Problems of a Causal Theory of Functional Behavior: What the Hayek-Popper Controversy Illustrates for the 21st Century – Part 1

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Abstract: What would constitute a scientific explanation of functional behavior? The physical sciences provide our knowledge of the *inanimate* realm, and also disclose the purely physical aspects of living systems. Despite numerous efforts over the centuries, no one has succeeded in providing a purely physical account of the phenomena of life, or its "higher" manifestations in human activity such as cognition and behavior. When life came into existence a number of co-occurrence relationships—a context of constraints—also arose. Most common in our experience as human beings is the pragmatic or goal directed context in which we find ourselves. While it might be possible for utopian physical analysis to say what is involved in the movements of living organisms, it is not possible for physical theory to either address or explain the most characteristic aspect of our existence: its functionality. Behavior is meaningful (intrinsically a functional concept), and manifests semiotic content and control. Usually discussed in teleological terms (such as human intentionality and purpose) we invariably state what we do as humans in functional terms. We do not concern ourselves with physically specified movements—we talk about actions, intentions, plans, purposes, goals, values, and myriad more abstract and nonphysical concepts. We regard "objects" that could potentially be purely physically specified in semantic or functional terms such as economic "goods," or money, or our behavior, as exhibiting "wishes," "wants," "intentions," "goals," "purposes," and similar concepts, with no reference whatever to how they are physically realized. But we possess no theory to explain functional behavior in subjects. This essay explains why that is so, and why the task is so hard.

Keywords: Hayek, Popper, purpose, teleology, functionality, dispositional analysis, causality.

I. INTRODUCTION

Why it matters. All aspects of the life sciences—biology and its related disciplines such as genetics—as well as the psychological domains and social ones, are composed of functional or purposive concepts at their most fundamental levels of analysis. On the traditional hard science model(s) those domains are "unscientific" unless the terms and concepts—and hence their ultimate entities—can somehow be shown to be "reducible" or "translatable" to what physical theory ultimately discloses. Thus there has been tremendous pressure on the practitioners of such “soft” sciences to “shape up” and pin their theoretical concepts to what physical science discloses. No one has ever succeeded in doing this. The life sciences and social domains are emergent from the physical ones and cannot be identified with physical phenomena without the additions that are found at their higher order level(s) of analysis. So it would appear that the hard science model simply cannot be applied to domains involving organisms. So how should we consider these domains—if they are fundamentally different from physical domains, are they sciences, or not? And if different, what would an explanation be in the functional disciplines?

We can explore what these differences involve (and in so doing, show the inadequacy of traditional conceptions of the philosophy and methodology of scientific research) by examining a case study from the mid 20th century involving a clash between the Nobel prize-winning economist Friedrich Hayek, and the arguably most important and well-known philosopher of science of the second half of the 20th century, Karl Popper. This controversy can be developed very simply. Consider what could be involved in constructing an adequate theory of communication both within the nervous system of an organism, and between organisms (of like kind). In an unpublished paper written just after *The Sensory Order* (hereafter TSO) was published in 1952, Hayek attempted to specify a purely “physical” theory of what is involved in goal-directed, and hence intentional and thus teleological or functional, behavior. Hayek’s argument was attacked prior to publication by Karl Popper, who claimed to have an argument showing the “impossibility” of constructing such a *causal* account or argument for certain functions of language. Popper assumed that this would show the untenability of any such “physical” account for the explanation of behavior. Hayek responded by removing the first part of his paper, which dealt with the nature of understanding in complex phenomena, and published it separately in 1955 as “Degrees of Explanation” (Hayek 1967). The purported “physical” account of goal direction remained unpublished, although Hayek (correctly, it turns out) did not regard Popper’s argument to be either correct or relevant. We first examine this controversy to show why both Popper and Hayek were wrong on central points of their positions. One cannot ever provide a “purely” physical account of functional behavior in any domain, and there is nothing intrinsic about the argumentative mode of behavior (which includes language) which would prohibit causal explanations within that realm. Due to the requirement, first understood clearly by von Neumann (1951, 1958, 1966), that no account of functional behavior can ever be provided *without acknowledging semiotic* (primarily semantic) *control factors* in a concomitant and complementary account to any physical specification, Hayek was inconsistent and ambiguous in his chosen task. Understanding teleology—or any functional concept such as human intentionality—*can only be accomplished by providing both a structural analysis of the physical movement involved in conjunction with a functional account* of the pragmatic and semantic components which a subject utilizes in their description for the construction of his or her overt behavior. This task is far more difficult than we can presently accomplish, and it is instructive to look at recent developments in the biology of life, complexity theory, linguistics, and economics to see how those areas have faced similar problems. Pointing out the shape of theory construction able to overcome this limitation is our second task.

Popper’s account was equally flawed and unacceptable, although for quite different reasons. While he was correct to emphasize the nondeterministic nature of the dynamical realm of physics, his application of that to the functional domain, specifically his analysis of the argumentative mode of behavior employed in language, did not support the claims he made. His account of creativity or productivity (as the linguist uses the terms) is incompatible with what is required for an explanatory account of such behavior.

We can use this historical controversy to illustrate how such issues must be dealt with very differently in the future.

Hayek’s problem: *what can we say about communication within and between systems?* After about 1950 Hayek prepared a manuscript, which he titled “Within Systems and About Systems,” which (now published for the first time in Vanberg 2017) was intended to discuss what he regarded as the central problem his recent work—psychological, economic, and theoretical—had faced. He characterized the problem as that of explicating the distinction between what we can say ‘within a system’ and what we can say ‘about the system.' Paragraph 1 of this paper summarized the conclusions he wished to reach: First, that there is a limit of complexity beyond which we can never explain all of the particulars of the system, and which prevents the system from ever providing an explanation of itself. Based upon von Neumann's specification of complexity (or high complication), this argument was later removed from this paper and found fuller expression in "Degrees of Explanation," published later (included in his 1967). Second, he interpreted his account as the provision of a "causal theory" of the mind, and noted that the difficulties such an account faces were often regarded as arguments for why the mind cannot be regarded as "causal." And as is well known, Karl Popper, to whom much of Hayek's argument was addressed, had recently argued for the "impossibility" of the mind being causal, primarily from an analysis of the growth of human knowledge and its inherent unpredictability. Third, and this is of crucial importance, Hayek recognized that there must be a duality of descriptions, such that "The world must necessarily appear not as one but as two distinct realms which cannot be fully 'reduced' to each other." Colleagues Hayek showed this manuscript to (mainly Popper and Heinrich Klüver) were not persuaded, and Klüver, more important of the two since he was in what would soon be called neuropsychology, was particularly discouraging, not understanding it at all. Thus the paper was never published until Vanberg's compilation of some major psychological writings of Hayek (Vanberg 2017).[1]

A quarter of a century after its preparation Hayek and I discussed these issues at length in conversations after various conferences. As Vanberg hinted in his published edition of "Within Systems and About Systems" Hayek asked me to elaborate upon it (end note 1). For personal and other reasons I was then unable to devote any time to academic issues, but now offer this essay as a response. The import of that response is that 1.) Hayek was correct in much of what he said, and that Popper's arguments were never correct in terms of providing a possible refutation of the psychology of TSO; 2.) Hayek and von Neumann are correct that complex phenomena such as cognition and the genesis of our behavior are fundamentally different from the "simple" objects of the physical sciences; 3.) On the other hand, Popper was correct that productivity or creativity (as linguists and psychologists have come to use those terms) is indeed a fundamental characteristic of human cognition, and cannot be explained in any linear or behavioristic account which attempts to ape the explanatory format of physics; but 4.) Popper was wrong on what that entails for an explanation of the mental realm, which is a further complication not noted by the initial participants, 5.) Hayek's account of the mental realm is inadequate for the twofold reasons of its reliance upon the (non-explanatory) concept of dispositions, and although he noted the centrality of the duality of descriptions to all adequate theory construction, in his attempt to reduce functional behavior (in his example of hunting prey in social dyads) to physical specification, he failed to employ it. Further, he simply did he understand its full consequences, which entail that any adequate theory of the psychological domain (or social, or economic, etc.) must make indispensable use of the distinction between surface structure phenomena and the deep structural level of activity that is "causally productive" of it. This leads to our conclusion, 6.) Without an adequate theory of how fundamentally abstract and thus non-physical (ally specified) deep conceptual structures eventuate into (potentially indefinitely extended) physical structures, any account of behavior (neutrally construed, as whatever it is that organisms "do") will be inherently ambiguous and incomplete and therefore non-explanatory. No purely physical or material account of functionality can ever succeed. Conversely, no functional or purposive account will ever be unambiguous *unless a concomitant structural*

1 Despite fame in economics Hayek began as a psychologist and an epistemologist (who also studied law) in Vienna, and continued those themes throughout his career. Many essays in *Individualism and Economic Order* (1948) and *Studies in Politics Philosophy and Economics* (1967) and *New Studies* (1978) are epistemological and psychological, and could not be included in a single volume of his psychological works which already contained a book (TSO) and previously unpublished material.

account is provided. There is an unavoidable *epistemic* duality[2] which has arisen with the origin of life and the emergence of the semiotic realm, which unavoidably separates the physical realm and the functional one. The explanation of behavior, since it involves subjects *and not merely objects*, is inherently functional, and thus requires concomitant and complimentary theory in both realms.

Hayek's proposed solution. Begin by understanding what Hayek took as his goal in "Within Systems," and its proposed solution. In paragraph 5 he described the goal to be achieved: "We must succeed in producing models which produce in-kind such mental functions as "thinking" or "having an intention", or "naming", or "describing", or "communicating a meaning", or "drawing an inference" and the like; …" So his problem ultimately is to produce a model of human functionality. He assumed it would be sufficient "if we can construct an instance which possesses all the characteristics which are common to all the instances to which we commonly apply any one of these terms." The question is whether or not this task, providing an abstract schema of human intentionality, can be realized in any actually physical model. Later, paragraph 25 argues that the decisive problem for such an in principle explanation of complicated instances "arises already in instances of the kind which seems so simple that at first neither the future nor "intention" seem to be at all involved … It makes little difference whether by "movement" in this connection we mean literally a single external move of some part of our system or a more or less complicated chain of actions, particularly, as with the kinds of systems in which we are primarily interested, even the simplest kind of movement is the effect of a more complex spatial or temporal pattern of signals." Here he stated that even the simplest bit of behavior is the result of incredibly complicated CNS processing *before* it occurs in overt form. Then paragraph 26 admits "the concept of "purpose"… has meaning something like the "use of variable means to an invariable goal, …" His example is that of a car gas gauge which would trigger the "car" to drive to a source of gasoline when necessary to replenish its supply. This in turn becomes the explanatory question of: "By what kind of causal connection between the apparatus classifying external effects on such a system and the apparatus disposing it to certain classes of actions can such behavior be brought about?" Claiming that this case provides no "insuperable" difficulties he noted that far greater difficulty arises when (in paragraph 27) "the disposition required for an explanation is not a disposition towards *particular kinds* of actions (definable by their physical characteristics) but a disposition to take *any* action which the representation of the environment shows to produce one of the class of results which will cause the system in its existing state to act." This presents the problem of apparently reversed causation: the action at the *end of a chain* somehow becomes the cause of the same chain of actions (end note 2) being actually carried out. Hayek argued that this difficulty is caused by thinking of things as nothing but linear chains. His solution was to propose *simultaneous* existence of chains or signals, so that, in paragraph 30, "a simultaneous existence of the signals making up the pattern is clearly mechanically possible, and so is some arrangement by which such a preformed pattern is translated into action whenever a representation of one of the effects singled out as significant by the state of the system appears as part of the pattern." This is clearly a hierarchical organization instead of linear chaining, but he did not label it as such.

Here is a crucial point. In paragraph 32, we can clearly "conceive of a kind of causal system which will respond to any one of a certain class of external effects by such a set of responses which in the situation which is represented within it will in fact produce the result (or one of the class of results) towards which it

2 Vanberg (2017, pp. 61-62), perhaps because he is not an epistemologist, is misleading on an important point. Hayek is an *epistemic* dualist with regard to mental and physical realms (in favor of the double aspect or non-reducibility argument). He is not a strict monist in the traditional sense. Hayek was an *ontological agnostic*, denying only the Cartesian conception of a "mental substance." Nevertheless his research strategy was to pursue a physically specified theory, while being clear not to make a definitive claim to monism and ontology. Indeed, the only tenable monism would not be identical to any extant physical theory, but something underlying both it and the mental realm. See End note 10.

is disposed … So this is a general state or disposition of the system in question. Hayek feels that this is "precisely what we mean and all that we mean if we ascribe to any of the familiar organic systems, such as animals or men, the *intention* of achieving a particular *goal*." Paragraph 34 defines intention as "the state of a system that, when ever its classifying apparatus represents a chain of actions as producing a result which at the same time the internal state of the system singles out as appropriate to that state, it will perform that chain of actions." This is a statement of intentionality as an anticipatory or feedforward system of neural activity within the ongoing patterning of CNS activity. And what will produce the chain of actions or class of actions is the goal or goals to which intention is intrinsically directed. He clearly stated that this was a simplified explanation of a minimal case. So it is to be a "bare-bones" representative explanation of the *principle of intentionality* and nothing more. Nor is there any discussion of whether or not "goals" can be defined completely in physical terms.

