

COGNITION and REPRESENTATION

edited by Stephen Schiffer
and Susan Steele



A Westview Special Study

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Cognition and Representation

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Cognition and Representation

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Introduction

Cognitive science is an interdisciplinary study of the nature of human information processing. It seeks to describe the ways in which knowledge and goals are represented and the faculties and algorithms that govern the transitions of mental representations in the acquisition of sensory knowledge, and in theoretical and practical reasoning. Cognitive science, accordingly, draws on the traditional disciplines that are concerned with aspects of mental functions: philosophy, psychology, and linguistics, among others.

In 1984 and 1985, the Cognitive Science program at the University of Arizona, with the assistance of the Arizona Humanities Council, invited a number of the most distinguished researchers in cognitive science to present a series of colloquia on the state-of-the-art in their fields. The goal of these colloquia was to identify some of the leading issues and approaches that currently dominate research in cognitive science. This book is a result of, and shares the goal of, these colloquia.

The papers are divided into four groups, each representing a general area of inquiry within cognitive science: The nature and content of psychological theories, Mental representation, Cognitive development, and Semantic theory.

THE NATURE AND CONTENT OF PSYCHOLOGICAL THEORIES

In "Wide Functionalism," Gilbert Harman begins with the assumption that psychological explanation is a kind of functional explanation: the psychological states invoked in psychological explanation are to be individuated not in terms of the physical states that realize them but in terms of the functional roles they

play in a creature's psychology. The question he addresses is whether psychological explanations are typically wide as opposed to narrow psychological explanations. Wide functional explanations appeal to the actual or possible environments of the creature whose activity is being explained, whereas narrow functional explanation "appeals only to internal states of the creature and says nothing about how the creature functions in relation to an actual or possible environment." Adherence to "methodological solipsism" and certain "Twin-Earth" considerations have, Harman claims, led Jerry Fodor and others to hold that psychological explanations are always narrow functional explanations. But, Harman argues, this is wrong: psychological explanations are typically wide functional explanations. He argues that we wouldn't know how psychological states worked if we didn't understand their relation to the agent's environment and to his actions, and that this is why actual explanations in psychology do refer to the environmental causes of, and to the activity caused by, the agent's psychological states. He argues further that narrow functionalism isn't even methodologically coherent and that Twin-Earth arguments for it are unsound.

Harman's position has important implications for the nature of semantic theories for languages of thought, that is, for inner systems of mental representations. Conceptual-role semantics holds that the content of a mental representation is partly or wholly determined by its functional role in perceptual belief fixation and practical and theoretical reasoning. Theorists who maintain that functional role should be construed narrowly are forced to adopt a two-level theory of content: one level will ascribe functional roles narrowly construed and the other level will ascribe a referential, truth-theoretic semantics. Harman, on the other hand, argues that the content of mental representation can be identified with its functional role if psychological explanations are typically wide functional explanations.

How important is the notion of causality to cognitive science? Not very, Henry E. Kyburg, Jr. answers in "Cognition and Causality." Causality, as a category of understanding, may be thought of in three ways: metaphysically, epistemologically, or psychologically. Kyburg argues that the metaphysical role of causality is a lot less significant than is usually thought, that the epistemological role is nil, and that the psychological role is merely of pathological interest. As regards its metaphysical role, he argues that universal causation, as a relation between individuals, can't be a necessary presupposition of science if quantum

mechanics can get along without it. As regards its epistemological role, its role in causal reasoning, he argues that "arguments and inferences concerning causal agencies can be dealt with syntactically by the device of adding and deleting certain sentences in a set of sentences construed as a body of knowledge." If this strategy succeeds, then "an extensional language in which nothing more powerful than mere uniformities can be expressed" will suffice for the representation of all of our factual knowledge.

The psychological role of causality is pathological, Kyburg suggests, in that people employ the notion of causality because they are so strongly oriented toward the manipulation of the world, but this interesting fact provides no special role for causality in rational thought. If we can find no better rationale for the notion of causality than the ones we have, then, he concludes, we should do without it.

MENTAL REPRESENTATION

Edward E. Smith and Daniel N. Osherson's paper is a study of the "compositionality problem" in typicality. Typicality is a relation between an instance and a concept. The instances of any simple concept, where a simple concept is taken to be that denoted by a single word, vary in how typical they are judged to be. Instances of complex concepts -- in particular for this paper, those denoted by adjective-noun combinations -- also vary for typicality. The problem is how to compute typicality for complex concepts from the simple concepts which compose it.

