind/brain problem, whatever differences might have appeared in our earlier writings seem to be resolved; with regard to induction, resolution is still to come.

Mind and Brain

First, the mind/brain issue. Dualism, monism, parallelism, interactionism, identity: every sort of approach and combination of approaches has been proposed to "solve" the problem of the relationship between phenomenal experience and the body organs. And each has been thoroughly argued and to some extent refuted. Where do we stand today? In *Languages of the Brain* and other publications (e.g., "Proposal for a Structural Pragmatism"; "The

Realization of Mind"),[1] I suggested that both "brain" and "mind" are constructions that begin with phenomenal experience: With a downward look in the hierarchy of scientific conceptual systems, brain comes into view; with an upward look, consensual validation results in mental constructs. A paradox arises, however, at the lowest "level"[2] of the hierarchy: person → organ → tissue → cell → organelle → molecule → atom → quantum. In the atomic and subatomic domains, observations rather than observables are being correlated, as Wigner[3] has so aptly noted. And these correlations are expressed mathematically. Here lies the paradox: relationships among observations are the province of a psychological science to unravel, and mathematics is a psychological process! There is at this level of inquiry a kind of "dematerialization of matter" that has led some, including Wigner and Whitehead, to flirt with subjectivism and panpsychism (which has been an anathema to Popper as well as to me) as an alternative to the currently overwhelmingly popular materialism.

But the dematerialization of matter is not the only paradox. At the other end of the hierarchical process of conceptual organization (i.e., person → family → social group → town → county → state → country → supranational organization) lies another paradox. The economy is composed of goods and services. A large component of these goods and services consists of what might be called "mental commodities." Money, information, inventions, books, musical instruments, and the like, and their distribution, servicing, and utilization, are in a very real sense "material." They comprise Popper's World 3, the cultural artifacts that characterize human societies. Are not the "tableness" of a table, the value of a dollar, the "battiness" of a baseball bat, the keyboard of a piano as much "material" attributions as the wetness of water, the blueness of the sky, and the firmness of earth?

You may well answer, not quite. Nor is mathematics solely "mental"—there do seem to be material correspondences involved in numerosity, geometry, and the fittingness of equations. My aim is not to materialize mind, nor is it to idealize matter. What seems to me apparent is that at certain levels of inquiry I can sharply distinguish a material brain from phenomenal experience; that at other levels this particular duality appears to be inappropriate.

Need I be concerned as to whether information or money or force or energy are "really" mental or material or neither/both? Take this example: $E = mc^2$ means that the mental concept "energy" can be materialized according to certain mentally (i.e., mathematically) specifiable rules. The concept energy has no "reality" apart from its "realizations" in the amount of potential or actual material or mental work that can be accomplished. In the "mental" domain, the experience of being energetic means that I feel that I can accomplish a lot. Further, such processes as changing a conceptual frame take effort and can be measured in terms of how much work was needed to get the

task done. In the material domain, the efficiency with which state changes are realized can also be measured in terms of the work accomplished. Efficiency is mathematized in terms of entropy; effort, in terms of information processing. Is not neg-entropy a measure on material, and information a measure on mental operations? If so, the organization of energy can be expressed in both domains, and energy per se must therefore be neutral with respect to this duality.[4]

One might argue that information processing must also become realized in material operations (e.g., computers, brains) in order to be manifest, and thus that information is also a measure on material operations. This problem returns us to the concept of "mental commodities." As Popper has shown so clearly, World 3 acts on phenomenal experience, on mental operations per se. And of course I can mentally think up programs and type them into the commodities we call computers.

Where have these examples led us? "Need I be concerned" was the initial question. Is there a difference that makes the difference? I believe the answer is "yes." With respect to "energy," the duality of mental/material appears to be inappropriate because energy is a precondition that needs to become manifest, and that manifestation can be either physical or mental. With respect to the ordinary level of experience, the mental/material duality appears to hold sometimes as exclusion, other times as complementary interactions. A stone (not the concept or word "stone") is experienced as physical, not mental. Imagining, thought, and intention are experienced as mental not physical. Money, information, and other mental commodities are experienced as interacting complementations. Why not take these experienced realities at face value?