Discussion thus far concerned what is *within* the system. But what of the problem of communication *between* systems? What if there are two systems, and their mutual interaction is to influence the patterns of actions they themselves exhibit? Here Hayek (following Popper) utilized Karl Bühler's functional analysis of language as propounded primarily in Bühler's 1934 book, *Sprachtheorie*: *Die Darstellungsfunktion der Sprache*. This was intended as an anticipatory reply to Popper, who had used Bühler's functional account in his essay "Language and the Body-Mind Problem" to show (at least to Popper's own satisfaction) the impossibility of a physicalistic causal theory of language. This was the part of the paper Hayek was least pleased with. He assumed for purposes of discussion two systems, or communicating individuals, that were as nearly identical as possible (knowing full well that no two subjects are ever totally equivalent as objects). After discussing stigmergy (first studied by Grassé, who observed termite interactions) as a beginning of the distinction between sign and symbol, the example began. But first we must note that a symbol, for Bühler, brings in the third function of language, its descriptive function. The key here is that the *representational* function of language is now present: (in paragraph 46) "a symbol thus differs from the two other kinds of signs (symptoms and signals) by the fact that it stands for and evokes, both for the emitters and the receiver, the same class of events." At this point constant conjunction, simultaneous or nearly simultaneous occurrence of two or more symbols, will allow them to substitute for each other in nervous system functioning. And as Hayek noted, if we were to add to the logical operation of conjunction the operation of negation, all the other logical constants could be built up from combinations of conjunction and negation.

At this juncture he introduced his example of hunting, involving two "nearly identical" communicating systems (hunters) coordinating their efforts to capture their prey (presumably a different kind of system!). It is extensively discussed to illustrate how the factors he had outlined exhibit (denote or refer to or represent) intentionality and purposive behavior. As noted in paragraph 51, this will include what we "commonly call the 'use' of objects in the environment as 'means' for reaching the goal, be it merely the choice of a surface on which it is easier to move or the employment of a 'tool'[3] (e.g., using a log as a bridge)." All that is required is a surface richness of the apparatus of sensory classification so as to be able to classify the effects of all the alternative combinations of actions and external circumstances which can arise from the initial situation. Of course, this ignores for the moment the tremendous complexity of the initiation of motor responses required to "run off" this pursuit. It is crucial to note that one of the "objects" of the external environment which will influence one hunter's actions will be his or her perception of the movements of the other hunter. Each hunter will have a *representation*, i.e., knowledge, of the other hunter and his or her movements. He ends the paper with an incomplete thought in paragraph 53: "all that we have to assume to explain the transmission of information is that the representatives of the classes which are formed in evaluating the environment can also be evoked by symbols shown by another."

3 Any use of tools or machines always puts our human functionality or intentionality into the construction and *use* of the otherwise purely "physical" object (see Polanyi 1969). Machines and tools cannot exist independently of teleological subjects.

With this as background we need a strategy for analysis of this cryptic account of intentionality. First, we must detour to dispose of an obvious red herring—the Popperian account of the alleged necessity of "noncausal" understanding of cognition (specifically, in the argumentative use of language). Second, it is necessary to show that Hayek's account, in common with those of virtually all economists, psychologists, and social scientists, cannot include dispositional analysis if it is to be actually explanatory. None of these fields seem to have understood that dispositions are factual, thus *pre-theoretical*, ways of grouping facts *that are to be explained*, rather than explanatory of facts. Third, no doubt most unfamiliar, we must overview the necessity of dual levels of description, and what that constitutes, for discussions of scientific theory, especially of living systems and society – while Hayek acknowledged this duality he did not implement it. Indeed, he did not understand what it entails. When it is understood that functionality (such as intentionality, purpose, or goal-directed behavior) can never be accounted for solely in terms of physicality (on this point Popper was right but for the wrong reasons) the way is clear to attempt to construct an adequate explanatory theory, the equivalent of a "grammar of behavior." Such a theory will utilize dual levels of description. Any theory which eventuates into "physically specified" movements on the part of an organism must have a complementary description of the functional specification of that movement in order to disambiguate it. Only then can it be an explanatory account.

So with respect to the substantive Popper-Hayek conflict (to which we must now turn) the situation is quite simple. It amounts to a "plague on both your houses." Neither approach was adequate, but for quite different reasons. And both approaches, but in quite different ways, showed the necessity for certain factors to be included in any adequate explanatory theory.

II: POPPER ON CREATIVITY, CAUSALITY, AND DETERMINISM

Popper's problems are not Hayek's problems. Note at the outset that Popper's argument only tangentially applied to Hayek's position, because Popper's account has to do *only with language*, and as such, with only two of the four functions of language that he and Bühler emphasize. It had, as Vanberg discussed, no bearing whatever on any "nonlinguistic" instances of teleological or intentional behavior. As Vanberg noted, considerable evidence from biology (as in the work of Mayr) and psychology supports Hayek's general thesis when restricted to areas that do not yet involve natural language. Further, as he noted, it is not crystal clear exactly what Popper's initial argument was directed against. So we must first examine Popper's brief paper (Popper 1963, reprinted as Chapter 12, and his brief reply to a criticism of that paper by Sellars, which is Chapter 13).

Popper on intentionality, causality, and the nature of language. Popper presupposed Karl Bühler's theory of the functional levels of language. Bühler noted that the first level is an *expressive or symptomatic* function, as when one hits oneself with a hammer and (probably involuntarily) blurts out the sound "ouch" (or something worse!). A second level, higher in the sense that it incorporates the first level, is found in a signal function that denotes the state of affairs. Ambiguously, that "ouch" can also express, as when it means something like "that hurt!" A third, inclusive of the first two levels, is found in description. As Popper stated, "an argument, for example, serves as an expression in so far as it is an outward symptom of some internal state (whether physical, or psychological is here irrelevant) of the organism. It is also a signal, since it may provoke a reply, or agreement. In so far as it is *about* something, and supports a view of some *situation or state of affairs*, it is descriptive (Popper 1963, p. 295)." To Bühler's three functional levels Popper added a fourth: the argumentative, also inclusive of the three lower levels. He defined it as "giving *reasons* for holding this view, e.g. by pointing out difficulties or even inconsistencies in an alternative view (ibid.)." While he did not state a reason for doing so explicitly, Popper identifies intentionality and teleological behavior as belonging to the argumentative function of language and not to the others.[4] He also wants to include the descriptive level (as well as the argumentative) as being beyond the possibility of causal determination. Here his argument (if indeed he actually presents one) is weak. This is all he says:

> The name-relation is therefore clearly not to be realized by, say, an association model, or a conditioned reflex model, of whatever complexity. It involves some kind of *knowledge that* "Mike" is (by some convention) the name of the cat Mike, and some kind of *intention* to use it as a name.
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> Naming is by far the simplest case of a descriptive use of words. Since no causal relation of the name-relation is possible, *no causal physical theory of the descriptive and argumentative functions of language is possible* (Popper 1963, p. 298).

One should note several things. First, the name-relation is not a relation. To call that cat "Mike" is not to designate a relation involving "a name" and "a cat," it is a *predication*. It does not have the relational structure aRb but rather the predication or *attribution* structure nA (name of A). "Mike" is a predication of that particular cat, which tells nothing at all about any relationship (to anything). Even if it were (contra factually) a relation, this is an argument not against "causal relation" in general but against the doctrine of associationism (and behaviorism), with its attempt to link surface structures (stimuli) with other surface structures (overt responses). Surface accounts based upon "principles of association" such as behaviorism are the target. But moving on without any focus on that, Popper switched from the limited problem of naming to the domain of all *abstract* exemplification:

> If I say, "Should this be your argument, then it is contradictory", because I have grasped or realize that it is so, then there was no physical "cause" analogous to Mike; I do not need to hear or see your words in order to realize that a certain theory (it does not matter whose) is contradictory. The analogy is not to Mike, but rather to *my realization* that Mike is here (ibid.).

Here Popper's argument became untenable. His "realization" is a matter of undergoing the acquaintance side of what is known (to others) by description (to use Russell's 1912, 1948, terminology) of the neural processes ongoing in his brain when that realization is occurring. Further, its proximal cause was very obviously physical—auditory or visual input to his brain when the argument was spoken to him or when it was read by him. Thus it definitely is physically caused, in any case, and is not an amorphous, disembodied and nonphysical "abstraction" floating around in some Platonic Third World, just waiting to somehow be instantiated in someone's concrete, functioning brain processes. There are no disembodied structures—all structures (and their relationships) are embodied in one form or another. In the case of so-called abstract entities, say the proposition "that is Mike," or "Mike exemplifies cat-hood," it is clear that such a proposition exists physically either in terms of neural activity in someone's brain, or sound waves transmitted through the air, or as marks on paper in a written language. Without that physical instantiation—that substratum—it does not "exist" at all. Any and all aspects of language (or cognition) require a physical instantiation. Even Popper's so-called "subject less" Third World epistemology cannot exist unless it has some actual instantiation in the space-time manifold. If no one discusses this concept in a language, writes about it, or reads it in some physical medium (or otherwise acknowledges its presence in his or her neural activity), it has no existence whatever. When Popper says something—for instance his "Should this be your argument it is contradictory"—it is just as physical as these marks on paper that you are now reading and com-

4 Fuller exploration of Popper's extension of Bühler's functional theory is found in Bartley (1971, 1984) and Weimer (1974, 1984). In the latter publications I generalized Popper's extension of a function from use restricted to language to the full range of the argumentative mode of behavior.

prehending in your own brain processes, or in sound waves impinging upon someone's brain when it is spoken to them. There are no disembodied representations or structures in the universe.[5]

Can one be more charitable to Popper? I do not think so. His basis for the contention that the argumentative function of language cannot be causally explained is the existence of genuine novelty or creativity or productivity in language use (as linguists post Chomsky use those terms). The contention is that because there is no way to *predict* when *new* knowledge will arise (analogously to when a totally novel sentence will be produced by a speaker-hearer) there can be no physicalistic or billiard ball deterministic account of the generation of novel utterances or occurrences. From his analysis of quantum physics Popper contended that it requires the acceptance of indeterminism rather than determinism, and he did so by (unfortunately falsely) reasoning that any sort of causality is presupposed to require a classic billiard ball account of determinism, and that therefore there can never be a causal account of language productivity which occurs in the descriptive and argumentative modes. Here he failed to note the fundamental distinction between inexorable "laws of nature" for the inanimate realm and rules for the genesis of behavior for living subjects.

We may begin to analyze this by asking "Does a causal account of novel but appropriate behavior require any "billiard ball" or strict deterministic basis?" Note that this has nothing to do with the thesis of indeterminism for quantum or "particle" physics. New knowledge claims or novel sentences are "classical" sized entities. So the question comes down to what "causes" one to speak, and in particular, to utter genuinely novel meaningful sentences. For example, what "caused" Popper to argue against causal accounts in this presumably novel manner? There are many answers available: the cause of our thoughts (and their verbal expressions) are our own or others' prior thoughts and experiences. Even mental doodles and daydreams have antecedents (often preconscious and, as depth psychology from Freud on up has shown, thus never in our awareness or conscious experience). No linguist or cognitive psychologist ever seriously argued that anyone has ever produced an "uncaused" novel thought or sentence as a result of an errant quantum jump in their brain. But any and all other denizens of our mental realm such as wishes, wants, desires, reasons, excuses, raptures, or whatever else one chooses to include, are not quantum effects—they are classical level affects. Can they be causal of new knowledge? Of course they can, at least in their effect (either upon ourselves or upon others). What is at issue in the mental realm of attributes is what they really are, not whether they are or can be causal. Everyone acknowledges that at least the pre-conscious determinants[6] of the conscious contents of behavior are indeed causal. Popper himself had to acknowledge this about 15 years later, and proposed what he called *plastic controls* to account for the nondeterministic but still determinate aspects of behavior.

