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General Contextualism, Ecological Science and Cognitive Research

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The present paper is an attempt at specifiying some principles of a new research-oriented movement which appears to be taking place in experimental psychology, a movement toward contextualist, ecological, and functionalist views. In order to analyze various "world views," we rely on the theory of S.C. Pepper. Our focus is on cognitive science, which includes the experimental psychology of cognition and the study of artificial intelligence. Since a major concern of cognitive science is the issue of "mental representation," a main concern of the present paper is with philosophies and theories of mental representations. Analysis of the metaphors that are relied upon in discussions about mental representations highlights some basic claims of cognitive science, for example, the claim that representations must be analyzed primarily in terms of their computational efficiency. Our analysis of the contextualist view focuses on research examples taken from Gibsonian ecological psychology and the recent research on event cognition by Jenkins and his colleagues. This research includes studies on expert knowledge, prose comprehension, event perception, motion perception, face perception, and speech perception. Contextualism entails a reinterpretation of the purposes and goals of cognitive psychology. Not only does contextualism define itself through contrasts with the prevalent information processing views, but more fundamentally, ecological research on perception and recent research on event cognition rely on a common set of positive contextualist principles.

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> The idea of metaphor as a logic of discovery . . . has profound implications for the philosophy of science as well as for the logic of method in the human studies . . . it suggests that both the inductive and deductive models of scientific explanation be reformulated by the view that formal representations be understood as metaphoric redescription or creation of the domain. (Brown, 1972, p. 17)

The word "context" appears in the literature of psychology with many meanings. In experiments on memory it has become possible to refer to

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sentences as the contexts for recall of target words. Traditionally, the entire sentence might be regarded as "the" stimulus. The contextualist agrees in general with such uses of the word context, but disagrees with the strategy of granting special importance to isolated "stimulus" variables. To the contextualist, large numbers of situational variables are present in every experiment (not to mention the real world), and so theories that are supported by experiments in which only one or a few variables are manipulated are shakey at best. In this paper we suggest some ways that research is possible in a domain where "everything depends on everything else."

Any paradigm or general approach to psychology—be it behaviorism, Gestalt psychology or whatever—will determine what counts as a worthwhile experiment, what counts as data, and what will work as a theory (Kuhn, 1965). There is a considerable diversity among approaches being taken in cognitive psychology today. Theoretical systems involving schemas, prototypes, inference nets and various types of memory stores can be found in the literature. Concern about the status, goals and accomplishments of cognitive science has manifested itself in a number of recent events. Rather than producing a new edition of his classic *Cognitive Psychology* (1967), Neisser (1976) rejected the pure information processing approach to the mind and adopted another language of "schemata." In a paper titled "You Can't Play Twenty Questions with Nature and Win," Alan Newell (1973) argues that modern cognitive science consists largely of a set of separate phenomena (such as mental rotation, release from proactive inhibition, and short-term memory decay) and a set of theoretical distinctions (such as episodic versus semantic memory and analog versus digital processing). It does not appear to Newell as if the field is leading toward unification: ". . . far from providing the rungs of a ladder by which psychology gradually climbs to clarity, psychologists' conceptual structure leads rather to an ever increasing pile of issues, which we weary of or become diverted from but never really settle" (p. 298)

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(see also Estes, 1978, 1980). Jenkins (1980) also laments this current state of affairs:

> I think that there is a malaise in cognitive psychology—a lack of direction. One of the questions that I am asked most frequently is "Where is the field going?" I think the emphasis on functionalism is an important emphasis, to be restored to American psychology. It seems to be coming back with vigor. (p. 236)

The movement to which Jenkins refers is the major topic of this paper. We attempt to describe a general paradigm which we believe underlies a number of somewhat separate trends in modern psychology. An approach which some are calling general contextualism (Baltes, 1979; Barclay, Note 1; Jenkins, 1980) is being taken in the psychology of learning and in life-span developmental psychology. In a recent paper on the history of psychology, Lichtenstein (1980) used the term contextualism to describe some parallels between the "event epistemology" of radical behaviorism (e.g., Kantor, 1980) and new "ecological" research on perception and learning.[1] Lichtenstein suggests that a general contextualist psychology seems to be on the horizon, and he emphasizes that there is an outstanding need for specification of the principles of such a science.

While all of the research we will cite points to an underlying research strategy, not all of those whose work we will cite would call themselves contextualists. Some have referred to this trend as a part of a "new functionalism" (Gibson, Note 2). The science which many call ecological psychology has established itself in the psychology of perception and action, in environmental psychology, and in the comparative psychology of learning and motivation (Gibbs, 1979; Johnston, 1980; Meacham, 1977; Neisser, 1982; Shaw and Turvey, Note 3; Wicker, 1979). A number of researchers and theorists have made reference to an ecological approach to community psychology and counseling psychology (Blocher, Note 4; Bronfenbrenner, 1979). We will not propose that ecological sciences should actually call themselves "contextualist." Quite to the contrary, within the general philosophy are principles which are defined and refined by the specific research sciences (for example, Newton's theory was "mechanistic").

Our paper has a number of topics, topics which are all intimately connected

[1]Behaviorists tend to be religiously anti-mentalistic, and when neo- and radical behaviorists do refer to experiential phenomena, their view necessitates a fairly drastic reformulation of what it means to "explain" mental phenomena. The general philosophy of contextualism is not at all constrained to be anti-mentalistic. Because of historical complexities (such as the lingering and often misguided criticisms of methods of introspection), much discussion of philosophical and methodological issues would be necessary to show how radical behaviorism is like both contextualism and ecological psychology (Gibson has been referred to as an "arch behaviorist"). We can only point to this topic here, and hope that our (behaviorist and contextualist) readers can see where we are pointing (see also Wilcox and Katz, 1981).

to issues in ontology, epistemology, and methodology. One topic we must touch on is the history of beliefs and world views (Kuhn, 1965; Pepper, 1942). We rely on Stephen C. Pepper's classification of philosophical-ontological viewpoints. This classificatory scheme allows us to contrast types of science, provides the means to analyze the prevalent information processing view, and establishes precedent for regarding modern ecological sciences as manifestations of the contextualist world view.

We will rely heavily on research examples in order to describe contextualism, since our primary aim is to describe a research strategy. We mention recent research on human learning by John Bransford, James Jenkins, and their colleagues as a paradigmatic example of the contextualist approach and we attempt to specify some aspects of the contextualist's strategy for research on learning. We take recent research on perception conducted by ecological psychologists as another example. The literature of theory and research which has been generated by James Gibson, Gunnar Johansson, Robert Shaw, and their colleagues is not through-and-through contextualist. We will show why this is the case, and will provide converging evidence that ecological psychology is fundamentally contextualist.

From our emphasis on learning and perception research comes our attempt to define contextualism in terms of what it *is*, what new principles it proposes. Another way in which we attempt to define the view is by focusing on what it is *not*: The reaction of contextualists against a certain style of information processing theorizing. Our strategy is to use the classic cognitive problem of "mental representation" as a springboard for showing how contextualism recasts metaphorical theorizing about representations into a pragmatic language of research on "knowledge description." As we hope to show, debates in the literature of cognitive psychology (such as that on mental imagery) suggest that discussion of the science of psychology at the "world view" level is appropriate and hint that an exploration of the principles of general contextualism might offer some insights into some of the current perplexities.

Metaphor and the Analysis of Science

Our method is the analysis of scientists' philosophical assumptions, their mental images, models, and their metaphor-based analogies—as these are revealed by their rhetoric and the historical growth of their ideas. Weimer (1979; Note 5) calls for research on the cognition and rhetoric of scientists with the goal of describing the psychological nature of inductive inference, creativity, and other aspects of science (see also Estes, 1978, p. 15). The psychologist who so analyzes science will benefit in that the cognition of scientists should certainly serve as a testing ground for theories from cognitive science.

There exists ample work on the rhetoric of problem-solving to justify this

method. The use of metaphor and metaphor-based analogies in the physical sciences has been amply documented (Boyd, 1979; Eberle, 1971; Hesse, 1966; MacCormac, 1976) (see Hoffman, 1980, for a review of the literature in philosophy of science on the use of metaphors, analogies, models, and imagery in science, especially physics). Metaphors often play a critical role in the generation of theories, even mathematical ones. A well-known example is the "*solar system*" model of the atom. The basic image and metaphor was suggested by Ernest Rutherford (cf. 1911). A few years later, Niehls Bohr derived equations for describing atomic spectra by adapting Hamilton's principle of the orbital angles of planets (Hoffman, 1980). Gentner (1981) has shown how metaphor-based analogies are used in the teaching and learning of problem-soving in basic physics. Her work on metaphors has led to experimental studies on how to facilitate learning.

Experimental psychologists have always used metaphors and metaphor-based analogies as tools for generating, defining, and explaining theoretical or research concepts (see Hoffman, Cochran, and Nead, 1984, for a more detailed discussion). In the modern "dichotic listening" experiment, people listen to speech signals over headphones. If a particular signal is switched across channels (ears), people have difficulty in following the message. This research was based on the metaphor of attention as a "*switch*" or a "*selective filter*" (Broadbent, 1958; Cherry, 1958). Critelli (Note 6), Estes (1978), Lakoff and Johnson (1980), Pollio and Smith (Note 7), and Roediger (1980) have used metaphor to categorize psychological hypotheses about memory mechanisms in the literature on human information processing. Runeson (1979) has used the polar planimeter drafting tool in a metaphoric analogy for explaining how perceptual systems can directly detect high order information. Carroll and Thomas (Note 8) are using metaphors to generate psycholinguistic research on the design and learning of program languages. Carbonell (Notes 9 and 10) is designing computer systems capable of metaphor-based inferences about topics in economics and politics.

Metaphor is a topic which is in the air in many fields. Beyond this is the important point that analysis of scientists' rhetoric helps to reveal their underlying models and assumptions.

What is Metaphor?

Special problems of complexity are likely to arise when the scientists whose metaphors, images, and theoretical models under analysis are themselves cognitive scientists, since one goal of cognitive science is to explain the very competencies that are being used in the description of science. Thus it behooves us to say something at the outset about our working definition of metaphor.

Careful examination of the literature of theories and research on metaphor

in linguistics, philosophy, and psychology reveals that even definitions of metaphor are themselves based on metaphorical notions of what meaning is (see MacCormack and Hoffman, Note 11). This is perhaps ironic to those who believe that genuine scientific thought must be literal. In theories of metaphor, metaphors are described as "*feature filters*," as "*ways of seeing the world*," as "*mirrors of the world*," as "*ornaments of language*," as "*analogy mappings*," as "*transformations of meaning features*," as "*masks of the truth*," and as "*puzzles to figure out.*" We feel it is prudent to regard linguistic metaphor as but a single manifestation of complex processes of perceiving, acting, and remembering (Verbrugge, 1980). An example which may be enlightening is the metaphor "*The land is an ocean*" spoken by someone who is riding in a car past a wheat field. From one perspective on the nature of metaphor, comprehension or production of this utterance would rely on complex linguistic and informational processing. Alternatively, understanding could be based on direct perceptual experience of waves, as these are preserved in the pattern caused by wheat moving in the wind. In order to emphasize that metaphor is not just a linguistic phenomenon, we will refer to comprehension in terms of the notion of "metaphoric understanding" (Lakoff and Johnson, 1982).

Metaphor in Science

From the point of view of rhetoric, scientific metaphors can be considerably complex (see Hoffman, 1980). They can take the form of metaphor-based analogies in which an original metaphor has been fleshed out into an analogy in which the relevant properties or relations have been specified or mathematized. They can take the form of thematic generalizations, such as the grand comparison of the mind to a computer; they can take the form of specific hypotheses such as the claim that the attentional "*switch*" takes a fixed amount of time to "*change channels.*" A given statement can involve mixtures of concrete and abstract references: "The primitive semantic features of a lexical item might be stored in the form of a push-down stack." The notion of sematic features is a reference to the belief that the mental representation of word meaning is like the manipulation of sets or networks, and the stack concept is based on concrete experience with spring-loaded dish racks. Literal sentences do occur, such as "The name of the Journal which this paper is printed in is *The Journal of Mind and Behavior.*" Literal scientific statements also exist—specific observation statements, for example—although such statements can also be theory-laden. Scientific statements can sometimes *seem* to be fundamentally literal generalizations, such as the notion that memory has a "structure." Some might doubt that this is metaphorical. However, underlying the sentence is a complex human history of cognition and experience: Many words which refer to language and to knowledge relate to a structure theme. One can "*construct*" a sentence or "*construe*" a meaning. A

theory can "*rest on solid foundations*" or an idea can be "*unfounded.*" People understand productive human activities through a comparison to buildings, their raw materials, the operations that put the parts together, and so on. This heritage of metaphoric understanding is apparent in the etymology of many abstract language terms. (For more detailed discussions of metaphoric understanding and etymology, see Breal, 1887; Müller, 1873; Smith, 1982). In the analysis of scientists' rhetoric, one must not let abstractions or thematic generalizations slip by as literal foundational claims—they may point to underlying themes of experiences and metaphoric understanding.