What then becomes of mind/brain identity, the isomorphism and/or parallelism between what goes on in the brain and what we experience? There are two metaphors that help in considering this issue: the computer and the clock. There is a fairly direct correspondence between a computer program and the switch settings the program effects in the hardware of the processor. There is isomorphism between the organization of the program and the organization of the computational process—an isomorphism similar to that which obtains between a musical score and its implementation during a concert. But, of course, the paper and notation of the score are not isomorphic to the keys and pedals of the piano being utilized in the concert. Nor is the duality between the "music" and its various manifest implementations in question. Thus, if the computer metaphor is appropriate to the mind/brain issue, an identity theory is tenable provided one states clearly what is being identified.

The clock metaphor is not altogether different. However, it is harder to see isomorphic correspondences between clockwork and its manifest exterior. There is a spring or battery, tuning forks, crystals, or the like, and, finally, cogs

running clock hands or electronic read-outs. The clock is "genetically" rather than "environmentally" programmed. At best, the clockwork can be perturbed, its setting changed—then it goes on to carry out its destiny. It is really difficult, though not impossible, to draw out isomorphic identities between the operations of the clockwork and the "time" it registers.

Are brain and mind related in a fashion more similar to a computer or a clock—or entirely different from either? The answer is not to be given *ex cathedra*. Rather, painstaking experiment is first necessary to see just how the brain machine works. The results of these neurological experiments and observations must then be related to the manifest behavior of the organism in its environment in order to establish a relationship between the operations of the machine and their manifestations. Finally, and only then, can a three-way comparison between brain machinery, manifestation, and phenomenal experience yield an answer. As in the case of the computer and, even more so, the clock, it is already clear from the evidence that identities between local machine configurations and manifest behavior are tenuous at best. However, it is also clear that precisely stated transformations can describe the relationships between, on the one hand, brain states and procedures that change those states and, on the other, the manifest behaviors of the organism, including verbal reports of phenomenal experience. I personally exclude describing such relationships as *iso*morphic (of the same form) since *trans*forms (changes in form) are involved.[5] However, Shepard[6] and others may prefer the mathematical usage of "isomorphism" that is applied to linear (i.e., reversible) transformations (Shepard denotes these as "secondary" isomorphisms).

Recall once more, however, that the question addressed by identity theory is different from that addressed by dualistic theory. Identity, if present, is between the forms that are variously manifest. Dualities, or better, pluralities, characterize the manifestations of the forms. The verbal reports of introspection can be considered as representing one such manifestation—this one, however, private and completely (or in reality, incompletely) accessible only to the introspector.

The identity issue is closely related to the question of representation: is there a brain representation of . . . ? The answer to this question, as to the earlier one on form, is to be sought by experiment. But to achieve answers one must (as Popper has insisted) ask the appropriate questions. Already we know that a brain representation exists—of the sensory and motor surfaces of the body. These are the well-known "homunculi." To the extent that phenomenal experiences match these homunculi, to that extent the experiences can be said to be re-presented in the workings of the brain. There are other experiences, however, that do not fit so easily into what is known about brain mechanisms. The word "cat" is different from an imaged cat, and the parts of the brain responsible for understanding words are different from those involved in

imaging. Analysis of aphasias (language disturbances due to brain damage) and their neural substrate does not yield much in the way of any simple representation. Nor even does the analysis of the imaging mechanism other than its relationship to receptor surfaces. Finally, much of what we might call re-presentation occurs the other way around. With the help of the machinery of the brain we experience an innovation and implement it in the environment. Bicycles, musical instruments, books—Popper's entire World 3—are such re-presentations.

In short, the re-presentation issue, just as the identity issue, can be cast into a set of scientific/philosophic questions. Some hard definitional choices ensue: is a code (such as a word) to be considered a re-presentation, or shall we limit "representation" to mean *identity* in form? If the latter, then we are back to the identity problem.