Here the problem of consciousness becomes a problem for Popper and his followers. Can consciousness "cause" our thoughts and overt behaviors? Popper and his followers (e.g., Feser 2011) have had to argue for indeterminism and, according to their understanding of that conception, thus the noncausal nature of consciousness. Here Popper's account is clearly self-contradictory (all that is, of course, ignored by Popperians). Popper first formulated his problem this way: "How can it be that such things as states of

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5 To use one of Popper's arguments against him on this approach to "subject less" knowledge, note that it is a "haunted universe doctrine" that, while superficially compatible with anything, can be refuted by no empirical state of affairs. That is not a very Popperian situation, since Popper defined the empirical realm in terms of that which it forbids to occur. This doctrine forbids nothing.

6 Elsewhere I have argued that while consciousness is caused by prior tacit processing (preconscious activity) it is not causal of behavior within the individual who has that consciousness. The actual causal role there is held by the prior tacit or preconscious neural activity. By the time something eventuates into one's consciousness it has already been caused, and your thinking about something or determining to do something is a concomitant of the causal processes responsible for moving your body rather than the only cause. An individual's consciousness is causal only to others, as when someone shouts "fire!" And you then move. Then your consciousness acts upon theirs (and their subsequent behavior) exactly as any other incoming stimulation does.

mind—volitions, feelings, expectations—influence or control the physical movements of our limbs (1972, p. 231)?" This was also J. C. Eccles' problem (1974, Popper and Eccles 1977), as when he somewhat gleefully asked materialists, "How can it be that physical states of the organism are influenced by its mental states? His ubiquitous example was, "Why is it that when I will to move my finger it moves?" Theories that attempt to answer such issues are "deterministic" (or correctly, determinate) whether they emphasize it or not, but they are, in Popper's view, "master-switch" models of control, as for example in Meehl's (1989) resuscitation of the "command neuron" hypothesis, and even in Eccles' approach to the cerebellum as a neuronal "machine." Yet it is this "billiard ball" connection that Popper and Eccles wish to disavow.

Popper felt this approach was a poor way to formulate the actual issue, and followed physicist A. H. Compton in a re-formulation of the issue into "*how do we combine freedom and control*?" Speaking of letters, public announcements, declared aims and purposes, general moral rules, and similar cognitive contents he noted that "*this content or meaning is something quite abstract*. Yet it can control—perhaps by way of a short cryptic entry in an engagement calendar—the physical movements of a man in such a way as to steer him back from Italy to Connecticut. How can that be (Popper 1972, p. 230)?" His answer was to search for *plastic controls*—controls with feedback and hierarchical structure that could learn from their experience. This was to be accounted for by an evolutionary theory incorporating feedback systems: "My theory … consists of a certain view of evolution as a growing hierarchical system of plastic controls, and of a certain view of organisms as incorporating—or in the case of man, evolving exosomatically—this growing hierarchical system of plastic controls (Popper 1972, p. 242)." Thus organisms when regarded as a hierarchical system of plastic controls become systems of clouds that are controlled by other clouds. The "physical" organism thus is an open system instead of a closed and deterministic one: clouds rather than 19th century deterministic clocks. Unfortunately for this account to work it must also include feedforward systems (in order to address teleology in the nervous system—as Pribram 1971 and Rosen 1985, emphasized, well after Hayek in 1952), but Popper did not know that. This issue will be discussed later, examining what "controls" hierarchical structures, and it is an unsolved problem for both Popper and Hayek.

Before noting how this "plastic" control account contradicts his earlier position it is worth emphasizing that this is exactly the problem for which Hayek proposed a solution in TSO: the nervous system as an instrument of classification capable of operating with hierarchical structuring to provide many simultaneous "levels" of causal control, which are thus "soft" or plastic (rather than "cast iron" deterministic.

Consider an unresolved ambiguity in consciousness and language with respect to causality in Popper's account. Twenty years after saying Hayek couldn't do it, Popper argued that consciousness is causally productive of behavior:

> Conscious states, or sequences of conscious states, may function as systems of control … Consciousness appears as just one of many interacting kinds of control … Consciousness can hardly be said to be the highest control system in the hierarchy. For it is to a considerable extent controlled by these exosomatic linguistic systems—even though they may be said to be produced by physical states; yet it controls them to a considerable extent. Just as a legal or social system is produced by us, yet controls us, and is in no reasonable sense "identical" to or "parallel" with us, but interacts with us, so states of consciousness (the "mind") control the body, and interact with it (1972, p. 257).

One may now ask Popper how consciousness as "control" is to be the equivalent of causal (as he put it, a system of control) if it is hierarchical and linguistic, when he argued for the noncausal nature of language in these argumentative modes of behavior, precisely because of that hierarchical and hence abstract nature. Popperians tended to slip back and forth, thanks to the word magic substitution of "control" for cause, from beating materialists with the alleged noncausal nature of language and/or consciousness into causal accounts of "plastic control" in the determination of behavior (including conscious behavior and novel language) in other contexts. What resolves the confusion here is an understanding of how, as Polanyi (in 1968) put it, *life harnesses inexorability* without violating physicality. Semantic controls are determinate, operating according to rules, not laws, and are constrained not to violate physicality (i.e., must be compatible with laws, but are otherwise "free"). This is discussed more fully in sections below. Parenthetically, we may note that in point of fact Popper has a small victory here: consciousness is in fact not *in itself* causal, because it is the *product* of tacit processes that are known to occur temporally prior to conscious experience. When we consciously "decide" to do something, we have *already* "caused" it to occur in those tacit processes. Properly speaking, the causality is in the tacit processing and not the after the fact reflection of that processing in our conscious experience.

What is wrong with determinism? Several auxiliary theses are usually found in conjunction with Popper's "causal" claims. One fares better than the original claim: the thesis of indeterminism, especially with regard to the predictability of language and cognition. It is certainly clear that the traditional Laplacean, "billiard ball" concept of determinism as involving the "necessitated" (as in Blanshard 1973) or constant conjunction (as in David Hume three centuries ago) of events has not had any currency even in physics prior to quantum mechanics. It has long since been replaced by principles or rules of determination, specifying *determinate* orders instead of deterministic particulars, in exactly the fashion Hayek discussed with respect to explanation of the principle replacing explanation of particulars in complex domains. Everything in the dynamical (lawful physical) realm, including especially physical theory, is statistical and probabilistic rather than billiard ball deterministic. This argument has been made chiefly by physicists, and Howard Pattee (2012, p. 25), referring to a common *misperception* of physics, noted that it:

> Holds that because laws are inexorable—that is, no event can disobey laws—the implication is that *laws determine all events. That is not the case*. Most fundamental complementarity in physics is between laws and initial conditions. Laws cannot derive initial conditions, nor can initial conditions derive laws—but both are necessary for experiments. Most of the structures in the universe are undetermined by laws or are accidental. Measuring instruments obey physical laws but are not determined by laws. Eddington (1929, p. 260) emphasized this fact in *The Nature of the Physical World*: "There is nothing to prevent the assemblage of atoms constituting a brain from being of itself a thinking object (including free will and consciousness) in virtue of that nature which physics leaves undetermined and undeterminable." Gell-Mann (1994, p. 134) again pointed this out in *The Quark and the Jaguar*: "the effective complexity (of the universe) receives only a small contribution from the fundamental laws. The rest comes from the numerous regularities resulting from 'frozen accidents'."

This is the framework in which Michael Polanyi (1969) pointed out that life or agency can harness physicality. Agency provides *higher order* constraints that can control (in Popper's "plastic" sense) the lower-level or physically inexorable laws of nature. That point we shall explore below. With respect to determination, we need to hold in mind the fact that the environment we inhabit is fundamentally statistical and fuzzy around the edges of everything we encounter. Indeed, all living systems are equally fuzzy and statistical. Determinism is a dead issue: the laws of nature of physical science and the rules of determination in the psychological and social sciences are *determinate but not deterministic*. Living systems cannot violate natural laws. But regardless of that fact, living behavior is not determined by natural laws.

Hayek had already provided a mechanism for this, in terms of how the brain functions, with the proposal that the nervous system is a classificatory mechanism based upon patterns of activity in the process of matching or modeling. Nervous systems attempt to model reality (whether the body surrounding the nerves or the world "external" to the body) by elaborating patterns of activity. Since the nervous system of a living organism is *always* active, as e.g., Sherrington (1906) and Helmholtz (1895) had long emphasized, all "new" stimulation or neural activity reflecting that which is external to the central nervous system itself must consist of patterns of activity that fit within, or are accepted by, the ongoing patterns of nervous activity that are already extant. The nervous system keeps records, or perhaps more accurately makes measures, of patterns that are consonant with its ongoing patterns, i.e., can be matched with those previous and ongoing patterns. These dynamical records in turn modify the patterns and thus have an effect upon any subsequent patterns.[7] And we are noting now that record-keeping and measurement are inherently probabilistic and statistical, and the brain's activity *must* reflect this.

Others had already noted that the functioning brain is a statistical device. Consider these cryptic remarks of von Neumann (1958, p. 79), whose views were complementary to those of Hayek:

> What matters are not the precise positions of definite markers, digits, but the statistical characteristics of their occurrence, i.e., frequencies of periodic or nearly periodic pulse-trains, etc.
>
> Thus the nervous system appears to be using a radically different system of notation from the ones we are familiar with in ordinary arithmetics and mathematics: instead of the precise systems of markers where the position—and presence or absence—of every marker counts decisively in determining the meaning of the message, we have here a system of notations in which the meaning is conveyed by the *statistical* properties of the message.

And twenty years later Jacob Bronowski (1978, p. 105) noted of word associations, "These responses must have this statistical character: you feed in a perfectly definite piece of information, you get out a perfectly definite answer, but what goes on inside is not at all a computer-like process. It must be much more like the process which we imagine goes on in a cloud of gas." The output of the dynamical brain in spoken language may be a linear string (of words or syllables or phonemes) but it is all too obvious that the processes constructing the strings are nonlinear, instead being statistical, multilevel, nondeterministic, and cloudlike. Popper may have come to indeterminism from his study of quantum mechanics, but Hayek was there, along with von Neumann, from the study of complexity in the functioning of the nervous system. The psychology of TSO provides a *determinate account* of the genesis of behavior that is as "physicalistic" as is possible (requiring that organisms follow laws of nature where they apply) without being billiard ball deterministic. So in retrospect we may say that Popper was quite correct on indeterminacy of the output of the human mind, since cognition exhibits creativity or productivity, but he was completely wrong in assuming that the principles of determination generating such creativity and complexity could not be "causal" because they were somehow "indeterministic." Coupled with that was his failure to comprehend that all structures are embodied structures, which led him into a contradiction in terms position of "epistemology without a knowing subject." What he meant to say is simple: "independent of any given subject, but not all possible subjects, and not all subjects at once." That, however, is all the difference in the world.

Before leaving the topic of determinism we should note that the fact that determinism does not hold leads to the existence of error and the inevitability of our ignorance. Indeed, it is the failure of determinism that enables our knowledge to exist, but in so doing also requires that it must be fallible and incomplete. If the universe were entirely deterministic, and its regularity were determined by the inexorable laws which held everywhere and every when, there would be no possibility of knowledge, or records, or measurements. The existence of knowledge presupposes—that is, requires—an inescapable separation between the knower, on one hand, and that which is known, on the other. If that separation did not occur one would not "know" anything at all, since there would be no distinction between the knower and known—they would be the same. Put another way, if inexorable determinism held, there would be no need for knowledge. Fallibility and ignorance become inevitable *if we have* any knowledge at all. In a world of unknown and unforeseen

7 Polanyi (1958) noted the same effect of an individual's action in slightly modifying the entire pattern of the social order, as when one selection of a radio program changes the entire balance of what is available on the airwaves, if only to a tiny degree, and in so doing affects the entire balance of human social interactions.

events and consequences of action as finite beings we are unable to come to know everything that we might encounter. Ignorance is an inevitable factor in our existential predicament. We cannot definitively predict or determine without omniscience. And indeed, we can never know anything at all completely, without the possibility of error. To see this consider the problems of measurement and record-keeping. We cannot know—or do science—without being able to measure and to record. If we make a measure we by definition select a particular temporally and spatially determined specification, and pull it out of dynamical reality as a "frozen accident" to be used in an experimental or conceptual situation. That measure, when so selected, becomes a record which we use in our determination of knowledge claims (as, for example, we must do when attempting to determine whether a "law of nature" applies to a given situation). The record is always and inevitably incomplete—it does not fix every property of the dynamical reality which applies to the "object" which we measure. A record always leaves out an indefinite amount of information. Thus any record is at best a fallible and incomplete one, and as such it must be subject to error. What little we know is, as Warren Weaver (1959) said, always surrounded by a larger circle of ignorance, and subject to errors of measurement and record-keeping. We will discuss these issues below; for now we note only that it is the failure of determinism (and hence the ubiquity of the laws of nature) that allows us to have any knowledge at all, and it comes at the price of indefinite ignorance and the existence of error.