World Views

Philosopher Stephen C. Pepper (1942) realized that metaphoric understanding is manifested in the philosophical metaphysical systems which have been proposed over the ages (see also White's (1978) historiographic analysis in Pepperian terms). Pepper could classify various specific theories and philosophical systems according to their underlying metaphor themes or "root metaphors." A familiar example is the mechanistic view of "*The world as a machine.*" Pepper is not alone in believing that the role of metaphors in cognition is to provide a critical link between experience and abstract theorizing. Cassirer (1942) and Müller (1873) provided analyses of various myths and language cultures. They both viewed language and reason as achievements of history based on the refinement of metaphors. In this process, some area of experience or some common image provides a way of understanding new experiences. The essential characteristics of the known experience (i.e., the metaphor vehicle term) can be singled out for use as knowledge about the new term (i.e., the metaphor topic term). From Plato on, many theories in science were based on metaphorical world views (Toulmin, 1961).

Root metaphors can be described as part logic and part myth. In a root metaphor, a single prototypic, salient, or paradigmatic concrete event is taken to represent a totality (thus, root metaphors are metonymies). Root metaphors are sweeping, and are made to encompass major portions of experience. Root metaphors are mythic in that they reduce everything to a unifying principle, concept, or image. They bring about perceptual fusions of properties, and not just comparisons or similarities. Root metaphors are also logical in that they can involve orderly comparisons of similarities, differences, causes, relations, and properties. While insisting on a fusion of things, root metaphors also affirm the separateness of concepts. While relating concepts to concrete events or experiences, root metaphors also refer to abstract conceptual matters. In the metaphysical world views, the features or categories common to all instances of the metaphor vehicle term (e.g., *machine*) are taken as the categories of things in the world (the metaphor topic term). World hypotheses are distinguished in terms of (a) their metaphor theme, (b)

their grounding in experience, (c) their categorization of things in the world, (d) beliefs that result when the categories are taken to be "real," (e) the distinctions between types of representation that the categories entail, and (f) the weak points or points of polarization with other world views (e.g., it is often said that mechanistic views have difficulty explaining beliefs).

From his analysis of sundry philosophies—from dogmatism to mysticism—Pepper distilled four "relatively adequate" basic world views: organicism, mechanism, formism and contextualism. The views have points of agreement and points of disagreement, and can even merge in specific theories.

For the world view called organicism, the basic metaphor theme is "*The world is organic processes.*" Organicist views involve such specific concepts as "adaptation," "conflict," and "drive toward integration." Organic processes or organizations predict and verify their own future course. However, future events are not strictly predetermined since there may be complex types of conflicts or interactions. An important experiential basis for the organicist view is that of historic processes—the "*growth of ideas*" as in Hegel's "thesis versus antithesis versus synthesis."

At this level, the level of world views, the question which criticism addresses is: What exists? Pepper found that the way in which a philosopher or theorist chopped up the world (the ontology) followed from the basic metaphor theme. For example, the categories of existence which organicist theories usually use to divide up the world are features of biological and evolutionary processes: (1) *drives* toward completeness and self-organization, (2) *unities* in that total process and to be integrated by it, (3) *contradictions* which are inevitable conflicts or struggles which the (4) *integration* must resolve, resolutions of the conflicts into some synthesis or "*organic whole*" (itself a unity for some even higher synthesis).

The psychodynamic theory of Alfred Adler (1930, 1935) is a very good example of a pure organicist theory. In opposition to Freud's emphasis on sexual factors and the role of one's past experience in the determination of personality, Adler believed that people are motivated just as much by their expectations for the future. Life is described as a continuous process of growing and striving. Rather than emphasizing the role of neurosis in adjustment, Adler described adaptation in terms of his concept of "life style"—how one's specific traits unfold and "*branch out as if a tree.*"

Another example of organicist psychology is Riegel's (1976) dialectical approach to development. To Riegel, such a developmental psychology should place less emphasis on the development of traits or mental entities, and more emphasis on the developmental effects of crises, conflicts, discrepancies, and surprises (such as occur in mother-infant dialogs). The developmental psychology of Piaget, "genetic epistemology," is also largely organicist. Piaget postulates mental operations and organizations of knowledge which

form various stages. At each stage, the child adapts to the world by "*assimilating*" parts of it (note the biological metaphor).[2] Piaget's and Riegel's versions of organicist developmental psychology differ in that Piaget's system merges the organicist world view with aspects of the formist view (i.e., the development of mathematical and logical operations) whereas Riegel merges organicism with contextualism (i.e., an emphasis on the temporal order to dialectical events). Thus, Piaget focuses on the development of relatively stable stage-like integrations, whereas Riegel denies the existence of stages of equilibrium.

Before discussing the principles of contextualism and formism, we describe a more familiar world view.

Mechanism

According to the world view called mechanism, "*The world is a machine.*" This view is exemplified by the work of Galileo, Newton, Descartes, Locke, and many others. The experiential basis comes from contacting and manipulating the world, of being an effective cause as in the use of a simple lever. Descartes and Newton based their laws about matter and motion on this basic experience. The mechanistic world view involves six categories: (1) *particulars* (parts) having specified locations, (2) *primary qualities* (those that are relevant to the workings of the machine), (3) *functional laws* which relate the parts, (4) *secondary qualities*, (5) *laws* for relating the secondary qualities to the first three categories, and (6) *laws* for the relations that hold among the secondary qualities.

To those who followed the Cartesian heritage of mechanism, knowledge was regarded as something that is generated in the brain as a consequence of sensations: We are aware only of our perceptions (secondary qualities) and not necessarily of the actual properties of physical existence. Objective knowledge can be inferred, however, since ideas are causally connected to sensations. In other words, the mechanistic heritage has given psychology the doctrine of "mental representation of ideas" as Descartes' answer to the problem of the relation of physics (inherent primary qualities) and psychology (the perception of secondary qualities) (Reed, Note 12). Numerous theoretical ideas relate to this heritage, such as the well-known "*camera*"

[2]We once heard a presentation by a colleague of Jean Piaget who was interested in learning about the then-new U.S. information processing views. She discussed her own research on the "*natural unfolding*" of certain Piagetian learning stages, but interrupted herself to apologize for having a theory which lacked a separate motivational component. To the Piagetian view, the developmental process is self-driven, and she did not understand how the information processing theory explains growth-like processes. While our information processing-oriented colleagues were somewhat nonplussed, we budding Pepperians understood that of course her Piagetian theory had no motivation component—the organic metaphors have no need for one. Given her basic metaphors we could have almost "predicted" a number of the specific aspects of her theory. In fact, this and similar events catalyzed our interest in pursuing a Pepperian analysis of views in modern scientific psychology (see also Hoffman, Cochran, and Need, 1984).

metaphor for vision and the British (associationistic or Newtonian) metaphors of the "*attraction of ideas*" ("Opposed conceptions repel in degrees proportional to their mass," Locke, 1690/1961, chap. 12).

Formism

A third major world view Pepper called "formism." This world view is manifested in most descriptions of rational or logical systems. The metaphor theme for formism is "*The world is patterns.*" The experiential basis for this metaphor is the perception of forms, that is, the perception of similarity and discrimation of the implied differences. The perception of similarity of form—as between all crystals or all oak trees—leads to the basic metaphor of pattern or plan. Formism divides up the world into three categories: (1) *particulars*, (2) *qualities*, and (3) *attributions* which connect the qualities to the particulars, such as the statement "This bird is yellow." Formism regards the world as being made up of classes and propositions, which are produced by the operation of the three categories. A class is a set of particulars which share certain qualities and a proposition is a reference to a class. Modern logical systems, predicate calculus, set theory, and information theory (in + form = to give perceptible form to) are examples of formism. In all of these, an observer perceives similarities that relate particulars according to rules about their properties.

As was the case for mechanism, formism also has a long history. Much of the history of logic and linguistics is formistic in that theoretical representations are defined in terms of truth or falsehood of reference or denotation (e.g., Tarski, 1944). Much of Wittgenstein's (1953) treatise on language and truth can be regarded as explicit analysis of various formistic metaphors for talking about semantics—in terms of the components of games, in terms of the categories of logic, in terms of a basic metaphor of meaning as "*pointing*," and others.

In formism, the philosophical concept of truth is usually assumed to be based on a literal correspondence of a description, perception, or theory to some real state of affairs in the world. The metaphor of pointing is used quite often in discussions of meaning and reference. Meaning is defined in terms of reference to true perceived form. To formism, all theoretical representations are essentially propositions which express the properties and relations among objects. The propositions are stated with predicates that derive from the perceptions of an observer. Truth in a theoretical representation is a matter of semantics and how names "*stand for*" things in the world. With regard to perceived form, many things can qualify as representations—maps, diagrams, sketches, portraits—as long as they preserve at least some correspondence with the form of the represented objects. Thus, symbolic statements of abstract qualities (such as rules and symbol systems) can also be representa-

tions of the world, according to formism.

The Eclecticism of Information Processing

Each world view has strengths and weaknesses. To Pepper, the main world views seemed irreconcilable. This was a decade before the advent of general purpose digital computers. The computer is a combination of machine and logic. If Pepper's method is correct, any merging of world views would require: (1) new factual content or experience on which to ground the new view, (2) a new basic metaphor theme, (3) new ontological categories of the world, (4) new types of corroborative evidence, (5) explanation or elaboration of the older views, and (6) no loss of precision or scope relative to older views. While it is popular to lampoon the computer metaphor because it is "mechanistic" (e.g., Pribram, 1981), the metaphor "*The mind is a computer*" actually merges the categories of mechanism and formism. With the computer has come the potential to instantiate any mechanistic model of the mind and any set-theoretic description of the mind. It has provided the information processing perspective on the actions of the mind; it is based on new kinds of experience; it is a theme which relates many specific metaphorical experimental hypotheses or claims; and it does involve a new type of corroborative evidence (i.e., the branch of cognitive science known as artificial intelligence or cognitive simulation). Furthermore, it expands upon the formistic and mechanistic theories of representation by identifying levels of description—causal relations hold at the level of the circuitry, intelligent actions hold at the level of the control language.

The categories of the mind according to the information processing eclecticism are: (1) particular *mental entities* or contents, (2) particular *mental processes* or operations, and (3) *laws* which relate the entities and operations in a way that preserves at least a partial correspondence with the world. The mind is regarded as a "*calculating engine*" which can do "*cognitive logic*" or "*cognitive algebra.*" In comprehending or perceiving, the mind is believed to "*compute functions*" (e.g., Pylyshyn, 1979, 1981) or to use symbolism as that found in mechanical devices assisting thought and computation. As Neisser (1967) put it, mental activity is the transformation of information, and the goal of psychology is to understand the "*programming of the mind.*" In all these examples, machine and logic are combined.

The Contextualist Alternative

Over the course of history, philosophy and psychology have distinguished a number of different types of hypothetical ontological entities, such as properties, qualities, processes, abstract entities (ideas, numbers) universals (causal laws) and dispositions (tendencies to acquire properties or other

dispositions). Much of the literature of philosophy consists of attempts at defining the more abstract types of entities.

The Event Ontology

The contextualist world view relies on a single ontological starting point, events. The basic metaphor theme, an abstract one, is "*The world is events.*" The experiential basis for this metaphor is that of written histories, dramas, plays, and theatrical events. Events can be factored in a number of ways. For example, an ocean cruise could be factored into successive episodes, patterns of weather, the experiences of separate travelers, and so on. Philosophers have discussed the necessity of an event ontology (see Davidson, 1980). For example, scientific explanations are supposed to be *of* events. That is, laws describe how properties are related to each other or how they change, but always with reference to certain boundary conditions or conditions of the observation events. Davidson has described the logical complexities in talking about sentences which are about events, in an effort to determine the conditions for saying when two events are the same or different. His discussion highlights the role of the theorist or observer in terms of perspective, intention and purpose in defining the boundaries and contents of events. For example, "Brutus killed Caesar" and, "Brutus stabbed Caesar" do not necessarily refer to the same event.

To contextualism, events are real and occur independently of cognition, awareness, perception, or judgment (Turvey and Carello, 1980; Wald and Wald, Note 13). However, any description of an event is tied to the observer's purpose and method. Therefore, contextualist theories are relativistic theories, that is, relative to specific domains, niches, or purposes, and are expressed in terms of changes and invariants. This dual nature of events, their residence in observer-environment interactions, shows in the basic ontological categories into which the event theme divides the world: (1) *events*, and (2) *changes*. It is not enough to say that all there is is events, as this might imply fixed categories. A critical aspect of events as contextualism defines them is the denial of permanent structures. To inject novelty into descritpions, Pepper included the additional ontological category of change. As a consequence of the operation of these two categories, dynamic, generative or emergent novelty appears.