Smith and Osherson reject all versions of what they term the "external" approach (e.g. fuzzy set theory) -- so-called because the computation doesn't depend on the mental representation of the simple concepts. In such, typicality of an instance in a complex concept is a function of no more than its typicality with respect to the constituent concepts. To use their example, on this view, a guppie cannot be a better instance of pet fish than it is either pet or fish. But, Smith and Osherson claim, it is.

They argue, rather, for one interpretation of the "internal" approach. This approach turns on interpreting prototype as an abstract summary that applies to all members of a class. For any attribute associated with a concept, the relevant values are listed accompanied by a probability score. For example, say, that one of the attributes of fish is size. Let's say further that most fish are between two and 15 inches, although there are both smaller and

larger fish. The values associated with size will represent and indicate the relative strength of all these possibilities. Any instance will, of course, fall into one of the three size classes we have established. Given the probability scores, where it falls will allow the computation of its prototypicality. The model presented allows a resolution of the distinction between typicality and vagueness. An atypical instance reflects a judgement of typicality, while an unclear instance reflects vagueness.

Lynn A. Cooper's paper examines the nature of the mental representations and processing operations that contribute to skill in solving spatial problems. Cooper's analysis of cognitive skill is an argument for the existence of multiple cognitive models addressing a single representational problem. Individuals differ in their ability to judge whether different two-dimensional representations of an object are equivalent, i.e. whether they represent the same object. One account of such differences has been that individuals construct the same kind of cognitive model in solving this representational problem, but vary in their efficiency. Cooper, however, argues that a single model is not adequate. Rather different kinds of cognitive models are available, but individuals may vary in their control of the models. For the specific problem at issue in her research, two strategies appear to exist. One involves the generation of a three-dimensional model consistent with the two-dimensional views; the second involves a number of local comparisons of the two-dimensional views. Individuals vary not only in which strategy they choose, but also in the flexibility of alternating strategies.

An interesting question is raised by the first strategy: "Given that the construction of an internal model corresponding to a three-dimensional object must require time, effort, and processing resources, why should such a construction occur when the problem solving task does not require it?" Cooper suggests that the answer to this question has to do with the unifying character of such a representation: this kind of model encodes information for many tasks of spatial reasoning and thus eliminates the need for additional computations on different pieces of stored information.

Cognitive science seeks to know the information-processing procedures by which we arrive at representations of the external world, and it would like to know the nature of the meaning and truth conditions of those representations. Computational theories of vision assume that vision is a nondemonstrative inferential process whereby a visual system infers representations of the

environment from images. In "Perceptual Representations: Meaning and Truth Conditions," Donald D. Hoffman and Bruce M. Bennett offer an account of the meaning and truth conditions of the visual representations that are the outputs of those inferences.

They first rigorously define the notion of an observer, which notion is itself a formalization of the visual system's nondemonstrative inferences. Their account of the meaning and truth conditions of visual representations is given in terms of the defined notion of an observer. This account is, in ways Hoffman and Bennett elaborate, causal and teleological, but makes no mention of functional role. The reader may therefore be interested to compare their account of mental representation with the conceptual-role theory sketched by Harman.

COGNITIVE DEVELOPMENT

Susan Carey argues for a theory of the child's cognitive development that mirrors the kind of knowledge restructuring familiar in the history of science. Children four to five years old differ systematically from adults and older children in their responses to tasks of basic reasoning. The Piagetian view of this fact was that young children have fundamentally different computational and representational capacities. Thus, the differences on a wide range of tasks devolve to a small number of basic cognitive concepts. More recently, researchers in cognitive development have come to believe that the child's cognitive capacities are not distinct in any important sense. The problem has been, then to explain the different responses in anything other than a piecemeal fashion.

Carey's proposal is an attempt to resolve this dilemma. She accepts the current view of the "competent child", but also maintains "that there are far reaching reorganizations of knowledge that unify the description of what might otherwise seem myriad piecemeal changes". Basically, the young child has a theory about a general domain of knowledge -- say, biology (an example that Carey explores in some detail). As the child's experience grows, she or he comes across new pieces of data which must be incorporated in the theory. Ultimately, the strain of incorporating data into the theory results in a change in the theory.