III: LIMITATIONS OF DISPOSITIONAL ANALYSIS OF BEHAVIOR

Hayek wanted to replace his earlier account of mapping and modeling (perhaps under the influence of Gilbert Ryle's then popular book *The Concept of Mind* (1949), which appeared only three years before TSO, with the concept of "dispositions." At the time it was assumed by Ryle and others that "dispositions to respond" was a more appropriate (read: more scientific) designation for what was involved in the patterns of neural activity that eventuated into behavior. That assumption was unfortunate, because dispositional accounts do not occur in any explanatory science. This chapter overviews why this is so. Without going into definitional issues (see Weimer 1984, and more extensively, Pap 1962) as to what dispositions are we can overview some common limitations of programs of dispositional analysis that show their unsuitability in explanatory scientific accounts. We need to address several problems: 1.) Dispositional analysis is incomplete; 2.) Dispositional analysis cannot be causal; 3.) Dispositions are pre-theoretical; and 4.) Dispositional analysis cannot address the problems posed by creativity or productivity. *A dispositional analysis is always incomplete*. Dispositional analysis invariably points beyond itself to another level of analysis. In exploring the particular size of objects that such analyses claim to be "the joints of nature," dispositional analyses disclose that these joints have further joints. Thus any "science" employing dispositional concepts is at best a halfway house to an explanatory science.

Arthur Pap (1962, p. 282) summarized the problem this way:

> There is the tendency … To assume that brain modifications are correlated with acquired response dispositions. Perhaps dispositional statements may be said to mark a transition from purely empirical science that gathers reliable correlations without attempting theoretical unification to theoretical, unifying science, because in subsuming an observed regularity under a disposition concept one anticipates an explanation in terms of the intrinsic, structural micro-properties of the things involved.

Wilfred Sellars (1958, p. 263) put the point in this fashion: "The plausibility of the 'positivistic' interpretation of theoretical entities rests on a failure to appreciate the way in which thing-kind generalizations by bunching rather than explaining causal properties point beyond themselves to a more penetrating level of description and explanation: it rests, that is, on a failure to appreciate the promissory note dimension of thing-kind expressions." In the progress of science it is conflicts between equally plausible and well confirmed knowledge claims within the common sense framework (of thing-kinds) which lead theorists operating within this framework beyond the initial common sense level, in that only by postulating further "joints of nature" *at a different level of analysis* is it possible to give an orderly or causal explanation of the irregular behavior at the observable level of ordinary discourse.

Bruce Aune (1967, p. 168-69) put this problem of different levels thusly:

> The logic of our ordinary reasoning about the world is such that it constantly and inevitably leads us to postulate unobservable entities and processes … This happens, for instance, when substances known to be soluble failed to dissolve under what had been regarded as standard laboratory conditions. When things of this sort happen, we are led to hunt for some interfering factor—some actual entity or process whose presence accounts for the failure of the expected reaction. Very often, the factor discovered is not describable in common-sense terms. This is why intelligent common-sense thinking constantly tends to lead beyond itself.

Attempting to provide a causal explanation (which is the same in both commonsense and theoretical science) leads to a search for regularity and order underlying prima facie conflicting observations. Dispositional analysis, because it makes use of "dispositions to behave" *at the same phenomenal level of analysis*, leads beyond itself to another level of analysis when faced with conflicting claims. All that dispositions do is bunch together a collection of data or "facts" and say, in effect, this banana is a banana because it is one of a bunch of bananas. Sooner or later one wants to know why something that does not resemble what is in extant bunches of bananas is still a banana. And the answer to that sort of question need not lie at a "micro" or smaller physical constituent analysis. Especially in the case of complex behavior—such as the phenomenon of deep structural ambiguity in language—the answer may lead to an analysis of *larger* conceptual entities within an entirely different framework.

Dispositional analysis cannot be causal. Dispositional analysis is incomplete in the sense that attribution of a dispositional predicate to something, at the molar level, leads to another (conceptually higher) more rarefied and penetrating level of analysis in order to explain discrepancies at the original molar level. Merely the attribution of a "disposition to respond" is insufficient as an account of what actually transpires. Dispositions per se are not explanatory constructs at all—they are condensed statements that anticipate the provision of genuine explanations. To present only a dispositional analysis of a domain is to reflect the fact that the state of development in that domain is pre-theoretical, and deals with *data summaries* only. A statement that an observed regularity is due to some "dispositions to respond" is not entirely empty, as it would be if it were a disguised tautology, nor is it yet an explanation. It is at best a promissory note to be cashed in by a *forthcoming* explanation. A dispositional analysis at best promises the discovery, in the future, of a theoretical and actually explanatory account that will cover the observed regularity. When such a causal account is made available, the dispositional account will disappear. It will have been rendered superfluous. Pap (1959, p. 285) put this succinctly:

> To say that turpentine is inflammable is to say that anything which is turpentine has certain (unspecified) physico-chemical properties K such that anything which has K and is exposed to fairly high temperature (in the presence of sufficient oxygen, etc.) will burn. Once K is *specified*, the anticipatory dispositional statement can be replaced by a specific causal generalization.

To suggest that psychological and social domains utilize primarily or only dispositional analysis is to suggest that they be *purely descriptive fields utilizing no theoretical explanatory terms.* Restriction to dispositional analysis requires one to exclude the possibility of theoretical or causal explanation entirely. Consider this now.

The impossibility of any causal specification in dispositional "explanation." Regardless of what account of explanation one accepts (the standard hypothetico-deductive or covering law model (from Hertz through Hempel 1965), Hanson's (1958) or Bohm's (1965) account of theories as pictures, or abstract mathematical structures, or whatever) it is very clear that no account of explanation has ever allowed self-explanation of factual propositions, which is exactly what is involved in attempts to explain a fact with a dispositional predicate.

No account allows one to have in the premises of an explanatory argument only the same type of statements that is found in the conclusion. The problem is that, as Pap put it, *explananda consisting of existential statements cannot be explained by other existential statements* (which is what dispositional predicates are). Explanations on all accounts must be premises that are more inclusive, more general, then the conclusion. But a putative explanation in terms of dispositions would have the same degree of generality (actually none: they are purely existential statements with no generality at all) in the premises as in the factual conclusion. Hence they are not, in any accepted sense of the term, explanations at all.

Suppose that person A acts reliably as though he disliked person B. Yet when queried, A vigorously denies, apparently quite sincerely, that he or she does indeed dislike B. What does, say, the psychodynamic account (which is dispositional) have to say about this? It is "explained" that A unconsciously dislikes B. Presumably the psychodynamic account claims that A's behavior toward B is not the result of some accidental factors, independent of A's real feelings and attitudes, but depends instead upon some intrinsic property K within person A:

> A has some intrinsic property such that any person with the same intrinsic property would probably react similarly in similar circumstances. The intrinsic properties in question may be A's believe that B threatens his professional position, for example. Once such a property is discovered, a genuine causal explanation is at hand, but the words "unconscious disposition" will have disappeared.… The (dispositional) word "unconscious" cannot appear in any genuine causal explanation whether rigorously deterministic or probabilistic, whether in terms of the postulates of a rigorous theory of human behavior or, more modestly, in terms of pragmatically reliable empirical generalizations, because it's function is only to *mark*, not to *solve*, a problem of explanation (Pap 1959, pp. 287-88).

Disposition statements thus *bunch facts together* by showing that particular behaviors are all instances of the *same kind* of behavior, just the way a banana attached to a common stalk is one of a bunch of bananas. Disposition statements serve the same function as what psychologists MacCorquodale and Meehl (1948) described as purely intervening variables: they are nothing more, nothing less, than shorthand abbreviations or data summaries. If we ask, are intervening variables observational or theoretical terms (as that dichotomy is construed in the philosophy of science), it is clear that they are the former and not the latter. They have no meaning that is *independent* of the particular observations that constitute their definitional basis. Thus to say that they could function as causes of behavior, as the early behaviorist E. C. Tolman (1935) did in introducing them into psychology, is false. A data summary cannot be a cause. Only hypothetical constructs, those concepts containing genuine theoretical content beyond the data they summarize, could function in explanations in psychology (or any other field).

Dispositional analysis and the problem of productivity. The argument thus far is variations on the theme that dispositional analysis is incomplete in the sense that it invariably leads beyond its own level of analysis, and that a disposition is insufficient to provide a causal explanation of its own chosen domain. Now we must indicate how it is inherently incomplete in a further sense: there are indefinitely extended areas (within its own chosen domain) to which no dispositional analysis can speak. Thus for Hayek, the human higher mental processes—as well as the functioning of the CNS—could never be explained by a purely dispositional account. Either a dispositional account cannot encompass vast domains of "dispositions to respond" or it must attribute to the finite human brain (and central nervous system) a literally infinite number of dispositions with no principled account of how that could occur. This argument replaces Popper's incorrect argument about novelty or productivity overviewed in section II.

This argument was made by linguist Noam Chomsky (1957, 1959, 1965) and his followers against stimulus-response accounts of language. It can be generalized to any account of psychological function. Since it is usually presented in terms of language and the concept of competence, we shall follow that presentation here. Neo-behavioristic psychology construed language, first, as the expression of a disposition to respond verbally (in certain absolutely unspecified stimulus conditions). The idea was that a speaker's *knowledge* of language was constituted by his or her being *disposed to respond verbally* to stimulation provided by, for example, the "verbal community" (Skinner 1957). Specific behavioristic accounts differed with regard to the unit of analysis (the sentence, phrase, word, etc.), the extent to which "mediation processes" were to be a factor, the nature of the mediation involved, etc. But all behavioristic formulations treated the problem of language, whether perceived as that of comprehension, or merely ascertaining the controlling conditions governing verbal behavior, in terms of learned dispositions to respond. Learning theory principles were taken to be necessary and sufficient for the explanation of language and the entire realm of higher mental processes or behaviors.

Chomsky destroyed all these accounts by pointing to an empirical phenomenon that could not be addressed by any behavioristic or learning theoretic account. The empirical phenomenon Chomsky pointed out, which renders dispositional analysis untenable, is that of the productivity or creativity of behavior. Speakers can produce, and hearers can understand, absolutely novel utterances—that is, utterances that need not have ever occurred at any other time (whether in our past, present or future) in the history of the human species. Such utterances show that the speaker-hearer has knowledge of language far in excess of any possible prior learning history, and indeed, in excess of any past experience of any sort. The number of sentences in any natural language is indefinitely large: there is no last number N such that N +1 exceeds the number of grammatical and acceptable, (i.e., meaningful) sentences in a natural language. There is thus at least a denumerably infinite set of sentences in (most) natural languages, and any speaker-hearer may produce or understand any one of them at any time. Language (and *ipso facto*, cognition) is productive. That phenomenon requires that an explanatory account must go beyond (or behind) the surface phenomena of language. It requires deep conceptual structures that are causally productive of (potentially infinite numbers of) surface strings.

One should note that this line of reasoning is analogous to Popper's claim that since there is genuine novelty in the growth of knowledge, that no account based upon prior knowledge (determinism) can explain how it arose. But the crucial difference is that Chomsky was able to provide a mechanism, in terms of a theory of the nature and rules of a grammar having certain properties and requiring powerful mathematical procedures, which could explain how this occurs. In contrast, while Popper recognized the phenomenon, he had no explanatory account other than an appeal to the fact of indeterminism.

No analysis that pictures language behavior as a matter of dispositions to utter sentences can deal with an infinitude of sentences that are within a speaker-hearer's competence unless one is willing to postulate an infinite number of dispositions in the CNS. Dispositional analyses must ignore indefinitely extended areas of the domain of the higher mental processes. As Chomsky (1966, p. 12) noted, there is no sense of habit, or any similar dispositional concept, able to address the problems posed by creativity:

> There is no sense of "habit" known to psychology in which this characterization of language use (as a matter of grammatical "habit") is true (just as there is no notion of "generalization" known to psychology or philosophy that entitles us to characterize new sentences of ordinary linguistic usage as generalizations of a previous performance). The familiarity of the reference to normal language use as a matter of "habit" or as based upon "generalization" in some fundamental way must not blind one to the realization that these characterizations are simply untrue if terms are used in a technical or well-defined sense, and that they can be accepted only as metaphors—highly mis-

> leading metaphors, since they tend to lull the linguist into the entirely erroneous belief that the problem of accounting for the creative aspect of normal language use is not after all a very serious one.