The ontological categories of contextualism must not disallow any degree of order or disorder. There may be no final or ultimate units for the analysis of anything. Pepper (1942, pp. 234-235), explained contextualism's two ontological categories thusly:

> There is an orderliness about [formism and mechanism]. But, so to speak, disorder is a categorial feature of contextualism, and so radically so that it must not even exclude order. That is, the categories must be so framed as not to exclude from the world any degree of order it may be found to have, nor to deny that this order may have come out of

> disorder and may return into disorder again—order being defined in any way you please, *so long as it does not deny the possibility of disorder or another order in nature also* . . . . Change in this radical sense is denied by all other world theories. If such radical change is not a feature of the world, if there are unchangeable structures in nature like the forms of formism or the space-time structure of mechanism, then contextualism is false. Contextualism is constantly threatened with evidence for permanent structures in nature . . . . Its recourse in these emergencies is to always hurry back to the given event, and to emphasize the change and novelty that is immediately felt there, so that sometimes contextualism seems to be headed for an utter skepticism.

A contextualist theory will be tied to specific domains and, based upon the observer's particular purposes, will deal with the salient or important aspects of events, their interrelationships, their similarities and differences, and alternative ways of factoring them into descriptions.

The basic problem is how to go from the fundamental event ontology to some alternative rational schemes for describing actual events, ways of parsing them, etc. At the time Pepper wrote, there were instances of specific theories which seemed to fit with contextualism in spirit (e.g., Tolman, Dewey, James). However, Pepper pointed to a need to construct a pure contextualist theory.

Ways of describing events have been proposed in recent times, such as James Gibson's abstract notions of "structural and transformational invariants" (which receive our special consideration in a later section of this paper). In general discussions of perception and cognition, terms such as "*event nestings*" and "*event boundaries*" have recently appeared (Mace, 1983). Analysis of events has been important in the generation of computer models of prose and discourse comprehension processes, involving such notions as "*event slots*" and "*scripts*" (Kintsch and Van Kijk, 1975; Schank and Abelson, 1977).

In no case has a scheme been developed and applied across many domains, tasks or methods. A basic premise of the contextualist view is that there may be no general formula for describing events that will cut across all domains (as distinguished by the judgments of the theorist). Each domain may be an "*island of regularity*" in a sea of incredibly complex phenomena. There will be no fixed categories for the analysis of events because all such categories will depend upon the theorist's purpose and method, as well as the complexities in the world.

Relative to the other world views, contextualism is a new perspective. It seems most helpful to therefore first consider examples of how event notions lead to research. We will then be in a position to test the adequacy of the event approach by applying it to the problem of "mental representation" as posed by the information processing view.

Contextualist Research on Learning and Expertise

The version of experimental psychology known in the early 1900's as functionalism can be taken as an example of a contextualist scientific theory.

In contrast with the elementaristic early behaviorists, the functionalists emphasized the place of specific stimuli and responses in their global situational contexts (Angell, 1904). They retained the introspectionists' willingness to study learning with respect to mental life. However, in contrast with mentalisitc and mechanistic structuralists such as Wundt and Titchener, the functionalists focused on mental "operations" rather than associative memorial structures (Dewey, 1896). Functionalists concentrated on analysis of the evolutionary, functional, and practical significance of consciousness, and the notion that perceptions and thoughts are of events rather than of elementary sensations, stimuli or responses (Angell, 1907).

As our discussion will show, all of these aspects of the functionalist view are paralleled within the modern ecological and contextualist learning theories. In addition, the latter have provided an important body of research findings.

We take as our paradigmatic example of contextualism recent theorizing and research on human learning and expert knowledge by James Jenkins (1975, 1980), John Bransford (1979) and their colleagues.

The event ontology suggests a general strategy for research: It places an emphasis on the "perceptual learning" which the theorist must undergo in order to specify the relevant events for the domain. Jenkins illustrates perceptual learning with the familiar experience of watching the expert television sports commentator, who asserts, for instance, that a highdiver's form is off in certain subtle respects, and sure enough the instant replay confirms the expert's perceptions. What is available to the expert perceptually and judgmentally is not available to non-experts.

A research program which serves as an excellent example of the perceptual learning aspect of the contextualist research strategy is a program being conducted on the expertise of cardiologists (Jenkins, Note 14; see also Newtson's research on expert fencing judges, 1980). The project involves a number of interdependent research stages: (1) Examination of the activities of practicing cardiologists, their problem-solving and inference-making; (2) examination of the psychoacoustics of heart sounds, to relate the acoustical properties of heart sounds to the cardiovascular system events which produce the sounds (e.g., how a "*freight train*" murmur is caused by a valve defect); (3) computer-based synthesis of heart sounds for experimental manipulation of event-related information; (4) studies of the acquisition of expert knowledge by means of experiments on perceptual learning (i.e., among medical students); and (5) characterization of "expertise" versus the skills of apprentices (interns) and novices (medical students). According to Jenkins, novices seem to rely on the perception of isolated cues as they listen to heart sounds; such cues are sometimes misleading or uninformative. Experts seems to be engaged in direct perception of the cardiovascular system, that is, they perceive heart events when they listen to heart sounds—just as when one is using a screwdriver one feels the screw at the tip and not just the handle. For the expert cardiologist, when an unexpected pattern occurs in the heart sounds, the

expert brings explicit problem-solving and inference-making to bear to determine what information is needed next. The inferences the expert makes may appear to be made in a serial order (e.g., where to put the stethoscope), but the actions are governed interactively and dynamically by past experience and present information.

The Spirit of Pragmatism and Realism

A second aspect of the contextualist research strategy is clear in the cardiology research example: The examination of real-world situations. This aspect falls out of the event ontology at the level of epistemology. According to contextualism, the world exists in the sense of being independent of the mental construction or perception of the world. Thus, contextualism involves a "realist" epistemology (Wald and Wald, Note 13; see also Reed and Jones, 1978). This puts contextualism in contrast with some of the major traditional positions on the issues of epistemology. Rationalism, a formistic position, assumes the existence of the psychologically deep, logical rules or categories which are necessary for the inferring of true knowledge. Empiricism, in part an offspring of the British "*mental chemistry*" of ideas, places an emphasis on "*raw*" sensory experiences which must be mechanistically logically associated to result in higher knowledge. According to contextualism, both views erred when they assumed an impoverished theory of the nature of experience: both assumed that the information available is not enough to specify our knowledge. In contrast, a contextualist does not assume any a priori necessary form for knowledge; a contextualist begins by looking in more detail at the events in the world, seeking constraints on learning by looking at the events in the world in which learning occurs (Mace, 1977; Turvey, Shaw, Reed, and Mace, 1981; we will refer again to epistemological issues when we discuss Gibson's concept of direct perception).

An example is work by Agar (1975). He studied a large corpus of counterculture jargon terms and phrases. The analysis showed that logical paraphrases of the meaning of isolated jargon terms were less able to capture meaning than expressions of the relations between events and event outcomes (e.g., concern about not "*getting burned*" or getting "*ripped off*," "*coping*" requires getting some "*bread*," etc.). Other research on the psychology of learning which is in principle coherent with contextualism by virtue of the systematic examination of learning in real-world contexts, is research on memory for advertising and broadcast messages (Bruno and Harris, 1980; Wagenaar, 1978), research on memory for narrated events (Black and Bern, 1981; Kintsch, 1974), research on the thought processes of expert teachers (Collings and Stevens, Note 15), research on autobiographical memory (Baddeley, Lewis, and Nimmo-Smith, 1978; Linton, 1978), and memory for mental operations such as for having recently forgotten something (Herrmann and Neisser, 1978).

Contextual Relativity

In demonstrations of contextual relativity effects, factors that are a part of the experimental context (tasks, instructions, etc.) are shown to make a big difference in the comprehension and memory of a target "stimulus." Olsen (Note 16) demonstrated contextual relativity for the case of descriptions of simple objects. People saw a star-shaped block along with various other sets of shapes. In every case, the star was placed under a small white block. How people described the location of the star block depended on which third block went along with the other two—they would say "the star is under the white block" if the third was black; they would say "it was under the small block" if the third was large and so on. In every case, the target was distinguished from the objects in its presentation context.

In many ingenious experiments, Bransford and his colleagues (summarized in Bransford, 1979) have demonstrated the context-dependence of phrase, sentence, and prose comprehension. In one experiment, people's memory for a paragraph was examined. The paragraph consisted of some observations of the activities in a city from the perspective of a person looking down on the city. The experimenters manipulated subjects' memories for the paragraph simply by altering the title, either as a "Visit to an inhabited planet," or "A view of a parade form the fourth floor."

In another experiment, Bransford was able to construct sentences which depended for their interpretation and recall upon the availability of additional contextual information: "The haystack was important because the cloth ripped" could be made sensible and therefore memorable by presentation of the disambiguating context, "parachute." Similar disambiguation occurred when the key "bagpipes" was presented along with the sentence, "The notes were sour because the cloth ripped." Other experiments involved the manipulation of the comprehension of sentences and prose passages through the presentation of contextual information in pictorial form. For example, an unusual description about some balloons and someone singing is made sensible and memorable by presentation of a drawing which shows a man serenading a woman—he is singing through a microphone which is attached to a speaker that is being held aloft by a bunch of balloons.

These experimental demonstrations were intended to show that sentence comprehension cannot be considered only on the basis of isolated sentences. Much early psycholinguistic research relied on tasks in which lists of semantically isolated sentences were read and responded to (recall, reaction-time, etc.). Such research was important in demonstrating syntactical effects in comprehension, for example. Bransford's research has shown, however, that sentences should not be taken as "the" units of comprehension or meaning.

Contextual relativity, as a class of phenomena, goes far beyond these specific learning studies. Recent research on speech perception (Strange and

Jenkins, 1978) has amply demonstrated that the phonemes in a spoken language are not represented by unique patterns of frequencies—how a given phoneme is produced can depend both upon the sounds uttered immediately before it and upon the sounds yet to be uttered. Similar research-based conclusions about contextual relativity factors could, no doubt, be made in all domains of modern experimental psychology. The claim of contextualism is that the interpretation of "basic units" at any one level of description will necessarily rely upon contextual factors at another level. It is only by research which specifies the contextual level that one will be able to disclose the full complexity of events at the "basic" level.

Event Cognition

Another aspect of the contextualist approach to experimental psychology involves demonstrations that psychological phenomena are tied to events—that perception is *of* events. One way in which learning relates to events is that we can learn about events themselves. An example is the experiment by Jenkins, Wald, and Pittenger (1979). They prepared a series of slides which depicted actual events, as if a subset of frames had been selected from a motion picture. One series told a story about a person making and serving a cup of tea, another series told a story about a person answering a telephone. A control series of slides consisted of unconnected photos of a party. After seeing a subset of one of the event series, participants were given a recognition memory test. If they had seen the slides as an ordered series, then they would incorrectly say they recognized slides they had never seen, as long as test stimuli were coherent with the depicted event. They remembered the event, not the slides. Only in the case of the control (party) slides were people good at recognizing details such as changes in the station-point of the camera. In the acquisition phase of another experiment, people were shown a series of faces in profile, half looking left and half looking right. People had difficulty in recognizing reversals in the subsequent memory test. However, if they had originally seen the profiles in the context of a meaningful event in which action and dialog flowed between left and right, then they were highly accurate at recognizing reversals (Kraft and Jenkins, 1977). Jenkins et al. (1979) reasoned that "event fusion" (a concept from S.C. Pepper) was the critical factor in these experiments:

> Any invariant of the visual experience or any invariant of the event has a high probability of being picked up by the participants in the experiment and made one of the constituents of the event . . . events generate their own significant criteria. (p. 230)

While stated here as a conclusion about research findings, the claim that events point to or define the important representational criteria or categories (rather than the other way around) has important implications, which we will

refer to when we discuss the contextualist approach to knowledge representation.

Contextualist Learning Theory

Another consequence of the event ontology for a psychology of learning is a tendency to adopt concepts from evolution and biology (as was the case for functionalism). An example of such theorizing for the comparative psychology of learning and motivation is the work of Johnston and Turvey (1980). They reject the assumptions of earlier psychologies of learning, assumptions about "laws and learning" and the explanatory power of concepts such as conditioning and reflexes. Instead, learning is described as a form of adaptation which falls on a scale that ranges from avoidance of obstacles in one's path on a second-to-second basis, to learning over the course of years about the location of food and water sources. Even beyond that, the processes which go on over the course of evolution of biological and psychological systems can be regarded as "learning" (see also Bransford, Franks, Morris, and Stein, 1979; Lockhart, 1979; Mace, 1977).