The question raised by identity theorists can, as noted earlier, be restated in precise mathematical form: which brain–behavior–experience relationships can be specified by linear transformations, and which relationships demand nonlinearities to be brought in? Whether one wishes to call the linear relationships evidence of isomorphism depends on whether one takes a geometric or algebraic stance toward that definition. The philosophical issue has been recast as a set of testable scientific hypotheses. Evidence can be obtained in support of each hypothesis, and disconfirmation (a la Popper) becomes feasible.

Cries have been voiced when I have suggested this approach to the mind/brain issue in the past. Philosophers have insisted that brain research can *never* shed *any* light whatsoever on the problem. It is the privacy of subjective experience that is at issue, not the description of the mind/brain relationship. I fully agree to the ontological primacy of my phenomenal experience—whether I am attempting to understand the brain or my feelings. Nor do I underestimate the privacy problem. But is the privacy of phenomenal experience all that different from the privacy of the atom? Can I not approach both by tried and true procedures that yield some approximation to what might be happening in those private domains? These procedures are used by artists and scientists as well as critical philosophers. I do not hold that any one of these ways to knowing has a toehold on truth to the exclusion of the others.

On Abduction and Induction

How then does the scientist proceed? Do we gather rosebuds as we may, induce theories from these gatherings and then confirm these theories by further gathering, as Bacon once held? Or does the scientist, as Sir Karl suggests, approach every issue with set hypotheses—questions—which, as I noted in my

Introduction, largely predetermine the shape of the answers found?

My own experience is that the bench scientist (as distinguished from a theoretician) does several things. First, the most likely, the scientist follows the Popperian principles of "conjectures and refutations." The conjectures are probably derived from the use of analogy—for example, the brain functions like a telephone switchboard, so let us look for the switching mechanism. Or, certain brain processes resemble thermostats so let us look for feedback operations. "The brain is like a computer—it processes information" leads to still other experiments. I have elsewhere detailed the influences of such analogical thinking—called "abduction" by Charles Peirce—on the development of the neurosciences.[7]

But what about induction per se? When Charles Darwin set sail on the *Beagle* did he have anything like the "selection of the fittest" hypothesis in mind? Reading the *Beagle* diaries, one is impressed by the stunning surprises that awaited Darwin at every turn. It would be easy to conclude from this that the voyage of the *Beagle* was an inductive experience. But if Darwin was truly surprised he must have had some notions in mind—surprise comes only to a prepared mind.

My own experience in the laboratory suggests that in fact we carry into each experiment, into each observation, conceptions—preconceptions—some derived from analogies, which we can articulate more or less precisely. More often than not we are surprised, that is, our preconceptions are *dis*confirmed. It is such disconfirmations that give rise to a feeling of certitude regarding the existence of a world apart from our phenomenal experience. It is this aspect of science that Popper has caught hold of so clearly. It is disconfirmation that leads to a belief that a truth can be apprehended but at the same time that certitude eludes confirmation.

Still, disconfirmations of hypotheses are not all the scientist is after. My uncle, Karl Pribram, an economist, wrote a book[8] in which he claimed that "patterns of thought" determine economic systems (not the other way around, as Marx had stated). Current capitalism, he suggested, resulted from a system of hypothesis testing whereas dialectics rule communist economics and politics. It could be therefore that our Western science also is shaped by hypothesis testing but that other approaches—perhaps more closely allied to what scientists call induction—might be equally useful.

For example, mercantilism depends to a large extent on mapping terrain. Could it be that the great mappings of modern science, Linnaeus's biological classification and the periodic table of elements, arose when patterns of thought were more amenable than they are now to inductive arrangements of observations into classes and subclasses, and so on? I have repeatedly deplored the lack of any attempts at such arrangements in current experimental psychology, where attention research and short-term memory research

(among many other examples) may be addressing the same problems and even coming up with identical answers without acknowledging each other's existence. The fad for hypothesis testing and disconfirmation has reached such a pitch that a recent Ph.D. thesis was submitted to me in which all conjectures were simply transformed into "null hypotheses" which were then, of course, readily "disconfirmed." This is not what Popper had in mind and shows how any proposal can be distorted when attempts are made to overgeneralize its utility.