The problem is that dispositional analysis deals with observed or observable phenomena *at the surface structure level* of analysis, and must in so doing make finite use of finite means. But the speaker-hearer is *competent to produce and comprehend* novel but appropriate utterances; therefore an adequate theory of language must use principles of explanation sufficiently powerful to explain this competence. No dispositional analysis of cognition can do this without admitting an indefinitely large number of dispositions to respond, which is a manifest absurdity. The only type of theoretical analysis that can make infinite use of finite means, and is thus capable, at least in principle, of explaining creativity, contradicts precisely those features of dispositional analyses upon which we have concentrated. Such accounts must be abstract and deep, conceptual rather than observational, causal and structural rather than purely functional, and above all explanatory rather than descriptive. The only explanation for creativity or productivity utilizes the same sort of abstract theoretical terms that specify structural relationships holding at a deep or abstract structural level of analysis that is causally responsible for surface structure appearances. Such explanations must require the surface-deep structure distinction. Surface structure analysis alone can never address complex phenomena such as productivity.

For reasons such as these Hayek's attempt to use dispositions in an explanatory account of central nervous system functioning can never succeed. Neither psychology (in the explanation of cognition in the CNS) nor economics (in the explanation of human economic action) nor any other social domain can possibly succeed with a purely dispositional account.

We must now step back to indicate what an actual explanatory account of Hayek's earlier terminology of mapping or modeling, in terms of deep conceptual structures which can disambiguate, and thus explain, an otherwise incomprehensible welter of surface structure "dispositions to respond" could actually look like. We shall see that talking about dispositions to respond at the level of neural functioning is at best a prescientific collating of data to be explained by a genuinely theoretical and causal account employing very different levels of analysis to become available at some later time.

IV: THERE MUST BE A DUALITY OF DESCRIPTIONS IN SCIENCE

Despite dutiful citation to theoretical biologist Ludwig Bertalanffy, Hayek did not really take anything of substance from general systems theory. As he indicated in our discussions, what Bertalanffy provided was an extension of an approach that at the time was called organismic biology, in which organisms were seen as systems (so that any life was a dynamic, living system, and not a static entity). Hayek had already come to that conclusion with respect to the activity of the nervous system in his first work in psychology, the unpublished *Beitrage* of 1920. And in his extension of the "Austrian approach" from economics to the entire social realm he had conceived of the market order as the same sort of spontaneously ordering, or mutually adjusting and coordinating, continuously evolving structure. When I asked him about the influences on his psychological work, he said that what he had taken from Bertalanffy was just the general idea of the system as an abstract framework, and a definite comfort that someone else felt that it could be applied to a wide range of phenomena. He was emphatic that the closest thinker to his position that he had encountered was John von Neumann. What Hayek had taken from von Neumann (as in 1951) when he had finished TSO was von Neumann's theory of complexity, published posthumously in *The Theory of Self Reproducing Automata* (1966). What von Neumann conjectured (and indeed had a rough and ready informal proof for) was that when a system reached a certain degree of high complication (complexity) the simplest possible model or representation of that system was the system itself. His example is the human visual system, and the argument was that one could not conceptually or practically "build" an exhaustive model, one that completely duplicated its characteristics, that would be anything less complex than the entire visual system itself. Thus there would be no hope of explaining it in the traditional sense of modeling its full particularity with something simpler and easier to comprehend. Understanding of such a complex system—one of high complication in von Neumann's terminology—in its totality would require a system that was more complicated than it was. Conversely, the only possibility of understanding it in terms of a simplifying model would be to employ what Hayek was beginning to call "explanation of the principle" rather than the traditional exhaustive attempt to provide "explanation of the particular." Understanding its full particularity would require a system that was more complicated, of a higher order of complexity, than the system itself. Hayek took his independently discovered version of von Neumann's conjecture (as I earlier called it, see Weimer 1987) and applied it to explanation in psychology (in articles such as The Primacy of the Abstract) and into the study of the market and social orders (as in *Law, Legislation and Liberty*), and then into the limitations upon interventionist programs in economic and political theory.

But there is another insight of von Neumann's, developed in sketchy notes and only published well after his death (by Burks in 1966), that is of crucial relevance. Von Neumann was the first theorist to comprehend the necessity of *complementarity* in scientific explanation. Initially a somewhat confused idea proposed in quantum physics by Niels Bohr (1934) to maintain an epistemic separation between quantum phenomena and the molar or classical level of description in scientific discourse about the quantum level, von Neumann saw it was also an epistemological *necessity* to have a duality of descriptions for all phenomena—especially those involving life or living systems. Hayek had intuited this in "Within Systems" when he said in paragraph 1 "to such a system (the human mind) the world must necessarily appear not as one but as two distinct realms which cannot be fully "reduced" to each other." Here Hayek was talking about a *subject* of conceptual activity "looking out" upon an *object*, the "external" world that begins outside of its own central nervous system and thus included the rest of its own body and whatever environment is external to it. Unfortunately this point was not developed or discussed further, nor was it understood as something that applied from the origin of life on up to the genesis of the human mind. In fairness to Hayek, he could not have known of work that von Neumann kept to himself at Princeton's Institute for Advanced Studies. Indeed, development of von Neumann's insight is primarily the work of other physicists, such as Howard Pattee (2012), in elaborating what Pattee called the "epistemic cut" involved in the symbol-matter divide as a necessary epistemic dualism. Pattee's question, directed that the origin of life, can be summed up as "How does a molecule become a message?" At issue is when does semiosis arise, and what conditions are necessary for its manifestation? Semiosis has to do with the nature and manifestation of meaning, and the semiotic domain is constituted by the areas of syntax, semantics, and pragmatics.

Questions about semiotics are seemingly sufficiently far afield that we must provide considerable background and context for their applicability to the problems Hayek tried to solve. We need to overview in some depth some inescapable epistemological dualisms in order to do that.

Subject and object. Human knowledge always entails a distinction between an observer as subject of conceptual activity, and that which is observed. It is *we* who have or *create* knowledge. The basic idea of complementarity is epistemic—the inescapability, literally the logical and conceptual incompatibility, of different modes of description in our cognition that we must employ in every knowledge gathering task. At least five modes of this duality of incompatibles are of paramount importance: (1) is this distinction of subject versus object in the epistemic predicament; (2) is the distinction of sign (or symbol) versus matter; (3) is that of rate-dependent versus rate-independent; (4) is the contrast of structure versus function; and (5) is the semantic versus syntactic distinction. These inescapable dualisms help us see why Hayek said "the world must necessarily appear not as one but as two distinct realms" to us. Then we must take things farther than he was able to do in order to begin to explain functionality. We begin this by mentioning what is involved in an indispensable distinction in our "hard" science since the time of Galileo.

Boundary and initial conditions versus laws of nature. Consider that paragon exemplar of science, physics. Galileo was the first to note that physics *requires* us to make a sharp separation between the observer and that which is observed. The observer is formally related to the observed system only by the results of measurement—measurements of the observables defined by the theory—while the formulation of the theory itself and the very choice of observables, as well as the construction of the measuring devices utilized, and the measurement process itself, *cannot ever be formalized* within that theory. As von Neumann said, we must always divide the world into two parts, the one part being the observed system, the other part being the observer. The boundary between the two is arbitrary, determined by pragmatic considerations, but that does not change the fact that the boundary *must be put somewhere*. Our epistemic predicament requires a separation between the inexorable laws of physics, on the one hand, and, on the other, ourselves and the theories we have formulated (as part of the boundary and initial conditions), that must be specified for the application of those laws to be either meaningful in themselves or to be applicable to reality. Pattee[8] called this separation between physical matter and functional symbol the epistemic *cut*. But as he said:

> This is simply another statement of Newton's categorical separation of laws and initial conditions. Why is this fundamental in physics?… The laws are universal and do not depend on the state of the observer (symmetry principles) while the initial conditions apply to the state of a particular system and the state of the observer that measures them. What does calling the matter-symbol problem "epistemological" do for us? Epistemology by its very meaning presupposes a separation of the world into the knower and the known or the controller and controlled. That is, if we can speak of knowledge *about* something,: then the knowledge representation, the knowledge vehicle, cannot be in the same category of what it is about (Pattee 2012, pp. 278-79).

Physics has had to make this separation in terms of the distinction between the seemingly inexorable laws of nature that apply every-where and every-when, and the nonregular or non-law governed specification of initial conditions and boundary conditions. Physical laws are meaningless and inapplicable unless we, as subjects of conceptual activity, make *choices* about what to measure and how to set up experiments. Newton was the first to make a sharp separation between the variable and non-lawful boundary conditions (referring to the "accidental" situation in which experiments occur) and initial conditions (referring to the choices made by experimenters), all on one hand, and the theoretical "laws of nature" on the other. Physicist John Stewart Bell (1985) called this the "shifty split" with respect to the problems of measurement in quantum physics, emphasizing the fact that where the experimenter chooses to put the distinction between the observer and the observed is crucial to the interpretation of what quantum phenomena actually are about and what our experimentation can disclose.

In 1968 Michael Polanyi was the first to emphasize the role of boundary conditions as *harnessing the laws of nature* when we observe and do an "experiment" upon nature. A boundary condition is always *extraneous* to the process which it delimits and harnesses:

> A boundary condition is always extraneous to the process which it delimits. In Galileo's experiments on balls rolling down a slope, the angle of the slope was not derived from the laws of mechanics, but was chosen by Galileo. And as this choice of slopes was extraneous to the laws of mechanics, so are the shape and manufacturer of test tubes extraneous to the laws of chemistry. The same thing holds for machine-like boundaries; their structure cannot be defined in terms of the laws which they harness. Nor can a vocabulary determine the context of a text, and so on (Polanyi 1969, p. 227).

8 Hayek and Pattee met when both participated in a conference in 1977 which David Palermo and I organized at Penn State. Unfortunately, neither took much notice of the other, perhaps because of working on different problems at that time.

Here Polanyi emphasized that this places a system under *dual control*: it relies on the operations of its higher principles to constrain the working of the lower-level (such as the laws of physics and chemistry). The higher principles are *additional to the laws of nature*, and can never be reduced to them.[9] All such systems must exhibit dual control, which is made possible by the fact that the principles governing the lower or physical level (the laws of nature) leave totally indeterminate or undeterminable the range of conditions which are to be controlled by the higher order principle. As Polanyi said: "you cannot derive a vocabulary from phonetics; you cannot derive a grammar from a vocabulary; a correct use of grammar does not account for good style; and a good style does not supply the content of a piece of prose (Polanyi 1969, p. 233)." We shall discuss this further in terms of the phenomenon of downward causation in evolution in other sections.

Subjects are not objects. Physical theory requires that an observer—a cognizing subject—make a decision. This active choice upon the part of the scientist determines the initial conditions (and thus an initial or starting point state description) for an ensemble, and constrains what the "experimental results" can be. Boundary conditions are not choices on the part of the subject. They are rather constraints that are the result of our seemingly "chance" location in the space-time manifold, and the unique set of particulars that happen to be there. Boundary conditions do not depend on conscious cognition—they are imposed upon us or imposed upon non-cognitive events by "accident" of the local state of the universe. Boundary conditions are frozen accidents in the unfolding of the universe. For example, the origin of our solar system depended upon the unique boundary constraints found here at our local star and the inexorable "laws of nature" exhibited through its evolved development. The origin of life depends upon the context of constraint in which self-replication of cellular structures evolved. So what we (incorrectly) choose to call "chance", instead of choice, determines the information structure in the biological realm. When we get to the cognitive realm happenstance (a far better term than "chance") is an ever-present background phenomenon, but *choice* is the prime suspect that we focus upon. Information becomes meaningful to us when alternatives must be distinguished. If things *could have been otherwise* a choice must be made to distinguish what path to take. If things could not have been otherwise (there is thus no possibility of choice) a boundary constraint (and inexorability) is present. Information became meaningful to the organism involved when choice first appeared. Initial conditions are always *chosen for some functional purpose* by a researcher. Such informational constraints are functional, not just physical boundaries.

The lowest level of neural functioning that must involve choice and thus be meaningful to the organism (in organisms with central nervous systems) is the orienting response to novelty. The orienting response is the point at which the CNS first makes a choice (see Sokolov 1960; Lynn 1966). It is the transition point from control by basic biological boundary conditions and apparent "chance" constraint to choice and the presence of agency—and in physical theory, it leads to the beginning of the separation of boundary conditions on one hand, from initial conditions on the other. The orienting response begins the informational context of constraint in which all higher cognition is embedded. Below this level (if there is anything below this level in living chordate systems) there would be only "chance" or random neural activity. The orienting response occurs when an input pattern of neural functioning is recognized as dissimilar from the ongoing pattern of background activity. This separates the novel from the ongoing level (background)—something new from what is expected and ongoing. This is the very beginning of choice: the nervous system has to choose whether or not this pattern of activity is different from or the same as what had been going on. That choice is functional, and as such, is the point at which meaning originates. This is why one can alternatively speak of the fundamental activity of the nervous system as either classifying or choosing or

9 Exactly this point was emphasized by D. T. Campbell (1974a) in his discussion of the "backward" causation of the fishscale model of natural selection. He emphasized that the higher order levels constrain the lower (physical) levels while not violating any natural laws, which constrain or determine the "lower" level physical movement. See end note 2.

making meaning. All these functions arise in the same activity. All are inherently functional notions that, while dependent upon a physical substrate, can never be reduced to it. The semiotic dimension is characteristic of all knowledge: all knowledge requires the presence of semantics (functionality, formality, intentionality, teleology, purpose, however one formulates it) to come into existence. The physical realm alone can never constitute knowledge or produce any complex structure that has knowledge. Knowledge is simply not a physical concept—it is intrinsically functional or teleological. Knowledge exists only in and for subjects. Knowledge arises only in the context of constraint in which life comes into existence. In a purely physical universe with no life or meaning there could be no knowledge—no subject would stand apart from that which was to be known, no semiotics could constrain physicality, no functionality could disambiguate syntactic movement, no regularity of any sort would be in evidence.