Jenkins (1975) has also rejected the assumptions of the psychology of learning of the 1950's and 1960's—that words, or sentences, or whatever are *the* fundamental units for remembering or for language, and that associations are *the* glue that puts words or ideas together. According to Jenkins, the failure of cognitive science to obtain unification of principles is because not enough constraints are being used in theorizing and the wrong kinds of constraints are being placed on research strategies. Most of the constraints on experiments come from theoretical considerations about specific phenomena:

> Thorndike's cats could not be anything but "trial and error" learners, Tolman's rats learned cognitive maps, and so on . . . . I do not want to suggest that the experiments are "untrue." Obviously they do tell us that subjects can behave in certain ways under certain circumstances. This will be of interest to us if the circumstances are interesting, or important, or highly frequent. But if the circumstances occur only in the laboratory, the experimenter must take on a considerable burden of justification . . . . (Jenkins, 1980, pp. 218-222)

While tending to use organicist metaphors (such as learning as adaptation), a contextualist learning theory must necessarily reject the Cartesian notion that learning results in mental copies of the world. There are phenomena of remembering, but the contextualist does not automatically assume that there is a single "laws of learning" explanation, nor that an explanation must be stated in terms of stable dispositions of the organism to either represent in a certain way or to process in a certain way. To the contextualist, to ask for *the* lawful relation is to ask the wrong question. The laws will be relative and they may only rarely be simple (see Turvey, Shaw, Reed, and Mace, 1981). The regularities in learning phenomena will depend on (1) the type of participants

who are being studied and their background knowledge, (2) the nature of the learning materials, (3) the types of tasks that orient the participants to the materials, and (4) the types of tasks that are used to assess learning (Jenkins, 1980). Rather than looking inward at a person's hypothetical memory representations and processes, the contextualist looks outward at what the experimental tasks might be doing to the participants and especially to what strategies they might be adopting. One will not be able to leap from specific situations to broad generalizations: For each domain of learning, research will be needed to find out what the important variables and events are. No laws will necessarily be transposable from one domain to another. Lawfulness at one level of description may break down or be transformed at other levels.

We will return to the problem of learning when we discuss the contextualist approach to memory representation. Our purpose here has been only to exemplify contextualism in terms of its approach to research on learning.

To summarize, some aspects of the learning research strategy of contextualism are: (1) The perceptual learning which the researcher must undergo to specify the event structure for the domain; (2) research on perceptual learning and expertise; (3) research on learning based on real-world constraints and contexts; (4) contextual relativity effects in comprehension and remembering; (5) "event fusion" of specific experiences into generative conceptual knowledge; (6) research on memory for events, event cognition, and event recognition; (7) sensitivity to the complexity of the evolutionary and biological constraints on psychological systems; (8) domain-specificity of event lawfulness; (9) rejection of the notion of "universal law"; and (10) adoption of a notion of disorder.

Contextualist research on learning has served as our first example of a specific contextualist science. It seems to be the clearest case available. We can turn now to a discussion of another example: The science of "ecological psychology" of perception.

Ecological Psychology of Perception and its Relation to Contextualism

The perception theorizing and research program of James Gibson (1977, 1979), of Gunnar Johansson (Note 17 and 18) and their students affords a good example of how rhetorical analysis can be put to work to express and contrast philosophical views and assumptions. According to the information processing view, the world provides bare sensations to which the nervous system must apply inferences and memories in order to derive percepts. To Gibson and Johansson, light does not provide bare clues or cues at all: the optic environment is a "*sea*" of light, defined over spacetime, which will have a specific dynamic pattern from any one point of view. Rather than adopting static retinal images as the starting point for visual perception, Gibson's theory takes ecological events as the starting place.

The Ecological Research Strategy

Gibson proposed that events can be analyzed in terms of "structural and transformational invariants." A striking demonstration of these two concepts is a study of form perception by Peterson (Note 19). Four basic cut-out figures (a square, a circle, a triangle, and a cross) were used. Composite figures were constructed by first putting the basic figures into various pair combinations and then partially overlapping the members in each pair. These overlapped pairs were used as the templates to cut out their composite perimeter. When presented (via slides) in an appropriate ordering, the perimeters would depict an event in which one of the figures could be seen to move "in orbit" around the other figure. When the ordering of the slides was disturbed, not only was there a loss of the perception of the orbiting event (a transformation of position which is rule-governed in that it leaves certain things unchanged), but there was also a loss of the perception of the two basic figures themselves (the structural invariant).

The analysis of motion and optic flow patterns (e.g., in terms of motion-oriented vector fields) is a basic aspect of the ecological research strategy. A demonstration of the flow concept comes from work by Lee (1979) and his colleagues using the "swinging room" apparatus, a ceiling and four walls which are suspended from above. Adult observers who stand in the room facing one wall can be made to sway as it looms towards them and swings away. Observers who walk forward while the room motion specifies backward motion report they feel as if they were walking backward. Infants who stand in the room can be made to fall over by the slightest glance at the swinging walls. Through the analysis of optical flow fields, Lee and others have been able to show how the "time to contact" of an observer with something in the world (e.g., a moving baseball) is directly specified in the dynamic optic information. This and other mathematical specifications are useful tools for the analysis of complex skilled motions (e.g., long-jumping, ski-jumping, etc.).

Much recent research on human motion and motion perception has relied on a fascinating dynamic display which is called "the point-light person." A person wearing dark material is filmed at high contrast against a dark background. The actor engages in motions while wearing a dozen or so small lights or strips of reflective tape at specific locations on the body (now, such displays are often computer generated). If the light sources are located at the joints (i.e., ankles, knees, hips, wrists, elbows, etc.) then inspection of the display results dramatically in the immediate perception of a moving person. If the lights are at off-joint locations, then the "person" disappears (structural invariant) and so does the perception of the movements (tranformations) which define the invariant structure—the display resembles a random blob or swarm of points loping across the field. Cutting and his colleagues (see

Cutting, 1981) have shown that observers are very sensitive to the information that is specified by the human gait. The gender of the walker and even specific individuals can be recognized through point-light displays.

What might be regarded as static structure from the information processing view can also be regarded as event or transformation-defined structure. Todd, Mark, Shaw, and Pittenger (1980) have demonstrated this for the case of the perception of the aging of faces. In one of their experiments, a set of computer-generated outlines of heads and faces was used to represent various types of transformations of shape (i.e., strain transformations on angles, shear transformations, polar coordinate transformations, etc.). The stimuli were presented in subsets of three, and the participants' task was to select which of two alternative faces was most similar to a target face. By arranging the alternatives appropriately, it was possible to demonstrate that people are readily able to perceive the similarity between faces which undergo aging (strain) transformations. This research is yielding precise analytical techniques which are actually proving to be of use in cranio-facial surgery. In order to treat a misfiguration, the surgeon may have to actually over-correct, but just enough so that the normal developmental process yields a good final form in the years following the surgery. Shaw et al.'s psychological research has led to mathematical techniques for describing that process and the final form toward which it points.

Another aspect of the ecological research strategy is the general prediction that perception should be tied to the ecological coherence of events. An excellent example of laboratory research on objects at an ecologically relevant scale is Runeson's (1975) experiment on the perception of motion. In his video display, a luminous ring moves downward, on each trial colliding with a ring that moves horizontally. The collisions would occur behind an occluded region of the field, and the participant's task is to predict the collision times by pressing a reaction time button. The falling rings were made to move in different ways: constant velocity motion, accelerated motion, natural motion (i.e., diminishing acceleration), and a decelerating motion. The results held even for people who were told of the hypotheses and instructed to "correct" their judgments: Only the natural motions appeared to have constant velocity, the motions with actual constant velocity appear to speed up and slow down. People's perceptions were in terms of natural events such as falling, braking, and pushing, rather than in terms of physical dimensions of acceleration and velocity. Only for the natural motions were participants good at predicting the collision times.

Research on auditory perception at an ecologically relevant scale is exemplified by experiments by VanDerveer (Note 20) and Warren (Note 21). VanDerveer found that errors in the identification of such sounds as hammering, scratching, knocking, jingling of keys, and the like, could be related to invariant information in the acoustic signal (i.e., temporal patterning in

amplitudes). People are quite good at identifying the type of event involved in the production of various sounds ("striking," "rubbing," and the like). The more alike in temporal patterning two sounds are (e.g., hammering and knocking), the more likely people are to confuse them. Warren's experiment was on the sounds made by bouncing and shattering glass bottles. The sounds made by dropping individual pieces of glass were synthesized into composites. Again, people were quite good at identifying the types of events involved, in this case, events such as whether or not the bottle had a resonant note as it shattered, whether a bouncing bottle was a large glass jug or a small plastic bottle, etc. Much more such ecologically relevant research on auditory perception can be done.

According to the ecological view, perception and action are fundamentally connected and constraining of one another. There will be a constant push toward taking supposed "cognitive" phenomena and rendering explanations and research in terms of event perception and effective action (Turvey, Note 22). An excellent example of this is recent ecological work on speech perception (Studdert-Kennedy, 1981). As classically posed, a problem for a psychological theory of speech perception is to explain how the perceptual system goes from the continuous physical stream to the perceptual awareness of the speech categories called phoneme sounds. Recent research on the production and comprehension of speech has led some researchers to entirely restate this classic problem in ecological terms. The perception of on-going speech involves the awareness of separate phoneme "*codes*" only in the cognition of people who are trained to believe that alphabets map into "*speech sounds*" (Repp, 1981). The speech signal is not a series of sounds like beads on a string; it is the outcome of complex events in which coarticulation during production results in an incredible complexity in the speech signal. No one combination of amplitudes and frequencies will ever represent a given "*speech sound.*" There are commonalities however among the various manifestations of a given perceptual category, and the only thing that consistently describes these commonalities is the articulatory apparatus itself and the events which occur in it (Studdert-Kennedy, Note 23). Ecological psychology is pointing researchers toward a commitment to realism and to ecologically relevant descriptions of perceptual situations and away from a reliance on Cartesian hypothetical cognitive mediational mechanisms (Mace, 1983).

Gibson's Orientational Metaphor

To psychologists who were trained in the classical Helmholtzian tradition (many of us), the Gibson theory is definitely curious. Gibson transforms the relation of perception and cognition. According to Gibson, information does not "*come into*" the mind. Rather, according to Gibson, perceivers actively "*reach out,*" "*sample,*" "*pick up,*" and "*contact*" the available information.

Rather than having impoverished stimuli undergo "*higher and lower levels of processing*" with conscious experience being of a constructed mediator, Gibson has experience reside a bit closer to the world in "*direct perception.*" "*Indirect perception*" occurs when the conscious perceptual experience is of an internal representation which manifests an input that has been altered or has had something added onto it ("adumbration") by the operation of memories and inferences (Shaw and Bransford, 1977). Gibson's claim is that a percept is not a product of conscious inference, but direct.

The concepts of direct perception and direct realist epistemology are complex philosophically, and deserve more analysis that can be presented here (cf. Dumett, 1982; Gyr, 1972; Horwich, 1982; Oatley, 1978; Putnam, 1982). In the present paper we tie these concepts to discussions by modern researchers. They refer primarily to (1) experiences such as Jenkins's example of feeling the screw while using a screwdriver and Gibson's example of direct perception of events, and (2) Gibson and Johansson's notion that there is knowledge (i.e., inquiry) which does not rely on inference (i.e., perception as it is classically defined). A contextualist psychology admits that conscious inference occurs and must of course explain such phenomena in order to be complete. However, contextualism would question whether unconscious processes should be called "inference" and whether either conscious or unconscious adumbration is always necessary for perception, learning, or action. Since contextualists take events in the world as being both real and informative, there is no push to claim that all knowledge must be either direct or indirect. To Jenkins, Gibson, and the others, this is actually more of an empirical matter than a philosophical issue, since so little is actually known about the ecological physics of events and the process of perceptual learning.

The concepts of direct and indirect perception as discussed by philosophers and psychologists are, we claim, fundamentally reliant on a basic and usually implicit metaphorical notion about the nature of consciousness.

The notion of direct versus indirect knowledge or perception makes most sense from the standpoint of our underlying metaphoric understanding (the orientational metaphor theme) that "*Consciousness has a spatial orientation and relation to the world.*" Lakoff and Johnson (1980, 1982), Reddy (1979), and Roediger (1980) reported on their analyses of hundreds of utterances that are about communication and cognition. Language about cognition can be categorized according to variations on the theme of a spatially oriented "*conduit.*" For example, common metaphorical utterences such as "The words carried great weight," "The concepts got put into words," "The words held no meaning for me," and "I didn't get anything out of it" all relate to the metaphor theme that "*Words and ideas are objects which contain meaning.*" Sentences such as "That thought really sunk in," "His meaning got across well," and "The ideas just poured out" all relate to the theme that "*The mind is a container and communication is the transfer of objects.*" According to the theme

that "*Consciousness and control are up, the unconscious and controlled are down,*" one can say "He sank into a coma," "It was a shallow trance," "He was under her thumb," and similar utterances.

Recently, Pylyshyn (1980) has offered a new distinction which exemplifies the orientational theme as it occurs in scientific psychology. Pylyshyn distinguished mental phenomena which are "*cognitively penetrable*" from those that are not. Phenomena which can be felt or experienced are ones which can be influenced by learning, beliefs, knowledge, and the like. By definition, any such phenomena must be at least partially mediated by cognitive processes. According to Pylyshyn's distinction, the border between perception and cognition resides in the organism and can vary somewhat in its orientational distance from the world.

The reason why Gibson's theory of information pick-up seems curious perhaps now becomes more understandable. He does not discard our usual interpretation (the orientational metaphor) of consciousness and perception; he changes the *direction* of the orientation, as his metaphors suggest (see Gibson, 1975, p. 310; Turvey, Shaw, Reed and Mace, 1981, p. 242). Figure 1 shows how information processing and ecological theory each interpret the orientational theme. The perplexing thing about Gibson's theory is not that he throws out our usual (and implicit) understanding of the mind, but that he twists it around, as Figure 1 suggests.