The same sort of distortions obtain in the neurosciences—those working in neuropsychology, those recording event-related brain electrical potentials, and those detailing single-cell recordings might as well be on separate planets except when an occasional result captures everyone's fancy and becomes misquoted, overgeneralized into an overworked "hypothesis," and considerably distorted (as, e.g., work on the so-called brainstem reticular formation or the current vogue regarding the functions of the right and left cerebral hemispheres).

In short, I agree with Popper's analysis with well-developed sciences, such as physics. But I believe that what he calls "conjecture and refutation" is, in the early phases of inquiry, what scientists (as distinguished from philosophers) call induction. True hypothesis testing demands a well formulated thesis—a theory—from which the hypo-theses can be deduced. Such formally stated theories do not characterize conjectures even when they stem from clearly specifiable analogies.[9]

Nor can the process of classification be readily reshaped into a hypothesis testing framework. Recent experiments have shown that the identification of a prototype is critical to categorization.[10] Prototypes are identified through correlation, that is, induction, not by hypothesis testing. Only when the prototype has been identified does template matching—that is, hypothesis testing—begin.

Conclusion

These are the thoughts stimulated in me by Sir Karl on this occasion: a pluralistic, flexible, and above all scientific approach to the mind/brain issue; a place in inquiry for abduction (analogy), induction (correlation), and classification, as well as hypothesis testing and disconfirmation. At other times, we have touched on issues ranging from a "quantum behaviorism" to "holographic homologies." Sir Karl's reach and depth continually impress. What amazes me, however, is that here is a man who is so surefooted in his procedures and beliefs, yet inspires in others the confidence to question and search for themselves—a confidence that extends to survival in the face of disconfirmation.

NOTES

1. *Languages of the Brain* (Englewood Cliffs, N.J.: Prentice-Hall, 1971); "Proposal for a Structural Pragmatism: Some Neuropsychological Considerations of Problems in Philosophy," in *Scientific Psychology: Principles and Approaches*, ed. B. Wolman and E. Nagle (New York: Basic Books, 1965), pp. 426–459; "The Realization of Mind," *Synthese* 22 (1971): 313–322.

2. A level is defined as any representation in which the terms of presentation, that is, description, are more parsimoniously organized than if that description had to be made in terms of the next lower level. Thus "it was Joan's face" is one level of description; whereas "smooth black hair, parted in the middle appeared above a high unwrinkled forehead, punctuated by wide-set clear blue-grey eyes—the aquiline nose, ruby red lips, high cheekbones, strong chin complete the picture of intelligence and beauty" is another. See my "Computations and Representations," in *Proceedings of Symposium on Language, Mind, and Brain* (Gainesville, Florida, April 1978), ed. T. W. Simon (Hillsdale, N.J.: Erlbaum, forthcoming).

3. E. P. Wigner, "Epistemology of Quantum Mechanics: Its Appraisals and Demands," in *The Anatomy of Knowledge*, ed. M. Grene (London: Routledge & Kegan Paul, 1969).

4. See my "Psychoanalysis and the Natural Sciences: The Brain–Behavior Connection from Freud to the Present," *Freud Memorial Lectures*, University of London, May 1981.

5. See my "Localization and Distribution of Function in the Brain," in *Neuropsychology Since Lashley*, ed. J. Orbach (Hillsdale, N.J.: Erlbaum, forthcoming).

6. R. N. Shepard, "Cognitive Processes that Resemble Perceptual Processes," in *Handbook of Learning and Cognitive Processes*, ed. W. K. Estes (Hillsdale, N.J.: Erlbaum, 1978); "Psychophysical Complementarity," in *Perceptual Organization*, ed. M. Kubovy and J. R. Pomerantz (Hillsdale, N.J.: Erlbaum, 1979).

7. See my "The Role of Analogy in Transcending Limits in the Brain Sciences," *Daedalus* 109 (1980): 19–38.

8. K. Pribram, *Conflicting Patterns of Thought* (Washington, D.C.: Public Affairs Press, 1949).

9. See, for example, J. D. Watson, *The Double Helix* (New York: Atheneum Press, 1968).

10. E. Rosch, "Human Categorization," in *Studies in Cross-Cultural Psychology*, ed. N. Warren (New York: Academic, 1977), vol. 1, pp. 3–50.