Are there objects in the universe? Common sense and science think the answer is yes, and we have developed elaborate processes of inquiry to study their purported properties. But the existence of objects presupposes—logically and conceptually entails—that there are subjects (at least one). The universe "out there" has neither subjects nor objects: it just "is." Whenever an object comes into existence it is always and inevitably within the conception of some sapient subject-of-conceptual-activity. The famous measurement problem of physics is simply an example of this. The epistemic judgment that an object exists or is in a certain state is the ascription by a subject of a meaning to an aspect of the phenomenal flux in which that subject is immersed. Thus subjects and objects come into existence *together*, with neither temporal nor conceptual priority assignable to either. Subjects cannot stand outside the objective order—they are part and parcel of its creation. As creators of that order they are inextricably linked into it. Subject and object are prior to all cognition, and prior to all judgmental attribution. Thus we can never ascertain what they are independently of each other. Study of the object presupposes a studying subject. Study of the subject requires objectifying him or her. Thus subjects and objects, even though they arise in unison in conceptual thought, are inherently ambiguous and underdetermined in both sense and reference.

The problems of epistemology begin with the beginning of life. Life, meaning, and the fundamental dualism of subject and object are co-occurrent emergent properties in the universe. The seemingly rarefied issues of modern philosophy (as in so-called advanced physics) have actually been present on this planet since life originated. When life began, so did subjects and objects and choices and measures and meanings—these dualisms, in their most primitive forms, emerged together as co-occurrent relationships with the origin of life.

Life depends on *records* being kept. Keeping a record requires the subject-object distinction in order for the record to be meaningful—it is an agent of some form that is required to be capable of keeping records. The records, once made, become objects, which in turn have functional (as opposed to merely physical) significance for the organism. What physical events (what we usually call matter) could keep records (symbols) when life arose? The best answer we presently have is folding. The folding transformation, in which molecular strings are folded back upon themselves, shows the first and most primitive form of record-keeping structures. Genetic symbols are not related to their physical referent processes by any formal or explicit manner, but only by the action of "laws of nature" and physical structures which needed no instructions from outside in order to occur. In contrast, conceptual symbols are rate-independent (outside of time or "timeless"), while their referents in physical space-time are rate-dependent (and nonreversible). Symbol and matter are on different sides of the rate-independent versus rate-dependent divide.

Meaning began in mensuration (and record-keeping). The first records, the strings that were folded, were measurements. Measurements can never be physically specified. They can arise only when a *functional specification*—a choice—determines that the measurement has occurred. Measurements are exactly like facts: impossible to specify in the absence of a prior conceptual framework that denotes what is a fact instead of a mere noise in the flux. Measures are functional creations, choices on the part of some self, some agency, that reflect what are ultimately semantic constraints imposed upon an ensemble of events in the space-time manifold. Is Schrödinger's cat, the classic instance of the measurement problem in physics, dead or alive? You cannot ever know without asking a subject (a self or agent). Some agency must make a measurement (such as looking) to say one way or the other.

What measurement does, how it functions in our conception, is to map indefinitely extended complex patterns (what we can neutrally call input information) into very delimited (simple in comparison, never as complex) outputs. At the most useful limit this mapping provides many-to-one mapping. As Pattee (2012, p. 183) put it, "This property of mapping complex input patterns to simple output actions [is what] distinguishes useful measurement functions from merely complex physical constraints. Without this complex-to-simple or many-to-one mapping process we would not be able to identify equivalence classes of events … *This classification property of measurement is an epistemological necessity*. Without classification knowledge of events could not be distinguished from the events themselves."

As Hayek noted in TSO, the entire nervous apparatus of complex organisms has evolved in order to fulfill the function of quickly and efficiently mapping the infinite welter of potential inputs into a very small number (by comparison) of outputs. This essential property of measurement (which is to say, meaning creation) is to reduce the complexity of input by means of internal constraints (cognitive processing) that allow a relatively small number of functionally specified outputs. This is the framework in which the nervous system is fundamentally an instrument of classification according to functional constraints common to the species in question. From this follows automatically the fundamental thesis of evolutionary epistemology, that the CNS of chordate organisms functions as a theory of its environment (Weimer 1973) that builds models via thought (Craik 1943) of the structural properties of the external environment (Russell 1948, Maxwell 1972). All of this arises from the most fundamental activity of neural systems—the response to novelty, or the orienting response, which is literally the fundamental act of classification and the beginning of meaning.

Rate-independence versus rate-dependence. The laws of nature apply to all *possible* systems, while measurement gives information only about a *particular* system *chosen* by a subject. The laws of nature are rate dependent equations that are reversible (they are always symmetrical in their time description). Thus in principle any physical process that is lawlike could be reversed. Measurements have no time—once made, they are rate-independent and exist, fixed and frozen, forever. They can never be reversible because they have been fixed and determined by definition of the operations producing them.

> The problem is that our description of laws requires the concept of rate-dependence, reversibility (time symmetry), continuity, and causality (determinism or the inexorable flow of events); whereas our description of measurements requires the concepts of rate-independence, irreversibility, discrete events, and acausality (natural selection or, at the highest cognitive levels, selection by free will). In other words, in order to predict or control event successfully, the brain of the physicist has been led to partition the world into *formally contradictory* languages. It is from the apparent inescapability of the situation that the principle of complementarity became acceptable, even though its application still produces a profound cognitive descendent (Pattee 1982, pp. 23-24).

It is only in our fixed-for-ever theoretical specifications, in which meaning (independent of time) fuses disparate things with the connection of necessity, that any determinism exists. In the rate-dependent regularity of actual nature *only statistical regularities* exist. As Popper said, following many others, dynamically speaking, all clocks are clouds in their underlying structure. This rate-dependence versus rate-independence complementarity has been raised in the context of *physical* theory. But it exists *in all theories*: the problems posed by the biology of life, the psychology of the mind, the social theory of complex human interaction.

Records are inherently probabilistic and can never be deterministic or complete. The concept of an infinitely precise (thus absolutely deterministic) measurement is literally a contradiction in terms, analogous to a square circle. This is because any measurement (even just "looking") makes a record of events and can never be the actual events themselves. Any record, no matter how exact, will *at best be* an approximation of the event itself. No record can ever capture all the infinite complexity of an event from all possible perspectives. Any record must inevitably have *error* resulting from its inherent incompleteness. Even if the laws involved are rate-independently "deterministic" there will always be an increasingly propagated error in recording of the initial conditions and any subsequent measurements. Thus any symbolic record, and the experiments based upon them, no matter how carefully made, must inherently be statistical or probabilistic and can never be billiard ball deterministic. Neither the hard sciences nor the soft ones ever were in the past or ever can be in the future strictly deterministic.

In living or biological systems (as well as physics) nothing is explained by natural laws alone. Life requires the concept of an adaptive evolutionary history, which is a record within the organism that, while obeying natural laws, cannot be derived from any natural law. Records are in this sense a special form of constraint that can "instruct" (control) or constrain. This is why Polanyi (1969) spoke of special types of boundary conditions as *harnessing* the laws of nature. This depends on an epistemic record within the organism that is a representation of our description which is distinct from the events that it records. In living systems genes provide historical records of prior adaptive natural selection processes. The record itself (the DNA) is deceptively simple. What is important is that for it to have a function or meaning requires immensely complex coding, reading, and interpreting mechanisms within cellular structures. As with any measurement or control, biological information (which is not the same as Shannon communication theory information) and instruction are not part of any physical theory—they are functional concepts rather than physical. We simply cannot identify a physical molecule as an informational constraint unless we can identify how it is interpreted by the organism (and, of course, how it functions for the organism). This means that the concept of biological information must be totally different (it is functional, not physical) from communication theory information as specified by Shannon and Weaver (1949). Shannon's theory is one of *structural* information, because of its formal relation to the entropy of a physical system. No biological interpretation of information, which is a matter of meaning to an organism, can ever be identified with Shannon information (or for that matter, with entropy). Functional information is provided by meaningful symbols, not by structural bits.

What are symbols? Symbols are activities in time that have been frozen into spatial properties. The mathematician E. L. Post (1965) noted that symbolic record writing involves the selective freezing out of degrees of freedom (as the physicist uses the term) according to rules that are independent of initial conditions. All such rules provide, as Pattee (1971) noted, a classical—either pre-or non-quantum—physical level *non-holonomic* constraint that is inherently statistical and subject to thermodynamic Second Law dissipation. The information that is contained in a record (such as a measurement) can never be integrated into the formalism of a law of nature. Record-keeping is irreversible; once made it is fixed forever, and thus can never be like the (theoretically) reversible laws of nature. Any act of physical record-keeping must be irreversible—otherwise it would not be a record at all—and thus is inherently probabilistic or statistical and subject to error. Records can at best only approximate a rate-independent "no exceptions" law of nature. The record-keeping of the central nervous system, in its incessant classification and reclassification of patterns (and patterns of patterns, etc.) cannot in principle ever be an *exact* copy of what it classifies. The nervous system is a representation that is always fallible and inexact and thus must be separate from, or intrinsically independent of, the "external" realm.[10] This is why the best theories, even the "final" one of some Utopian science, can never be a true or exact match to reality. We are fallible, we are prone to errors, we are finite, and all we can ever hope to do is to eliminate as many errors as possible. That intrinsic fallibility and finite nature is why no measurement or initial condition can ever be integrated into a law of nature. If one attempts to integrate, for instance, a simple initial position measurement operation into a law of nature the function—the meaning—of the measure will disappear entirely, and it will have to be replaced by another measurement, and so on, indefinitely.

Structure versus function. Structural analysis, in common with the formalisms of mathematics and logic, is a denizen of the rate-independent realm, and is like record-keeping—frozen forever once it occurs. Functional specification, by definition abstract and not physically specifiable, is time-dependent, requiring specification of initial conditions such as the here and now so conspicuously absent from physical laws. No functional analysis—for example an intention or a statement of a goal to be achieved—can ever be formulated or be meaningful as an "any where, any when" law of nature like the statistically determinate laws of physics. All semantic constraints, all meanings, which are functional constraints by definition, are not compatible with reduction to rate-dependent equations of (physical) motions. This is at the heart of the insurmountable ambiguity of purely functional specification of psychological (actually, of all pragmatic and semantic) concepts. We cannot reduce function in any unambiguous manner to physically specified movement. In this sense Hayek's program of analysis in "Within Systems" is chimerical, and doomed to failure.

Consider the semantic constraints on physical and biological systems evidenced in classification, measurement, decision-making (by an observer), even such things as catalysis in biology. These functional concepts are not specifiable in solely physical terms. Consider again our old friend measurement: "if we take a functional measuring device and try to incorporate it entirely into the dynamical equations of the system which it is supposed to measure, we find that the measurement itself disappears—we have destroyed the epistemic function of measurement" (Pattee 1978, p. 516). The purpose or function of any measurement is epistemological—to make a record, and to do so without specifying any rate or a time derivative that would appear in the equation itself. Measurement, as Pattee said, is therefore a non-holonomic constraint: measurement cannot ever be integrated into the equation (s) specifying the lawful regularity of the system being measured. They must stand *outside* the system being measured, and must forever so remain or they will no longer be records.