Ecological Theory Versus Information Processing Theory

If Gibson's criticisms of the information processing view were to be boiled down to a single sentence, it might be this: "The Cartesian-Helmholtzian mechanistic tradition is guilty of misuse of a metaphor—it took an apparently cognitive phenomenon (inference-making) and made it the paradigm for explaining all psychological phenomena, including perception." The dependence on the event ontology together with Gibson's rejection of the mechanistic and formistic categories of information processing, imply that Gibson's ecological science can be taken as an example of the general contextualist world view.

As the vertical boundaries in Figure 1 are intended to suggest, Gibson separates the psychological problems of cognition and inference from the ecological problems of perception and effective action (Turvey, Shaw, Reed and Mace, 1981). As a research strategy for perception and action, ecological theory avoids reliance on memory stores and inference operations. The problems of a psychology of perception are not aspects of a psychology of cognition. And yet, one important thing a complete psychology must do is make some explanatory contact with the phenomena of the perception of similarity and difference. At the general world view level, the perception of patterns is itself the experiential starting point for formist philosophies. In this

case, the common experience of perceived patterns is taken as the starting place for describing things in the world. Thus, although a psychological science can be mechanistic, contextualistic, or whatever, it must accommodate the categories of formism—it must allow for them, include them, or explain them in some way. Gibson's theory (1977) does involve formistic concepts, from the Gestalt psychology of perception: The notion of an "affordance," similar to Koffka's (1935) concept of "demand character" and Lewin's (1936) concept of "affordance character." To the Gestalt psychologists, these perceived properties were bestowed on objects by the perceptual

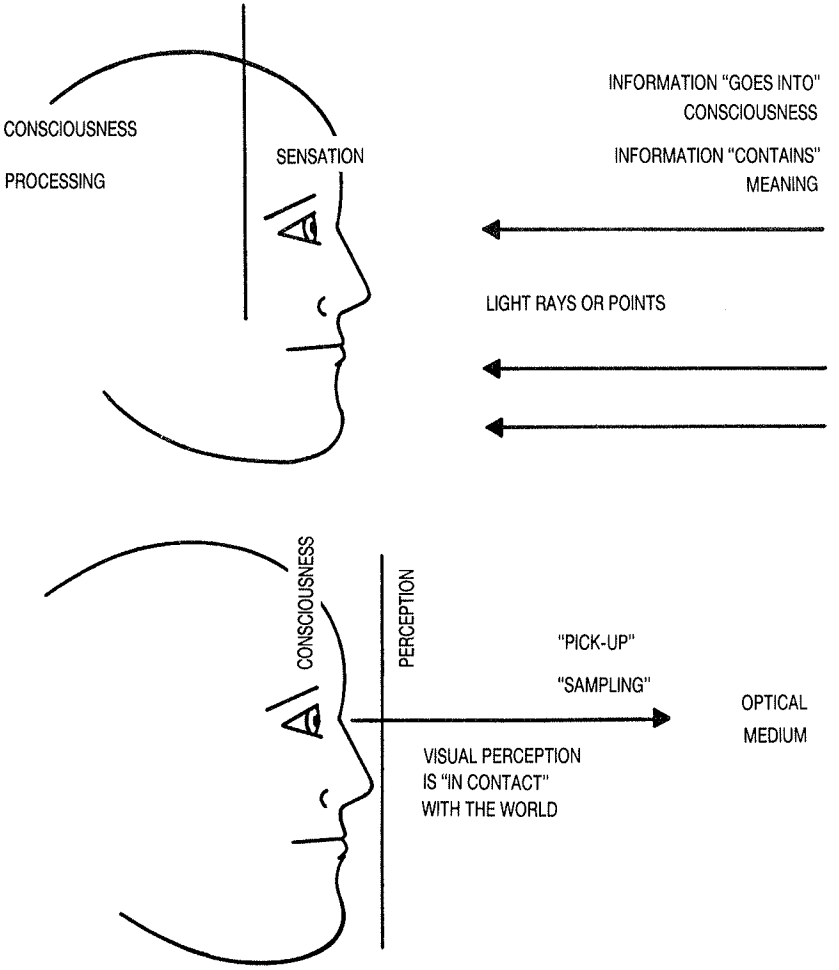

Figure 1. Interpretations of the orientational metaphor theme according to the Information Processing view and according to Gibson.

acts of the observer. To Gibson, affordances are what perception is *of*: Things like the drinkability of fluids, the edibility of food, the graspability of a stick. These affordances are not properties, they are "in" observer-environment interactions, in events (Turvey, Shaw, Reed and Mace, 1981).

It comes as no great surprise that Gibson's work evolved in part from a background in Gestalt psychology. Gestalt psychologists (e.g., Koffka, 1935) emphasized the role of context and "*perceptual and environmental fields*" in the process of interpreting individual features of stimuli.

In a recent paper on the philosophy of the ecological approach, Turvey, Shaw, Reed and Mace (1981) list the following claims, remarkably consistent with general contextualism: (1) There are no bare particulars, only properties, things and affordances (invariants); (2) what is regarded as an individual, class, category, relation or disposition will be context-relative; (3) there are no things that do not change and no changes that take place independently of things; (4) events involve persistences and changes in properties or relations; (5) descriptions of perceiving, knowing, and acting will be disposition-based and event-based.

The relations of Gibson's ecological theory to the world views of contextualism and formism are described in Table 1. The science of ecological psychology shares with general contextualism a preference for dynamics and a preference for looking at the world rather than in the organism. In this sense, both tend toward pragmatic and functionalistic views. Formism regards the world as being composed of independent structures, like hierarchies. Turning away from the world, formism tends towards abstractions and idealisms.

Formism emphasizes the formal or logical validity of all observations and all theoretical descriptions. Contextualism and ecological psychology, on the other hand, focus on the relevance of descriptions to ecology and context. To perception researcher Egon Brunswik, "ecological validity" was an important variable aspect of observation situations. It referred to the interrelations between potential cues and proximal stimuli, and was a thing to be studied in and of itself, and was not a property of research designs or theoretical descriptions (Brunswik, 1952, 1955).

In recent years, the concept of ecological validity has been misused; it has been taken to be a necessary aspect of a piece of research in order for that research to be ecological. Thus, to some, the point-light display seems to contradict the ecological spirit by being "artificial." A given experimental condition, experimental design, or stimulus display may or may not be representative of the organism's ecologies; it may or may not be relevant to ecologically valid descriptions of psychological phenomena. Presumably, any theory in psychology must ultimately be ecologically valid. That is, it must relate to the organism's ecology (Shaw and Bransford, 1977; Turvey and Carello, 1980) and to laws of evolution and biology (Turvey, Shaw, Reed and Mace, 1981). Nonetheless, a specific experiment or design need not be

Table 1

The Relations of the Gibsonian Ecological Psychology of Perception to General Contextualism and to General Formism

	ECOLOGICAL PSYCHOLOGY	CONTEXTUALISM	FORMISM
METAPHOR THEME	"Perception is of events"	"The world is events"	"The world is patterns"
EXPERIENTIAL BASIS	Direct manipulation of the environment and participation in events	Relatively bounded salient events such as histories, novels, drama, plays	The perception of similarity and difference
ONTOLOGY	Persistences and changes, which, taken together, define invariants	Events and change, which, taken together, generate emergent novelty	Particular forms and their qualities, which, taken together, define classes and propositions
EPISTEMOLOGY	Realism	Realism	Idealism
UNITS FOR THE OBSERVATION LANGUAGE	Invariants and affordances	Units to be event-defined and relative to the observer's purpose	Attributions, propositions, symbolism, features, etc.
FORM OF JUSTIFICATION	Ecological relevance, validity, and reliability	Ecological relevance, validity, and reliability	Logical validity, consistency, and completeness

representative of the ecology (even though an experimental procedure consists of events, they may or may not be relevant to actual ecological situations, and they may or may not appear consistently in various ecological settings). The point-light display is an *ecologically relevant* display in that it is directly generated by biological actions. The display is not *ecologically representative* in the sense of not being something that people usually perceive. However, the display manifests the invariants which underlie human motion—it preserves relations between elements in the stimuli. This is in fact exactly what Brunswik meant by the *ecological validity* of a display. The display is also *ecologically reliable*: observers can identify the point-light-person's gait, body build, gender, and other information (Runeson, Note 24). In the actual point-light experiment, the demonstration itself consists of *violating* the condition of ecological validity (i.e., locating the lights at off-joint locations) in which case the coherence of the percept is disrupted.

To ecological science and contextualism, research itself should justifiably pertain to or say something about what the organism is capable of doing (ecological relevance), whether or not it is something the organism usually does (ecological representativeness). Individual experimental designs do not necessarily have to possess ecological validity; it is at the level of theoretical explanation where the strict criterion of ecological validity must always hold. Even so, some of the statements in a theory may refer to events which are not ecologically representative (i.e., events which occur only in the lab).

We are now in a position to contrast general contextualism with the information processing view on cognitive ground, namely in terms of their respective approaches to the problem of the representation of knowledge.

The Metaphors of Cognitive Science

Lakoff and Johnson (1980) define metaphor as a form of understanding in which "one thing is taken to stand for or model something else." In a recent monograph on cognitive theory from the perspective of artificial intelligence, Palmer (1979) defines theoretical representations as "the understanding or experiencing of one thing in terms of another." The parallel between these two definitions is striking (and in fact is what initially led us into our analysis of the metaphors in experimental psychology). Both metaphor and representation have to do with the experiencing of one thing "as if" it were something else. Some theorists define metaphor as a comparison or analogy that is drawn across different domains. So too have theoretical representations been defined as analogies that go across separate domains. Just as there are "semantic feature mapping" theories of the meaning of metaphors, so too are there feature-mapping theories of the logic of representations. It is often said that a theoretical representation is incomplete—that it will only capture some aspects of the represented world. A similar point has been made about metaphor (e.g., Eberle, 1971, p. 230). Like metaphor, a representation may

differ in perceptual form from the represented world and it may omit some important features of the represented world. Representations have thus been said to "*hide*" information at the expense of focusing the user's attention on certain salient aspects.

What all these parallels between metaphor and representation suggest of course is that philosophical and psychological problems involved in theorizing about representation *are* problems with metaphors.

The Rhetoric on Image and Propositional Representations

The recent debate on the nature of imagery and propositions is our paradigm case of the information processing approach to a specific scientific problem involving representations.

Introspection provides very good evidence for the image phenomenon—as in the task of mentally counting the windows in one's home. A common assumption of imagery theories is that images are "*picture-like.*" They seem to be "*scanned in parallel.*" They have been described as "*drawings,*" "*working spaces,*" "*blackboards,*" "*scratch pads,*" "*constructed possible worlds,*" and it has been said that images can be "*dim,*" "*sharp,*" "*fuzzy,*" "*focused,*" "*clear,*" and "*fragmentary.*" Our language for describing images is a language of pictures and objects (Pylyshyn, 1973). "*Mental rotation*" of images is a term that fits with phenomenal experience. One can change one's perspective on an image in such a way that spatial relations are preserved while orientations shift. In the classic experiments (Shepard and Metzler, 1971) the time it took people to mentally compare drawings of three-dimensional shapes which appeared in different orientations was a direct function of the angular separation of the two depictions of the object, as if people mentally rotated the image in order to compare the two views.

Critics of the picture theory have pointed out that while images may feel visual, they are not copies. When we try to draw the Charlie Brown cartoon character from memory, we may forget what his nose looks like, but if given an outline of his face, we can more easily reconstruct the nose shape. The picture theory implies that mental images are "*raw*" and need analysis or interpretations when in fact images already are interpretations (Kosslyn and Pomerantz, 1977; Pylyshyn, 1973). Images can leave out relations, details, and qualities that pictures cannot leave out. Images are influenced by beliefs, expectations, and prior knowledge. Furthermore, mental images can add on non-pictorial aspects such as causation and fantasy (Verbrugge, 1980).

Anderson (1979) argues that the picture theory is a workable one, a flexible one, one that can profitably be used to generate research. Other theorists have criticized the picture theory by saying, "It's only a metaphor" (e.g., Paivio, 1976; Pylyshyn, 1973). Theorists use the metaphor to specify the ways in which images are like pictures, but then other theorists use the metaphor to specify ways in which images are not like pictures. Pylyshyn claims that the

picture metaphor hides issues implied in the notion that images are perceived. And yet, Pylyshyn used the metaphor to systematically reveal what the metaphor supposedly hid. The metaphor is doing exactly what a scientific metaphor is supposed to do: generating theoretical classification systems and ideas for experiments. The metaphor can also be used to specify the ways in which the theorizing needs further refinement. The fact that metaphors sometimes seem "wrong" is one of their great virtues—a metaphor in science is a process of showing similarities and generating new research ideas.