The critical issue for Carey, of course, as she herself recognizes, is the last one. What is theory change? What kind of

evidence or weight of evidence triggers such a change in the organization of knowledge?

The issue concerning **Thomas Roeper** is that articulated by Carey but applied to a particular domain of development: Since the linguistic behavior of young children (even younger than Carey's four-year-olds) is obviously different from that of adults, what accounts for the development from child grammars to adult grammars?

Roeper's position is not obviously compatible with the wholesale theory change suggested by Carey. Rather, Roeper uses the "subset principle" as his touchstone. The "subset principle" (from Berwick 1985) is the idea that each "step of a child's acquisition of grammar must involve movement from a smaller set to a larger set" and never the reverse. The major value of this principle for Roeper is the existence of situations where it appears not to apply -- forcing exploration for an alternative hypothesis.

Roeper examines three examples of acquisition where the two grammars in question are not in a subset relation. All his examples turn on the notion of parametric variation. Parametric variation is the attempt to incorporate into linguistic theory the fact that grammars differ. For example, some languages have obligatory lexical subjects and some don't; English is an example of the former and Italian, of the latter. Since children have to be able to learn both English and Italian, grammatical theory has to include both possibilities -- as well as offering an explanation of how a child decides on the basis of primary data which kind of language she or he is hearing.

Such situations have been argued to present "retreat" cases of acquisition. For example, the data suggest that a child in an English-speaking environment might make the "Italian" choice, only to revise it later. Roeper's idea is that such cases can be solved by a fully articulated modular theory of grammar.

SEMANTIC THEORY

A semantic theory states the information sentences encode relative to contexts, and semantic competence seems to consist in the ability to pair sentences with what they contextually encode. It is therefore tempting to conclude that a semantic theory is itself a theory of competence, at least in the sense that semantic competence consists in knowing what a correct semantic theory states. **Scott Soames** argues that this is a temptation to be

resisted. According to Soames, the theorems of a semantic theory should say what proposition each sentence expresses relative to a context of utterance, where the correct conception of propositions is Russellian. Soames spells out the Russellian theory of propositions (according to which, roughly speaking, the proposition expressed by 'Pluto is a planet' is the ordered pair <Pluto, the property of being a planet>), and then shows that, on the view of semantic theories advocated, knowledge of semantic theorems is not necessary and sufficient for semantic competence.

Having argued that understanding a sentence doesn't coincide with knowing what proposition it expresses, Soames uses this result against the familiar "Augustinian" picture of language competence. According to the Augustinian picture, the first language learner has a prior acquaintance with the objects, properties, and propositions that are, in fact, the semantic contents of expressions in the language he or she hopes to learn, and learning the language consists in learning to correlate expressions with the right contents. But this picture appears inconsistent with the noncoincidence Soames claims to have demonstrated. Besides, Soames argues, there is a more fundamental problem with the Augustinian picture. The picture requires us to grasp propositions prior to understanding sentences that express them. But often it is by virtue of understanding a sentence that one acquires knowledge of what proposition it expresses. The Augustinian picture has semantic competence deriving from semantic knowledge, but in many cases -- as when one's only epistemic contact with a proposition is mediated by sentences that express it -- it is just the reverse.

But what is the point of semantics, if not to account for semantic competence? Soames concludes his article by suggesting that semantic theories explicate the representational character of language and by elaborating on what such an explication would accomplish.

The issue of modularity which Roeper raises directly forms a subtext to **Richard T. Oehrle's** paper on the semantic effect of English stress. The problem is simple to illustrate: Each of the three words in the sequence *Bill shot Phil* can be the location of the nuclear accent, but the three sentences do not occur in identical contexts; how can the relation among syntactic form, stress, and context be characterized?

Oehrle's conclusion is that the full range of facts is "not predictable from properties of order and category alone, nor from

discourse context alone." Rather than saying that each of these properties obeys some principle or set of principles and that such principle sets can interact, he argues for a theory that directly relates to the location of nuclear accent in a grammatical structure to its acceptability in some context. This theory is relatively powerful, in the sense that it accommodates a greater range of cases than those which actually occur. Oehrle's claim is that no weaker theory can accommodate the actually attested range. He concludes by showing a correlation between the accentual properties of an expression and its other grammatical properties, thereby introducing an inherent limit on the theoretical possibilities.

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PART ONE

**The Nature and Content
of Psychological Theories**