The structural specification of functional concepts in psychology provides an analogous rate-independent specification of inherently rate-dependent dynamical events or processes. The problem with all purely functional (i.e., non-physically defined) concepts in biology, psychology and economics (or any life or social science) is that without a *concurrent* rate independent specification of the underlying structure that realizes or embodies it (for psychology a grammar of behavior, for economics a grammar of economic action, for linguistics a grammar of language, etc.), the rate-dependent functions are ill defined and inherently ambiguous. Functional "explanations" alone (without that concurrent structural analysis) fail to provide sufficient regularity and, in whatever domain is in question, to provide an explanatory account. This is because there can be no principled specification of what counts as "behavior" (see Weimer 1984, pp. 192-196 for details). This is exactly the same problem as attempting to account for the behavior of a physical system while restricting one's account to statements of boundary or initial conditions without including any physi-

10 Hayek was always a representational realist. This is because the CNS patterns of classification can never be the "external" objects themselves. They are representations of external objects. What the external objects intrinsically are is unknown and unknowable, exactly as the Russell (1948) and later Maxwell (1972), and Weimer (1975, 1976) interpretation of structural realism portrays. Structural realism is an *epistemic* position, and has as a consequence an ontological agnosticism, precisely because we can *never know* the intrinsic nature of the non-mental realm. So one can never endorse either "physicalism" or "mentalism" *as an ontological position*.

cal laws. Specification of initial conditions alone is infinitely ambiguous, not determinate, and hence ultimately as useless as it is meaningless. We need structure *and* function.

Thus classic structure versus function distinctions simply miss the point of what is required for explanatory analysis. Their relationship *must* be complementary—both-and—instead of one or the other. This dualism can never be overcome by favoring one over the other. To do so leads to infinite ambiguity and lack of specifiable meaning (if structures are ignored in favor of functions), or it leads to timeless and disembodied structures with no dynamical meaning at all (if function is ignored for structure).

Semantics and syntax. Recall the symbol-matter duality. How do emergent forms of matter lead to life? When does matter become a sign? What is the relationship between matter and symbols? How does a molecule become a message? Symbols are not temporal: they are rate-independent processes that are also independent of initial conditions. How does life translate symbols from rate independence into dynamical processes? Living systems depend on internal rate-independent descriptions, particular *signs*, that are *interpreted* by the system in question to guide the cellular processes. Those dynamics are purely "physical" events, albeit of immense complexity. Somehow those instructions harness that physical realm. To do that they must be abstract and general (which is to say they must be a compressed instruction set) by comparison to what they control (which is a (long!) list of particulars). The problem for understanding the origin of life is to find how the syntax and semantic code of the descriptive language (the gene's control structures) gets related to the dynamical laws of the underlying physico-chemical substrate of cellular processes:

> The possibility of describing function as a dynamical process depends upon the constraints of rate-independent linguistic descriptions of structure. These constraints are of two essential types, there must be syntactical constraints which are relatively time-invariant (e.g. the genetic code) and there must be informational (semantic) constraints that are rate-independent but which can change in time (e.g. the genetic message) (Pattee 1978, p. 515).

So here we have the duality of descriptions in what appears to be its most primitive and fundamental form in the evolution of life on earth: we have to have a syntax to structure semantics. The language of the genetic code exemplifies the symbol-matter divide.

With cognition—human conception—the problem becomes ubiquitous—literally everywhere. On one hand the physical universe has no intrinsic meaning, and on the other, the universe we know is filled with meaning and structural devices that both lay out and attempt to disambiguate that meaning. Meaning is timeless, rate-independent and given in the specious present moment. But equally, meaning is evolving and developing, rate-dependent, and the construction of our patterns of nervous system activity. We cannot understand anything, ourselves or the external order of events, without simultaneously involving *both of* these perspectives. The situation is syntax *and* semantics: it can never be understood as syntax *versus* semantics. There is a complementarity intrinsic to specification of either.[11] But how can it be that way in our construction of theories of ourselves and external reality? How can it be that functionality and meaning is seemingly manifested in both rate-independent and rate-dependent accounts? How can it be in our construction of theories of ourselves and external reality, and also be independent of any particular human activity or cognition? How can it be that meaning is instantaneously available to us and also requires linear syntactic structuring for its representation or presentation?

11 This means the famous generative syntax versus generative semantics controversy current from the mid-1960s up into this century is a misguided waste of time. The creative power of meaning is *realized* through syntactic structuring devices. However, syntax has absolutely nothing to do with meaning *except to provide its means of realization*. Syntax itself is meaningless.

The brief answer is that this is a surface appearance, and no one has any detailed idea as to why this is the case. Perhaps it is only an artifact of perception. This is clearly an epistemic issue, but we cannot legitimately move from epistemology to any ontological speculation. Before leaving the topic consider four additional things that are of importance.

First, *pure syntax is meaningless*. All syntactic systems or structures are nothing more, nothing less, than empty symbol manipulation systems. Symbol manipulation systems that are internally consistent have valid derivations, while those that are inconsistent have no valid derivations, because anything and everything can "follow from" inconsistent premises. The concept of *validity* is a purely syntactic notion—it has nothing to do with anything except how well-formed a symbol formula is, and whether it exhibits the possibility of correct derivability. Validity is far less important in the actual world than the concept of truth. Truth does not apply to correct syntactic derivations at all—only validity applies. Predication of truth applies only to propositions, which have semantic content as well as syntactic structure. If an empty symbol manipulation system is given semantic content—say by a theory that attaches it to some empirical domain—then a valid derivation from the system would also be a proposition. The (rate-independent) concept of knowledge applies only to propositions, and does not have any determinate relationship to syntactic structuring systems per se. The syntax (assuming symbols are used consistently and correctly—i.e., according to the rules of derivation of the system in question) provides correct or valid symbol *manipulations*, but not in itself meaningful or truthful *propositions*. Propositions require both syntactic structuring *and* semantics supplied by a theory. One can have a perfectly true proposition that was "derived" from an inconsistent or even a false theory. Note in this regard that philosophers have interpreted the relationship between truth and validity in backwards fashion. They have put validity, as a property of that "wonderful" domain of logic, on a pedestal (as did Popper, discussing validity as a definitive property of the argumentative function of language) in comparison to truth. This is completely backwards—truth, which requires both syntax and semantics for its ascertainment, is far more complex, and far more important in our theories and understanding than "mere" validity. Only empty of content logic or mathematics requires validity of derivation. We, as sloppy and "invalid" humans, fortunately do not.

Second, syntax eventuates into linear strings of symbols largely because of thermodynamic considerations. We speak and write, and thus do the majority of hearing and "thinking," in linear strings—sequential words in one or another natural language. This allows ambiguity in the surface structure that could possibly be avoided if we would just communicate and think in the underlying deep conceptual structures. Why can't we just skip the surface structure linearity and communicate in Bronowski's "cloudlike" deep conceptual structures? Why are we so one dimensional in this regard?

Thermodynamic considerations constrain the basic physical requirement necessary for a symbolic system to exist. Symbol use must be *free* in the crucial sense that symbols *must be underdetermined* by physical laws or any physical constraints. This underdetermination requires energy degeneracy, which means that the thermodynamic "cost" or the energy expended in creating symbols, as well as the energy differences between any particular symbols, is very low or virtually non-existent. Indeed, when we talk we take advantage of something that is already there—the fact that we must exhale from our lungs in order to prepare for the next inspiration. Speaking is usually always on exhaling. Exhalation takes no muscle effort—it is the relaxation of the effort just expended for inspiration. Most of the physiological-thermodynamic cost has already been paid—we have to breathe anyway, and speaking is all but free is a consequence.[12] Silent thought requires less energy still, and the residual basic cost is in the functioning of our brain, which has already been paid for by its increased survival value from producing superior cognitive power. (This increases our overall metabolic demand—need for better nutrition—but in so doing allows thought to be nearly "free" otherwise.) These factors allow a practically endless number of symbol strings (surface structure sentences) to come into existence that are *unconstrained by physical laws*. So linear strings, as one-dimensional entities (essentially: they have length only, as we can neglect their width or depth) are about as cost-effective

12 See Fitch (2010) for further discussion of this point.

and efficient as we can get. Utilization of higher dimensional entities instead of strings (such as whatever goes on in the clouds of neural activity in our brains) would require greater energy costs to communicate and a physical substratum far more complicated than our present language system requires. What goes on in the brain is, as I have repeatedly emphasized, cloudlike and statistical even though the final output in behavior appears to be a deterministic, linear string. Consciousness, not dependent upon that final motor output of speech, mainly employs linear strings, but our brain *is not restricted* to them. Our amorphous "feelings," apprehensions, pre or unverbalized hopes and fears, premonitions, and the myriad tacit and other "vague" notions of ANS and enteric functioning seem to involve global and diffuse—multilayered and multidimensional—levels of processing either instead of or in addition to linear strings of symbols. This is why the linguistic formulations that we use for these tacit, deep structural processes appear to be so "vague" and "unformulated" (as the Freudian and other "depth" psychologists have long known) to the mathematics-über-alles mentality of the computer programmer or AI theorist, who wants to "clean them up" by lowering them into the form of linear strings. Third, there is minimal utility in trying to model human or animal cognition in terms of the symbol manipulation systems model employed by the computer-based modeling and artificial intelligence approaches that are presently available. Those theorists assume that what is important is to understand the "computer programming" that could represent intelligence and behavior, and that how it is realized in any physical form is either irrelevant or of much lesser importance. They are concerned only with the programs that constitute life and cognition, and could care less about the hardware that is required to realize it. Against this approach is one stemming from the realization that biology cannot be reduced to computational procedures since it is always embodied or represented in biophysical structures ((wetware and not "hard"ware as Pribram (1971, 1977, 1995) constantly emphasized)). Biological constraints determine how neural processing "programs" actually occur. Theorists in this camp resonate to "embodied mind" or neural network or "connectionistic" accounts to try to comprehend the incredible amounts of distributed "information" processing going on in actual living brains-as-physical-entities constrained by the Second Law of thermodynamics and the boundary conditions of life on earth. This is an enormous and crucial difference between these two camps, and Hayek and I are clearly in the "embodied" camp.

Fourth, *thought and experience are fundamentally different*. Concepts that embody meaning are generative rules of determination. They can provide an indefinitely extended domain of particular instantiations, none of which is absolutely necessary or definitive in order to specify the meaning in question. Since Kant, we have known that the concept is a representative *function* contained in an indefinitely extended domain of possible instances. Concepts are abstract rules of determination—they map a given deep structural content (meaning) onto potentially infinite surface (physical) instantiations. Hence the model for concepts and their formation is analogous to Chomsky's model for generative grammar. *All concepts*, even those most intensely subjective and private, are objective: their application in embodied concepts is a process of objectification, a distantiation from any uniquely given particulars in the flux of experience. In order to be meaningful, thought must step back from what is presented or given in awareness. *Thought exists in opposition to momentary experience*. The purely subjective, to the extent that it is expressible at all, becomes objective in thought. The residue (if any) of intrinsic subjectivity and "experience" *plays no role whatever* in our knowledge or in any meanings we entertain. As Hayek noted, that residue does not fit into any pattern of neural activity we possess. Cognition creates our world by structuring and restructuring patterns of meaning which can never be identified exhaustively with any of the processes underlying it. Thought is apart from acquaintance and *gives it its meaning* in that distancing from it. In this cloudlike process, syntax and semantics become an ultimate complementarity in the human existential predicament.

NOTES

1 Since all of history is not (and can never be) recorded in written correspondence, some "personal recollections" are in order. At a conference in the early 80s Hayek and I discussed what had happened to what was to have been his intellectual biography, then moribund, but long promised to be undertaken by a young Indian economist. Hayek asked me if I would undertake the task instead. Quite reluctantly, I declined, for two reasons: my ability to translate his German (and the correspondence of others) into idiomatic English was nonexistent. Also, I knew that I would have no time to devote to such an enormous task. I suggested to Hayek that we ask Bill Bartley, who had been in undergraduate honors major in languages at Harvard, and who spoke six languages (including German) fluently, to undertake the task instead. With some persuading Bartley agreed. In Bartley's mind the biographical task morphed into what was to be his magnum opus—an elaborate discussion and critique of the dominant intellectual trends in the 20th century. He proposed to do this by contrasting the positions of, in the social realm, the clashes between Hayek and Keynes, and in the philosophical domain the clashes between Popper and the hated enemy, Wittgenstein. In the 80s this led Bill, often with the help of Gerard Radnitzky, to organize sessions in several conferences centering on Hayek's views in one form or another, as well as on Don Campbell's approach to evolutionary epistemology, as an organizing theme for the lifelong work of both Popper and Hayek. Because of cancer Bartley did not finish any of this grand project. The closest he came was in persuading the University of Chicago press to undertake the re-issue of the "collected works" volumes (with editorial commentary), rewriting large portions of *The Fatal Conceit* to reflect the Campbellian-Popperian evolutionary epistemology framework, and finally, in his last (posthumous) book, the very uneven *Unfathomed Knowledge, Unmeasured Wealth* (1990). I was originally to be responsible for republication of the "psychological writings" in that edited series. Bill and I had a falling out over this, as I wanted to include a comprehensive representation of Hayek's psychological writings—not just TSO and the unpublished material included by Vanberg. Disciplinary boundaries being what they are, this did not sit well with Bartley's overall plan or with some of the editors of particular volumes, who could not see any psychological relevance to, for example, the essay "The Primacy of the Abstract." At this point, having left academia and overwhelmed by other tasks, I dropped out, and saw Hayek only at conferences, usually after dinner, while he slowly consumed a half bottle of scotch in order to dull the pain that crept up on him at the end of the day. In that setting we usually discussed topics centering around the issues of complexity and what I have called, emphasizing the meta-theoretical implications of his position, "rationalist constructivism" (and which he had initially called constructivist rationalism). Interspersed in that milieu were brief discussions of the development of TSO from the early unpublished papers, and his desire to finish the paper on communication, meaning the second half of the paper "Within Systems and About Systems." My understanding of his dissatisfaction with the paper was that it centered on two factors—politely but firmly responding to Popper, which he was very reluctant to do because of long friendship, and elaborating how an abstract system of teleological behaviors—such as the hunting example—could actually eventuate into the specific responses of particular individuals. Having written the substance of the "dispositional analysis" section in this volume over that time, I questioned how that approach could succeed. Hayek saw no alternative to the disposition the concept, as a shorthand, that did not make the problems even more intractable.