Many in cognitive science argue that perceptual and linguistic meaning is represented with propositions (Anderson and Bower, 1972; Field, 1978; Kieras, 1978; Kintsch, 1977; Kosslyn and Pomerantz, 1977; Palmer, 1979; Pylyshyn, 1973, 1980). In general, a proposition is defined as a statement with two terms that are connected by some relation, an "*atomic fact*" with truth-value. Some authors consider associations or binary relations to be propositions. This is a formistic metaphor—reason consists of symbol manipulation. With propositions one can represent any type of information (logical validity as justification—see Table 1). Since people can give a verbal description of an image, there must be some common representation, some sort of "*interlingua*" or "*common code*" in which using images is like "*assembling a structure*" (Kieras, 1978), like assembling a "*semantic net*," or using a "*workspace for building a data structure*" (Pylyshyn, 1973).

Words are invariably used to express propositions, accessory logical symbols not withstanding. "Proposition" is no less a metaphor for representation than picture is a metaphor for imagery. Introspections reveal considerable evidence about imagery—people "have" images. The phenomenal counterpart of the abstract proposition metaphor is that "thoughts can have the quality of being feelings or judgments" (Brentano, 1874; James, 1890; Pillsbury, 1908). Hence, predication, relation, and other abstract formistic logical concepts can be applied metaphorically to describe how thought and judgment work (modern symbolic logic arose from attempts to describe the rules for proper thought or argument; Boole, 1854). Advocates of the proposition theory claim that the picture metaphor demands some internal homunculus who can interpret the picture/images. But their own computational metaphor demands a homunculus who can "*call up*" subroutines and who can "*make*" inferences about picture fragments and relations. Both approaches are metaphorical. Our point here is that theorists are taking up metaphors for representation and using them—to critique other metaphors, to generate experiments and to refine theorizing.

The Rhetoric on Template, Prototype, and Schema Representations

One may wonder whether the information processing view offers any literal concepts. Consider the concept of a recognition template. A template is, fundamentally, a stencil with an outline form cut out from it. Upon shining

a light through a stencil one casts a shadow which can be compared to the shape of an input or test pattern. It is commonly held, although there are few explicit arguments, that a prototype can be a template, or that templates can be prototypes. Some call prototypes sets with central tendencies. The representations do differ in terms of their basic metaphors. The metaphor for prototype is that of an idealization or an "*average*" of a set of patterns. Prototypes express the form that is common to all or most instances of a class. Templates are in a sense prototypes, for a template will recognize best those instances that most resemble the stored pattern: A template is a prototype by fiat.

One of the most important hypothetical mental representation formats is the "schema." It is generally assumed that schemas are learned through a process of abstraction or concept formation which can occur even without exposure to a prototype or a template (Evans, 1967). A schema, if defined as a family of related instances, may or may not have a prototypical member in the family. However, if a schema is defined as a set of instructions for producing instances of a family then the rules would describe an abstract prototype in terms of most commonly occurring characteristics.

Historically, schemas were regarded as wholistic, abstract representations of patterns that underly movements and perceptions (Attneave, 1957; Keele and Posner, 1968). As defined by neurologist Henry Head (Head and Holmes, 1911) schemas are: ". . . that combined structure against which all subsequent changes in posture are registered before they enter consciousness . . . . We are always building up a postural model of ourselves . . . . Every change is recorded on this plastic schema" (Head, 1920, pp. 605-606). Bartlett (1932) gave an example of a motor schema, that of the tennis player's swing—which never exactly repeats itself and yet is never exactly novel.

The concept of a schema is an abstract conceptualization of mental representations—a dynamic pattern which may only be approximated by individual instances. Barlett described schemata as "*memorial preservations*" or "*storehouses of mental contents.*" Also, schemas were believed to have "*forces*"—to play a causal role in mental events. Furthermore, consciousness can involve "*turning around on one's own schemas*" in deliberate searches of one's own memory (p. 206). Barlett's primary desire was to explain the reconstructive aspect of remembering: The memory schemata are constantly active in organizing the perception of events.

In modern cognitive theories, schemas are regarded as plans or formats that allow efficient information processing and storage (Neisser, 1976; Rumelhart and Ortony, 1977). Schemas have been called "*skeletal categories*" (Paul, 1967). As an abstract concept, a schema can contain just about whatever the theorist wishes them to—practice effects, spatio-temporal qualities, even intention (Northway, 1940). For example, to Schmidt (1975) a schema is a "*rule*" (p. 233), a "*set of abstract information*" (p. 235), and an "*agent that generates responses*" (p. 236). In Schmidt's theory, the schema-boxes in the

information processing diagrams are both memories and intentional agents. Schemas are not static: they "*coordinate*," they "*integrate*," and they "*generate*." They can also be "*strengthened*" due to knowledge of results.

The formistic pattern-oriented schema notion is quite coherent with information processing theories. Schemas have two critical characteristics. First, they provide a ready-made explanation of the perception of patterns, of Gestalt-like perceptual acts, and featureless family resemblances—aspects of perceptual form which seem beyond the grasp of some feature-analytic information processing systems. Second, their internal structure is rarely specified, and for such cases there must always be some experimental phenomena that the schema concept will fail to capture.

The general point which seems to arise from the survey of the metaphors of cognitive science is a notion that strikes a chord in the heart of the contextualist: Different hypothetical metaphorical representation formats get invoked by different researchers to get at different aspects of psychological phenomena for different purposes.

Knowledge Representation and Artificial Intelligence

The general metaphor theme that is used in cognitive science to describe representations is a combination of the formist and mechanist philosophies: "*Representations are containers for information and processes which preserve perceptual or symbolic correspondence to forms in the world.*" An exemplary manifestation of this theme is theorizing about cognition from the perspective of artificial intelligence by Palmer (1979). He defines representations as logical "*information mappings*." Since such mappings preserve information about the world, they can be analyzed in terms of relative "*computational efficiency*" and "*equivalence of information content*." The formist-mechanist view is quite clear in Palmer's treatment of representations.

To be certain that our claims about the formistic-mechanistic theme apply to the field of artificial intelligence in general, we analyzed the content of a recent *Issue on Knowledge Representation* of the journal of the *Special Interest Research Group on Artificial Intelligence* (Brachman and Smith, 1980). We quickly gave up on counting metaphors, as opposed to apparently literal claims or hypotheses since most of the statements were clear-case metaphors (i.e., "*access skeleton*," "*combinatorial explosions*," "*systems hygiene*"). We identified over 350 common expressions and found that they fit into the same metaphor themes which stemmed from our analysis of the metaphors in cognitive psychology. Just a few examples of these scores of metaphors are, "*Programs have a logical architecture*" (buildings and structures); "*Ideas can be embodied as formal objects*" (object entities); "*Cognitive maps can be made of associative links and notes in a tree-like structure*" (paths and trees); "*Computers use computational languages and primitive vocabularies*" (abstract metaphors on

language); "*There are mechanical procedures for making inferences*" (machines); and "*Computers manipulate information, activate entities, and look for interpretations*" (causality and intention).

The Representation of Temporality

According to Fodor (1979) and others, language comprehension involves the "*computation of functions.*" Representations of meanings get assigned to stimuli by means of "*rational calculation.*" Fodor claims that he wants to avoid reference to consciousness or intention in composing linguistic transformational grammar models, but he cannot avoid such references. Since the language humans use to talk about the mind is now the language we use to talk about computers, and since the language of computers is now the language we use to talk about the mind, there is no way to avoid talking about linguistic rules and models except in terms that sound suspiciously like psychological processing models. The metaphoricity of information processing theories shows most clearly when one explicitly attempts to inject time and process into the processing schemes (Newell, 1972).

If time is halted and allowed to run forward in steps, one can imagine a process as a sequence of states (representations) and transformations (operations). Static representations (for example, the contents of a hypothetical long-term memory) are in "*frozen time*" insofar as time, change, and process are frozen out. In a theoretical representation of such a memory, there need be no indication of temporality (this is the case for most actual written memory representations which cognitive scientists rely on). An example would be a proposition list which expresses the "content" of a mental image. Such a list need not contain any information about temporality. As fas as the propositions go, the list exists at any time, or for all time. At the level of frozen time, processes are described as static operators, which themselves must also be represented or stored (since they are manifested in the organization of the thinker). An example would be linguistic rules when taken as process models (e.g., noun phrase + verb phrase = sentence). The transformations which the rule describes could be applied at any time, but once applied, bring about a transformation which must occur over time (at least in the cognition of the linguist).

Representations can take frozen time and "*thaw*" it—show how the statically represented objects undergo discrete changes over time, with temporality indicated as a part of the discrete symbolic form of the presentation. Processes, themselves void of content, would change or adumbrate the represented objects. For example, the list of propositions about a mental image might contain statements which assert that "This data structure was created at time x and existed until time y when process z was applied." In the case of thawed temporality, the changes also involve static entities and

therefore the temporality involves static physical marks: Our conception of the dynamic is a metaphorical static one! The ways in which cognitive science expresses temporality are in terms of statics: "The slices of the system at any given point in time reveal its structure, and what propels it from state to state reveals the processes of which it is capable. What the system contains when not performing can be a process-like object which really plays the role of structure when time for performance comes" (Newell, 1972, p. 138).

To summarize our analysis of the metaphors of cognitive science, problems involved in defining exactly what we mean by the term "representation" seem to involve a set of related metaphors, different ones being invoked to get at different aspects of representations or different phenomena of memory or perception. Cognitive theories have become a Gordion Knot of metaphors: Schemas get defined as sets of propositions, inference-making gets described as the construction of vectors in an n-dimensional semantic hyperspace, and so on, until it seems as if cognitive theories are rather like Dagwood sandwiches—the theorist is perfectly free to choose among representational entities and processes. How does the contextualist deal with the issue of mental representation? The contextualist can talk about representations, but what it is that is being talked about undergoes a transformation from our usual conception.

From "Mental Representation" to Knowledge Description

In the case of contextualist psychology, the issue of mental representation involves two problems. First, how does general contextualism deal with representations? The second is, how does a contextualist psychology deal with representations of memory or knowledge?

Let us begin with the fact that some representations are written theories, diagrams, or programs—things that theorists make and perceive and debate about. The acts involved in creating, using and making judgments about representations seem simple enough in the case of, say, an engineer who is analyzing the effects of stress on concrete. The represented world (concrete) is described mathematically in terms of relevant or important aspects (i.e., the color of the concrete is not very important, its temperature and moisture content is). Theoretical descriptions or representations in general must involve some sort of systematicity—rules or guidelines for describing distinctions and for generating correspondences. In the case of cognitive science, however, the represented world includes mental phenomena. Mental representations must make some contact with mental actions or behavior events, or both. Since a mental representation, as a theory, is out in the world in the form of written marks, and since a theorist can then perceive and interpret those marks, we have set ourselves up to a problem of reflexivity: The perceiver perceiving a flow-diagram of the perception process. The informa-

tion processing theory must represent both the world and the mind by virtue of the ways in which the mind represents the world. But since a mental representation is supposed to be what exists *in* the mind, the written theory is technically a representation of a representation. The problem of representation folds in on itself like the puzzle of sealed bottle that contains its own picture (see also Efron, 1983).

Representing as an Event

The contextualist approach must begin of course by describing representations in terms of various types of *events* (of perspective change and judgment) that are involved in the use of representations. Let us lead up to this by considering again the distinction between symbolic and pictorial representations. The major distinction for representations which currently appears in the literature defines representations as symbols and formulas by contrasting them with representations that preserve the perceptual form of the represented world (i.e., models, pictures, etc.). Notational systems involve "arbitrary" conventions for use and for the representation of functions, properties and relations. They "*decouple*" the representation and the world in terms of perceptual resemblance (Shepard and Chipman, 1970). We could construct a continuum with three-dimensional motion holographs at one end along with motion pictures and photographs. Closer to the other end would be abstract symbolic representations. At one extreme, the representation, like a movie, re-presents the perceptual form of the represented world; at the other extreme none of the perceptual form is preserved. The perceptual form must of course still be the key since a theorist (or user) must go from the perceived form of the written symbols to an experience of meaning or judgment. What is required is a different perceptual and cognitive contribution on the part of the theorist than what is required in the case of representations which do preserve perceptual form.

At the level of such judgmental events, is there anything which seems to hold true about all or most representations, anything that seems generally true about how people use or talk about representations? One thing that does seem to be common to all discussions of representations—be they art, mental representations, symbol systems, or written psychological theories—is an event of judgment in which the form of the representation is taken to stand for the content of a mental phenomenon. This is honest to the etymology of the word: Representations re-present some conception or experience. To some cognizing theorist or observer, the perceptual form of the representation (which could itself be marks on a piece of paper or a process model believed to be in someone else's head) is taken to refer to the content or meaning of an experienced (mental) phenomenon. This state of affairs is depicted in Figure 2. The represented world, which can be of physical objects or events, or of

mental phenomena in the case of cognitive science, is entered into a representation as a perceptible form. The form can be that of written marks, diagrams, programs, or whatever. The observer or theorist must go from that representation to a re-presentation of the concept or meaning that is to be related. Since a representation can be a "mental" representation, it can be regarded as re-entering the physical world not only as a perceptible form, but also as a mental content, thus "closing the loop." This is what cognitive scientists do when they take their hypothetical models as objects of study. In constructing hypothetical mental representations, cognitive scientists may actually be building the most abstract and convoluted form of ontological metaphor.

To make these "judgmental event" concepts clear with an example, suppose that we observe a theorist enscribe some marks on a piece of paper. We do not yet know what the enscription "is" but we can see the perceptual form of the marks on the page. If the theorist were to say: "This is a turtle," we would know only that the marks somehow name, refer to, denote, or point to turtles. But if the theorist were to say, "This describes turtles" we would know that the enscription is not just a name in the sense of referring to a label or to arbitrarily assigned characteristics of turtles. It might refer to the outline form of turtles or it might refer to their vegetarian diet. However, the theorist might further specify that "These marks on the paper describe what people think about when they think about turtles." How people conceive of turtles may not at all be like the perceptual form of turtles since their ideas may be biased or fragmentary. So, the marks on the page are a description of what people might think about whenever they think about turtles. We still might

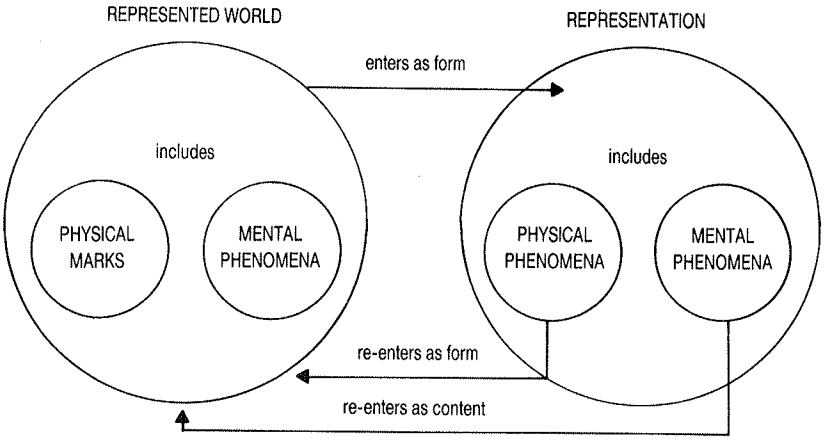

Figure 2. Relations of the representation to the represented world. In general, use of representations involves interpretation by an observer based on perceptual form. Looping occurs since a theoretical representation (written marks) in cognitive science can be a re-presentation of a mental phenomenon.

not have the theorist's perspective exactly right however: "What people *have in their minds* when they think of 'turtle,' *what that thought is*, is very much like these marks on the page."

One begins with an act of *enscription* of marks on a page, a behavioral act of the construction of a perceptible form. Then we changed our perspective in a judgment act which refers to the perceptual form as a *referential description* of aspects of something in the world. Then we changed our perspective again and referred to those aspects as *representations* of perceptible qualities: a re-presentation of that which is also described. We can then change perspective again. Since minds are also in the world, we can have representations be *mental representations*, which technically are descriptions of the mental re-presentation event, descriptions which may or may not preserve the perceptual form of the world. Finally, we can *reify* the mental representation when we take that description of the mental event of re-presentation as *both* a theoretical description and a re-presentation (to the theorist) of the mental event of re-presentation. The theoretical representation of perceptual and conceptual qualities gets stuffed back into people's heads. The theory not only describes what heads do, it is believed to be what heads do.

The basic ingredients for an event of representing seem simple and few (enscription, judgment, and perspective change). It may seem strange to talk about representations this way, since psychology seems to talk easily about them all the time. Common-sensically, if we see an outline shape that is marked on a page as if it were a turtle, then something somehow like those marks must have been "in" the mind as an aspect of the observer's experience.

Reification

The set of mental acts—from enscription to description to representation to mental representation and finally to reified mental representation—is fundamentally a set of psychological acts; the difference is one of perspective. At each shift, the theorist is being set-up to commit the "stimulus error" or the "psychologist's fallacy" by attributing to a mental process exactly those characteristics which the theorist has found useful for the purpose of description. As William James put it (1890, pp. 196-197), it is a confusion of standpoints that commonly occurs in mechanistic psychologies when it is assumed that people's experiences are what the theorist intended or believes are necessary (see Humphrey, 1951, p. 119). The distinction between mental representations (descriptions of knowledge or mental actions) and reified mental representations (which are also assumed to be what heads do) is important in this regard (Johnson and Malgady, 1980). The single term "representation" is used to refer to both perspectives. It is so easy to slip from one meaning to the other, with the result that no theorist can be certain of what another means. Perhaps cognitive science does not emphasize the differ-

ence between knowledge description and reified mental representations because of the tendency to define representations only in terms of informational equivalence. Information is supposed to be real and representations are supposed to carry it.

To drive home our claim that cognitive scientists seem blind to such ontological assumptions, we present but a single example passage:

> There are several possible ways to introduce integration as a property of propositional representations. One approach to integration is that a well-integrated memory structure is simply one that has many redundant connections that firmly tie the material together and also connect it with permanent memory information (cf. Norman, 1970). A second approach is an assumption that the links in a representation are not retained or lost as a group . . . a third approach is that configural nodes represent configurations or combinations of concepts, so defined that they facilitate retrieval only if the cue contains the proper combinations of concepts. (Kieras, 1978, pp. 549-550)

Is this passage about computers or about heads? Are such things enough of a reason for believing that the propositions happen to be the *only* thing heads do? While some cognitive psychologists deal explicitly with ontological issues, many never do.

A reified mental representation has these characteristics of perspective: (1) It is a *written* theory, program, or diagram (enscription); (2) it represents aspects of the *world* (description) by virtue of representing (hypothetically) the ways in which the mind represents the world; (3) it may represent *perceptible qualities*—it must at least represent conceptions (re-presentations); (4) it is a *mental* representation of the events which occur in the mind when the qualities or conceptions are re-presented. Reification occurs when both (1) and (4) obtain. Notice, however, that there is an option in (3). Reified mental representations are sometimes regarded as conscious mental phenomena or representations (i.e., images, visual recognition, etc.) and sometimes as nonconscious entities which are not perceptible forms, such as unconscious inferences, abstract memory schemas, motor programs, and so on (i.e., when (3) is not in effect). Many of the representations which cognitive psychologists rely on are ones that do make some contact with phenomenal experience. A good example is mental imagery and the prevalent picture metaphors. Yet, there is also the experience of "imageless thought." For instance, in comprehending the sentence "The sun sets in the _____" one may be aware only of the content "west" and there may be no awareness of images, propositions or inferences. There may be no representation of perceptible forms except for that verbal content. If some representations can be nonconscious how can one be sure that their theoretical counterparts can ever be honestly reified?

Once one is at the level of reified mental representations, verification of the reification is critical: Some rationale must be given for the reification *other* than the phenomenon which led to the invocation of the representation in the first place. The fact that cognitive science tends to reify its representations and

metaphors is obvious in the voluminous debates about representations (e.g., Haugeland, 1978; Pylyshyn, 1979, 1981). Most of the debate centers on issues of the "psychological reality" of various hypothetical informational processing metaphors, units, grammar rules, and so on.

In reply to claims about images and propositions Anderson (1979) argued that the critical issue is how evidence can allow us to logically discriminate among competing representations to determine which one the head "really" uses. Anderson's reasoning includes these points: (1) There are many categories of types of processes and representations (i.e., according to logic and mathematical modeling theory); (2) any representation of given aspects of the world can be made to behave (logically speaking) like any other representation by altering the processes which operate on them; (3) any process can be made to behave (logically speaking) like any other process by altering the representations on which they operate; (4) therefore, we may not be able to tell, on the bases of experimental data, which of the hypothetical types of representation the head "really" uses.

We can certainly question Anderson's own basic metaphor of propositional reckoning, in which case his logical theorizing may have much more to say about mathematical model theory than it does about cognition. We must certainly wonder where Anderson gets the basic claim that scientists make decisions about theories only on the basis of experimental evidence. What his paper does make clear is that the information processing view offers no free ticket for going from a nice metaphor to a theory of what things the mind is. As Jenkins argued, it seems cognitive science may be underconstrained in its theorizing.

Knowledge Description

The contextualist's response to the reification debates is one of wonderment. There appears to be no end to the philosophical distinctions we might draw. While metaphors are undoubtedly necessary in scientific problem-solving, events in the world are so complex, and theorists so clever, that there must be additional constraints placed on our theorizing. Otherwise, there is no end to the metaphors and eclectic combinations of metaphors when it comes to talking about mental phenomena in ways that are not rigidly tied to the explanation of specific experimental outcomes or effects. If one fails to constrain the purposes or domains of a representation, one can create as many hypotheses or theories as one can metaphors. To the contextualist, the important questions to ask are, "What good is a given representation format to the experimenter?" and "Does a particular representation make any difference to what we do or can do in the lab?" To the contextualist experimental psychologist, representations are descriptions of tasks, instructions, stimulus materials and other contextual factors in addition to the knowledge of the

subjects (as ecological psychologists would put it, theoretical descriptions refer to complex organism-environment interactions in events involving effective action and perception of affordances). The contextualist's solution to the complexities involved in the in-folding of representations is *to not make that final perspective shift*, to maintain an awareness of implicit ontological assumptions and commitments. The world is events and change.

Where specifically are constraints on theorizing to come from? The present analysis of metaphoric understanding and the cognition of scientists has so far suggested these constraints: (1) We understand the world in terms of *distinctions* (Brown, 1972). That is, we chop it up, and the distinctions operate to produce categories and correspondences. An example is the way we represent dynamics in terms of statically represented processes or operations; (2) we understand the world in terms of *metaphors* which get at different aspects of things (i.e., mental and behavioral phenomena); (3) we understand the world by generating *descriptions of experimental outcomes* (selections of stimulus materials, methods, etc.) in terms of the distinctions and metaphors. These three constraints seem to be in effect in cognitive science, and by themselves have resulted in the morass of metaphoric relations which we have charted here. To these three constraints, the contextualist would add another and powerful constraint: (4) A representation must represent some *domain of events* to some *person* (theorist or observer) for some *purpose*. A good representation of a problem for a computer may not work at all for a human. A reason why the debate about representations continues is because different theorists are invoking different metaphorical representations for different purposes (i.e., to get at different aspects of mental or behavioral phenomena).

Contextualism and Computers

Contrary to what some may initially suppose, the contextualist or ecological psychologist does not say to the information processor "throw out your metaphors." The contextualist's criticism is more refined than that. Representations can be metaphorical and instrumental in making research predictions or in solving problems. To use Pepper's example, a blueprint for an engine is not literally an engine, it is a metaphorical representation since it freezes out the event. However, it could participate as a reference in a series of events that lead to the manufacture of an engine. To the extent that the diagram can be verified by effective action, then it is a useful ("true") representation.

Compared to the other world views, contextualism has great freedom in its dealings with representations (descriptions). Some have wondered how the contextualist can adopt, say, affordances or invariants as units for analysis. Indeed, the contextualist feels quite free to adopt alternative units (see Table 1). Rather than looking for a commitment to certain "real" units, the contex-

tualist remains committed to research on events as the foundation for a scientific realism.

By adopting contextualism one does not give up the possibility of describing psychological phenomena in terms of machines or logics: One is constrained however to take machine and logic notions and redefine them in terms of events! The contextualist makes extensive use of formal flow charts (for example, in the description of expert decision-making in the cardiology project), but will not regard these as reified representations. They are "knowledge descriptions" and not ultimate explanations although they may have some explanatory value to some people in some contexts. The contextualist advocates the use of computer models and simulations because one must specify all the necessary control processes that are needed for a given task. Technically, the contextualist advocates research on robotics and not just cognitive simulation because robotics necessarily involves effective perception and effective action as well as effective knowing (see Shaw and Bransford, 1977). Thus, at the same time that the contextualist might adopt a computer analogy to talk about learning or cognition, the contextualist refuses to let constraints on how computers work appear as constraints on how people (or, for that matter, computers) might work.

A good example of this flexible contextualist attitude is Shaw's (e.g., Carello, Turvey and Shaw, 1983) and Jenkins' (1980) treatment of the computer theme. Since one computer can be programmed to behave like another computer, it may sometimes not be possible to tell what kind of a machine a given computer is because it could be simulating the behavior of other machines. Even more fundamentally, the human being is a different type of machine than the computer (i.e., a Turing Machine) in that it has perceptual systems allowing it to transcend the basic capabilities of the machine. Specifically, a Turing Machine is a hypothetical computer which can be programmed to compute solutions to the problems in mathematics and logic which humans can solve. One version of the machine consists of a control device for reading expressions on a potentially unending tape. The reading of an expression occurs as a computation in the device. However, a basic problem for such a simple machine is to know when to stop the computation of an expression of indefinite length. This is called a "halting problem." Suppose, reasons Shaw, we add onto the machine's basic capabilities one more rudimentary skill, that of reading expressions through the layers of folded transparent tape as well as the usual ability to read sequential patterns. The tape reader can not only read the information at the given location, but also the information on the tape position that lies under the given location. Shaw calls this The Folded Tape Machine and has demonstrated that the addition of this simple capability of "depth perception" yields a new class of machines whose computational power differs from that of the standard Turing Machine, in the following sense: While a Turing Machine can compute functions encoded in its lan-

guage, it cannot compile the languages of the Folded Tape Machine. The more versatile Folded Tape Machine could not be simulated by a Turing Machine.