2 The problem of "backward" causation can be addressed by two approaches. First, by employing a surface-deep analysis (requiring hierarchical, or even more complex, structuring) in which higher order "causal nodes" eventuate into lower-level, and finally surface structure linear strings. Such an analysis occurs in the timeless or rate-independent realm of conception, and is in itself independent of dynamical constraints. A second, rate-dependent way it can be addressed is by the concept of *downward causation* as introduced into biology by Campbell (1974a, 1974b) especially in "'Downward Causation 'in Hierarchically Organized Biological Systems.'" Campbell's position adds to three positions that are accepted as "facts of life" in present-day biology. First, any and all higher levels are constrained to act in terms of the laws of the lower levels down to those of sub-atomic physics. Second, the teleological achievements at higher levels require for their explanation a full account of their implementation by specific lower-level mechanisms and processes. Third, "laws" of biological evolution are emer-

gent with respect to the laws that are sufficient for physics and inorganic chemistry. To this Campbell added a fourth position: downward causation. And he specifically noted that this type of "causation" can be considered downward only if substantial extents of time, covering several reproductive generations, are included as one unit or "instant" for the purpose of conceptual analysis. This is an aspect of the fact that organisms are the product of *group selection over generations* rather than individual "mutation" or individual behavior. As an example he discussed the jaws of a worker termite or ant:

> We need the laws of levers, and *organism-level selection* (the reductionist's translation for "organismic purpose"), to explain the particular distribution of protein found in the jaw and hence the DNA templates guiding their production … Even the *hence* of the previous sentence implies a reverse-directional "cause" in that, by natural selection, it is protein efficacy that determines which DNA templates are present, even though the immediate micro-determination is from DNA to protein … If we now consider the jaw of a soldier termite or ant, a still more striking case of emergence and downward causation is encountered. In many of the highly dimorphic or polymorphic species, the soldier jaws are so specialized for piercing enemy ants and termites, huge multipronged antler-pincers, that the soldier cannot feed itself and has to be fed by workers. The soldier's jaws and the distribution of protein therein (and the particular ribonucleic acid chains that provide the templates for the proteins) require for their explanation certain laws of sociology centering around division-of-labour social organization (Campbell 1974a, p. 181).

To reemphasize, this has consequences for both biological selection and the problem of explanation:

> For biological systems produced by natural selection, where there is a node of selection at a higher level, the higher-level laws are necessary for complete specification of phenomena both at that higher-level and also for lower levels. Scientific description is still incomplete when all the details of points 1 and 2 are solved (Campbell 1974a, p. 182).

(Point 1 refers to lawful constraints of the lower levels, point 2 refers to higher-level implementation by specific lower mechanisms.)

The import of this is straightforward:

> Questions about the function of a process at one level are questions about a selective system at some higher-level. For complete scientific description of the distribution of restrictions in biological systems we need additional laws, restraints imposed by the selective system of the highest level of selection and affecting distributions at all lower-level levels (ibid.).

This conception of higher-level constraint is discussed later, in the problem of disambiguating surface structure linear strings by looking back over their history of derivation from the deep conceptual structures at "higher" levels of analysis. Hayek's account fails because it makes no explicit provision for the higher order constraints to act upon the "lower" or physical domain underlying action.

REFERENCES

Aune, B. 1967. *Knowledge, Mind, and Nature*. New York: Random House.
Bartley, W. W. III. 1971. *Morality and Religion*. London: Macmillan and Company.
________. 1984. *The Retreat to Commitment*. La Salle: Open Court.
________. 1990. *Unfathomed Knowledge, Unmeasured Wealth*. La Salle: Open Court.
Blanshard, B. 1973. *Reason & Analysis*. La Salle: Open Court.
Bohm, D. 1965. *The Special Theory of Relativity*. New York: W. A. Benjamin, Inc.
Bohr, N. 1934. *Atomic Theory and the Description of Nature*. Cambridge: Cambridge University Press.
Bronowski, J. 1978. *The Origins of Knowledge and Imagination*. New Haven: Yale University Press.
Campbell, D. T. 1974. "Downward Causation" in Hierarchically Organized Biological Systems. In: F. J. Ayala and T. Dobzhansky (Eds.), *Studies in the Philosophy of Biology*. London: Macmillan and Company.
________. 1988. *Methodology and Epistemology for Social Science*. Chicago: University of Chicago Press.
Chomsky, N. 1959. A Review of B. F. Skinner's *Verbal Behavior*. *Language* 35:26-58.
________. 1965. *Aspects of the Theory of Syntax*. Cambridge, MA: MIT Press.
________. 1968. *Language and Mind*. New York: Harcourt Brace Jovanovich, Inc.
Craik, K. J. W. 1943. *The Nature of Explanation*. Cambridge: Cambridge University Press.
Eddington, A. S. 1929. *Science and the Unseen World*. New York: Macmillan.
Feser, E. 2011. Hayek, Popper, and the Causal Theory of Mind. In: L. Marsh (Ed.), *Hayek in Mind*: *Hayek's Philosophical Psychology*. Bingley: Emerald Group.
Fitch, W. T. S. III. 2010. *The Evolution of Language*. Cambridge: Cambridge University Press.
Gell-Mann, M. 1994. *The Quark and the Jaguar*. New York: Henry Holt & Co.
Goffman, E. 1956. The *Presentation of Self in Everyday Life*. Edinburgh: Edinburgh Social Sciences Research Centre.
________. 1974. *Frame Analysis: An Essay on the Organization of Experience*. London: Harper and Row.
Hanson, N. R. 1958. *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science*. Cambridge: Cambridge University Press.
Harris, Z. 1982. *A Grammar of English on Mathematical Principles*. New York: John Wiley and Sons.
Hayek, F. A. 1948. *Individualism and Economic Order*. Chicago: University of Chicago Press.
________. 1952. *The Sensory Order*. Chicago: University of Chicago Press.
________. 1967. *Studies in Philosophy, Politics, Economics, and the History of Ideas*. Chicago: University of Chicago Press.
________. 1978. *New Studies in Philosophy, Politics, Economics and the History of Ideas*. Chicago: University of Chicago Press.
Helmholz, H. 1895. *On the Sensations of Tone as a Physiological Basis for the Theory of Music*. London: Longmans, Green.
Kuhn, T. S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
MacCorquodale, K. & Meehl, P. E. 1948. On a distinction between hypothetical constructs and intervening variables, *Psychological Review* 55(2): 95-107.
Maxwell, G. 1972. Russell on Perception: A Study in Philosophical Method. In: D. F. Pears (Ed.), *Bertrand Russell*. Garden City, New York: Doubleday & Company.
Meehl, P. E. 1989. Psychological Determinism or Chance: Configural Cerebral Autoselection as a Tertium Quid. In: M. L. Maxwell & C. W. Savage (Eds.), *Science, Mind, and Psychology*: *Essays in Honor of Grover Maxwell*. Lanham: University Press of America.
Pap, A. 1962. *An Introduction to the Philosophy of Science*. New York: Glencoe.
Pattee, H. H. 1971. Can Life Explain Quantum Mechanics? In: T. Bastin (Ed.), *Quantum Theory and Beyond*, pp. 307-319. Cambridge: Cambridge University Press.
________. 1978. The Complementarity Principle in Biological and Social Structures, *Journal of Social and Biological Structures* 1: 191-200.
________. 1982 Cell Psychology: an Evolutionary Approach To the Symbol-Matter Problem. *Cognition and Brain Theory* 5: 325-341.
________. 2012. *Laws, Language and Life*. Dordrecht: Springer.
Polanyi, M. 1958. *Personal Knowledge*. New York: Harper and Row.
________. 1969. *Knowing and Being*. Chicago: University of Chicago Press.
Popper, K. R. 1963. *Conjectures and Refutations*. New York: Harper & Row.
________. 1972. *Objective Knowledge*. Oxford: Clarendon Press.
Porges, S. W. 2011. *The Polyvagal Theory*. New York: W. W. Norton & Company.
Post, E. 1943. Formal Reductions of the General Combinatorial Decision Problem, *American Journal of Mathematics* 65: 197-215.
________. 1965. Absolutely Unsolvable Problems and Relatively Undecidable Propositions—Account of an Anticipation. In: Martin Davis (Ed.), *The Undecidable: Basic Papers on Undecidable Propositions, Unsolvable Problems and Computable Functions* (2004), pp. 340-433. Hewlett: Raven Press.
Pulvermüller, F. 2014. The Syntax of Action. *Trends in Cognitive Sciences* 18(5): 219–220.

Russell, B. 1948. *Human Knowledge Its Scope and Limits*. New York: Simon and Schuster.
Ryle, G. 1949. *The Concept of Mind*. Chicago: University of Chicago Press.
Sellars, W. S. 1958. Counterfactuals, dispositions and the causal modalities. In: H. Feigl and G. Maxwell (Eds.), *Minnesota Studies in the Philosophy of Science*, Vol. II. Minneapolis: University of Minnesota Press.
________. 1963. *Science, Perception and Reality*. London: Routledge and Kegan Paul.
Shannon, C. And Weaver, W. 1949. A Mathematical Theory of Communication. *The Mathematical Theory of Communication*. Champagne: University of Illinois Press.
Sherrington, C. S. 1906. The *Integrative Action of the Nervous System*. New Haven: Yale University Press.
Skinner, B. F. 1957. *Verbal Behavior*. New York: Appleton-Century-Crofts.
Tolman, E. C. 1935. Psychology versus Immediate Experience. *Philosophy of Science* (2): 356-380.
Vanberg, V. 2017. *The Sensory Order and Other Writings on the Foundations of Theoretical Psychology* (Ed. By V. J. Vanberg). Chicago: University of Chicago Press.
von Neumann, J. 1951. The General and Logical Theory of Automata. In: Jeffress, L.A. (Ed.), *The Hixton Symposium*, pp. 1-31. New York: J. Wiley & Sons.
________. 1958. *The Computer and the Brain*. New Haven: Yale University Press.
________. 1966. *Theory of Self-Reproducing Automata*. Champagne: University of Illinois Press.
Weimer, W. B. 1969. The Syntax of Action: Prolegomena to the Transformational Analysis of Behavior, Unpublished Doctoral Dissertation, University of Minnesota.
________. 1973. Psycholinguistics and Plato's Paradoxes of the *Meno*. *American Psychologist* (28): 15-33.
________. 1974. The History of Psychology and its retrieval from Historiography: Part 1, in *Science Studies* (4): 235-258.
________. 1975. The Psychology of Inference and Expectation: Some Preliminary Remarks. In: G. Maxwell & R. M. Anderson (Eds.), *Induction, Probability, and Confirmation*, pp. 430-86. Minneapolis: University of Minnesota Press.
________. 1976. Manifestations of Mind: Some Conceptual and Empirical Issues. In: G. G. Globus, G. Maxwell, & I. Savodnik (Eds.), *Consciousness and the Brain*, pp. 5-31. New York: Plenum Publishing.
________. 1977. A Conceptual Framework for Cognitive Psychology: Motor Theories of the Mind. In: R. Shaw & J. D. Bransford (Eds.), *Perceiving, Acting, and Knowing*. Hillsdale: Erlbaum Associates.
________. 1984. Limitations of the Dispositional Analysis of Behavior. In: *Annals of Theoretical Psychology*, Vol. 1, J. R. Royce & L. P. Mos (Eds.), pp. 161-198. New York: Plenum Press.
________. 1987. Spontaneously Ordered Complex Phenomena and the Unity of the Sciences. In: G. Radnitzky (Ed.), *Centripedal Forces in the Sciences*, Vol. 1, pp. 257-296. New York: Paragon House.