The laboratory experiments of cognitive psychology bring certain constraints to bear on subjects, leading them to behave as if certain types of processes were going on. If the head is to be regarded as a calculating machine at all, it must be regarded as a kind of machine that can *become* other machines depending on the contextual constraints at hand: "When one looks at the models that psychologists build, one discovers, in fact, that they are not models of the mind, but rather, models of the task being performed by the subjects in particular ways, they are only models of a particular strategy . . ." (Jenkins, 1980, p. 216).

What, then, is Memory?

A general contextualist approach can be taken to the problem of saying what "remembering" is (cf. Bransford, 1979). An important consequence of the event ontology and the commitment to realism will be a constant push toward explaining cognitive phenomena in terms of ecological events of perceiving and acting (see Mace, 1977; Turvey and Shaw, 1983; Turvey and Shaw, Note 25). This does not mean that the ecological approach denies or ignores cognitive and linguistic phenomena, nor that there cannot be a general contextualist program of research and theorizing about remembering (see Mace, 1983). Philosophers Goldman (Note 26), Hatfield (Note 27) and Ben-Zeev (Note 28) have recently argued for the accommodation of the notion of direct perception with the mediational mechanisms of cognitive science, claiming that in principle there is nothing wrong with the attempt to do this for the sake of a complete epistemology. As the present analysis of contextualism suggests, however, there may be something wrong with certain kinds of ways of making that accommodation.

Shaw and Wilson (Note 29) attempted to describe an ecological approach to learning in which the notion of direct perception was included in a system which is also capable of manifesting linguistic and memorial phenomena and generative conceptual knowledge. Their proposal combined ideas from formism (memories as abstract perceptual-motor schemas) as well as contextualist principles (direct perception is of events). Neisser (1976) proposed a system in which direct perception occurs along with schema-based anticipations of events and affordances. Thus, rather than making direct perception the fundamental aspect of cognition, Shaw and Wilson and Neisser make it one aspect of a system based on inference-making. To do this, they adopt metaphors from other world views.

A pure contextualist theory of remembering must always explain in explicitly dynamic terms every instance which the information processing theorist provides of evidence for static memory structures. A contextualist approach

to the domain of learning in the context of the purposes of psychological researchers must satisfy these criteria: (1) It must reject the representation/process dualism that is inherent in the mechanistic and formistic categories of the information processing view; (2) it must reject the Cartesian-Helmholtzian dualism between perceiving and acting systems on the one hand, and remembering systems on the other; (3) it must accommodate the four constraints on human understanding (i.e., distinctions, metaphors, static descriptions of the dynamic, and relativism); (4) it must generate an accommodation between the category of direct perception and the categories of the information processing view. The important thing is the exact way in which the accommodation is generated. To assert that the human organism perceives affordances directly and is also capable of mediated perception is simply to produce an eclectic hypothesis which apparently adds very little to ideas about research.

Most hypotheses about memory can be categorized into two basic themes (Hoffman, 1980; Roediger, 1980). These are the static "*stored contents*" metaphors and the dynamic "*trace*" metaphors. It turns out, trace metaphors are historically also a part of the Cartesian heritage of psychology. Descartes hypothesized that perception in the brain involves tubes and fluids. The dynamic trace metaphor likens the brain to a riverbed substrate: Experiences flow through the channel and in doing so, alter it to determine the course of future processing (cf. Hobbes, 1650, chap. 17; James, 1890, chap. 5). Both types of memory metaphor have been very productive of research ideas (e.g., encoding or storage, retrieval, and other hypothetical events involved in the use of containers and the inspection of their contents). However, in order to remain faithful to the categories of contextualism (events and novelty), a contextualist must certainly reject the dualistic static storage systems which freeze time, as being inappropriate to the scale of psychology.

In the history of psychology there has been a series of attempts to rid mentalism of the static language. Brentano's "empirical psychology" is an example, as is "act psychology." Both of these systems involved reference to mental phenomena in terms of verbs such as imagining, judging, remembering, and so on, rather than in terms of the then-current Wundtian mental entities and sensation properties. In his final work, Gibson (1979, chap. 14) also described aspects of cognition in action verb terms. Gibson, Jenkins, and their colleagues do use metaphors for remembering; they use the dynamic trace metaphor and variations of it. To Gibson and the ecological psychologists, the entire organism is an "*attuned*" memory trace. Every aspect of its being, its morphology, its biomechanics, its cognition, its pragmatic actions, all of these involve remembering, or acting with material reliance on the effects of past events. It is *not* necessary for there to be specific isolated acts of the remembering of copies or semipermanent representational replicas in order for cognition to occur. Even memories for words, the psychologist's epitome of hypothetical static entities, would be regarded, must be regarded,

as dynamic capacities: "In a radio, a record is not stored . . . tuning is accomplished by arranging the vibrations . . . proper tuning in the receiver causes a current in it to resonate in response to one of the incoming signals and not to others . . . a radio station is not 'in' the radio" (Michaels and Carello, 1981, p. 63). To this, the information processing theorist might reply that there *is* a permanent structure in the radio which is the material support for the tuning event. The ecologist's response is that the structure of the radio is *not* a static representation of something in the world (as is usually the case in information processing memory models): *If* properly arranged, the radio's structure allows it to dynamically pick up information in the world (Mace, 1977; Turvey, 1977).

It follows from the foregoing that contextualism is constrained to reject representational systems which freeze time. As we indicated earlier, all theories and representations are fundamentally constrained to generate distinctions. Even event-defined representations in thawed time assert at a basic level that "this is different from that." The problem for contextualism which stems from this constraint is, how does contextualism justify its use of particular representations? Contextualism is continually faced with a tension between eventfulness and specificity. The contextualist is not constrained, however, to take representations as anything more than relativistic descriptions. It is the relativity which saves contextualism from paradox. What cognitive science usually regards as representations—either written theories or reified mechanisms—are to contextualism only one part of a process of representing. No representation is a static thing from the perspective of the psychology of its use. Even representations which freeze time (such as Pepper's example of an engine's blueprint) are one part of a larger event-full process.

In order to accommodate the constraint on human understanding that we must "chop up the world," the contextualist seems forced to adopt the category of thawed temporality as the preferred means for describing remembering, acting, or perceiving systems. In any case, the specific way in which temporality will be indicated will depend on the contexts (situational variables) and the theorist's purposes. In other words, relevant events and changes will indicate how temporality is to be expressed, and not the other way around. In the case of learning, the type of acquisition tasks, the type of criterion performance tasks, and the nature of the subject's background knowledge and perceptual-motor learning capabilities will all work to constrain the participant into behaving as if it has a particular type of thawed-time remembering system (Jenkins, 1980).

To get at this another way, suppose we set up a continuum in which direct perception is set at one pole and mediated cognition is set at the other pole. The continuum would be generated as a consequence of the operation of the situational variables. An old distinction in philosophy is between "natural"

representations like a photograph, and representations which rely on rules or conventions, such as abstract logic or abstract art. The latter are apparently arbitrary in form and require inferences for comprehension. These are the cases which Gibson might call "cognition" and separate from his perception theory. We can set the perceiving and acting system at one end of the continuum and our abstract concept of a remembering system at the other end. The specific constraints (methods and purposes) brought to bear in a given learning situation will "set" the subject into behaving as if it possesses a particular type of perceiving-acting-remembering system. On the side of direct perception fall theoretical concepts such as direct comprehension of affordances and "comprehension without representation" (Verbrugge, 1980). Toward the other side fall theoretical concepts such as inference, adumbration and construction. It is important that this accommodation does not put the direct perception versus mediated cognition continuum in the organism—the organism consists of dynamic events. The continuum is placed where it is and where it should be—in a consideration of how we as cognizing beings are apparently constrained to talk about cognition in our scientific theorizing and research.

The injection of context, methods, and purposes into theoretical descriptions allows contextualism to bring to bear its strongest defense against evidence for permanent structures. This is to indicate ways in which they are epiphenomenal of the tasks that are used in the laboratory. For example, how could the contextualist deal with the existence of short-term memory? After reviewing the literature on this, Estes (1980) came to a contextualist conclusion. According to Estes,

> . . . the capacity of short-term memory appears to be small only when we insist on measuring it in terms of discrete items . . . the functional properties of human and computer memories differ sufficiently to make the same method of measuring capacity inappropriate in the two cases . . . in the human memory, forgetting is the progressive loss of precision of information about an event rather than a matter of the total recall or total loss of recall of a stored item . . . even if considerable forgetting has occurred, the individual may remember something about the events . . . . (p. 65)

The information processing theorist might ask, how can anyone deny the existence or importance of iconic (or sensory) memory? To this, a contextualist might reply:

> If by this one means the brief persistence of neural activity that follows the end of a brief, bright exposure, iconic memory certainly exists. And, if by important one means necessary for the superiority of partial-reports over whole reports in post-stimulus recall, it is important. Usually, however, psychologists would want to say a great deal more, explicitly or implicitly, about iconic memory . . . that it is purposive, that its role is to maintain the input while the slower processes of attention and pattern recognition are brought to bear . . or that it is the first stage in information processing . . . statements of this sort are the sources of objection. (Michaels and Carello, 1981, pp. 174-175)

In trying to say what memory "is," contextualism, ecological science and the event ontology point us back in the direction of empirical inquiry, its purposes, methods, and goals.

Conclusions

We believe that this paper has a number of important things to say to both philosophers of science and to psychologists. With regard to philosophy of science, we hope that this "case study" in the method of rhetorical analysis of science has demonstrated how natural language metaphoric understanding manifests itself in complex ways in scientific discovery and justification. Most of the literature in philosophy of science consists of attempts to define "theory" as a static entity with logical meaning that is independent from cognizing theorists. We would claim that the field of philosophy of science is guilty of committing itself solely to a formist approach. Good and proper theories are believed to be literal logical things that can be satisfactorily analyzed for their empirical content with little or no consideration of their psychological context.

Our analysis of the metaphors used in cognitive science reveals how constraints on the cognition of scientists (e.g., the reliance on metaphor) appear as dynamic constraining philosophical assumptions in theories and in research. The analysis of scientists' cognition suggests that a collaboration of philosophers of science and psychologists in a research program on real domains of scientific problem-solving will be more productive for philosophy (i.e., what is inductive inference really?) and more productive for psychology (i.e., does this theory of cognition work for the case of scientific discovery?) than a philosophy of science which focuses on postulational theories and repeated attempts to salvage empiricism through refinements in logical calculi (Weimer, 1979).

With regard to psychology, we hope to have made a number of points. As the analysis of the information processing metaphors shows, much more than informational equivalence is involved when actual theorists invoke and use representations. The metaphors are productive of research ideas; it is the related assumptions that seem to lead toward philosophical debates and away from research.

Contextualism involves a shift in emphasis from a traditional learning theory approach and from a traditional process-modeling approach, to a description of knowing in terms of the situational and task variables which define experimental situations and which constrain subjects into behaving "as if" they possess a particular form of knowledge. Contextualist research on learning emphasizes studies of perceptual learning and perception of events, research on real-world domains of perceiving and acting, and the demonstration of contextual relativity effects in comprehension, recall and recognition memory tasks. In addressing the problems of cognitive psychology, contextu-

alism seems to offer a strategy for inquiry and a theoretical orientation which, at the expense of requiring explicitness of purpose, offers great flexibility.

The principles of a general contextualist world view and the principles of its research strategy can be spelled out, as we have attempted to do here. As contextualists we resist the suggestion that ours is *the* description of contextualism—we hope to promote its research strategy rather than to rigidly define it.

It is perhaps only natural that information processing psychology, predominant for over twenty years, has recently led to voluminous philosophical entanglements and debates, and that it is now being confronted by alternative views. The movements toward ecological research in social psychology and in perception research, the movement toward consideration of ecological and evolutionary constraints in comparative psychology of learning, the movement toward research on perceptual learning and expertise, all hold out great promise for future research in psychology in which there is a "genuine commerce between theory and reality" (Gibbs, 1979, p. 135).

We conclude with a statement by Pepper from the work which not only announced and described but also criticized contextualism:

> We can offer the contextualist this dilemma: Either you must confine yourself to believing only in the facts of direct verification [of events] in which case your theory lacks scope; or if you admit the validity of indirect verification and acquire scope, you must admit that nature has a determinent structure and so fall into the contradiction of both affirming and denying this structure of nature. To this the contextualist's final reply probably is: How can you be so sure that nature is not intrinsically changing and full of novelties? (p. 279)

Pepper would no doubt be extremely pleased to see how his remarkable insights have recently begun to manifest themselves in a host of research projects that seem to be bringing cognitive psychology much closer to ecological descriptions of the full range of the human potential to perceive, to know, and to act effectively in the real world.

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