Talking Minds: The Study of Language in Cognitive Science

edited by

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INTRODUCTION

This volume contains chapters by a number of distinguished linguists, psychologists, and computer scientists. In the past several decades, new approaches to the description of language and thought have appeared in each of the disciplines these authors represent. In the winter of 1979-80, we invited the authors to discuss their own work in the light of three questions:

- To what extent can a theory of language behavior be developed without a theory of linguistic structure?
- To what extent can there be a linguistic theory without a general theory of cognitive functioning?
- To what extent can there be a cognitive theory without a theory of language behavior?

These questions focus on three fundamental issues in the philosophical and methodological bases of modern research on language and mind:

- the relation between language behavior and linguistic structure;
- the relation between linguistic structures and cognitive processes; and
- the relation between cognitive processes and language behavior.

In dealing with these questions, each chapter often works from assumptions that have crystallized during the past several centuries, without making those assumptions explicit. It is useful to understand how each article attempts to meet or avoid the basic issues. To this end, we review six basic questions about the scientific study of behavior, each with two extremely different traditional answers.

1. How Do Human Beings Acquire Knowledge?

This question comes down to the matter of what the newborn child is prepared to learn from the world. One of the earliest positions on this question is that of Plato, who suggested that when we seem to be learning essential forms we are actually awakening built-in memories. This claim that knowledge is innate contrasts with the more recent position that all empirical and formal knowledge derives from objects and experiences available to the child in the world around it. In recent years the conflict between empiricism and nativism has stirred up much controversy, especially in relation to claims about the innateness of linguistic structure.

At first blush, the debate seems puzzling. After all, it is trivially true that a child is innately equipped to learn to do everything that

it learns to do. In that sense, we must accept nativism. We must also accept the fact that the environment informs us in crucial ways. At issue are the specific details of the relationship between the environment and the individual. The empiricist argues that the child learns only what there is to learn – that is, what can be learned by induction over objective experience. The nativist argues that the child forms a representation of what is innate, to a large extent regardless of what he is exposed to. The standard nativist argument for language, as presented by Chomsky and others, takes the following form:

- Language has property P.
- Property P cannot be acquired by any known mechanism of learning.
- Therefore, P is innate.
- Therefore, language is innate.

The strength of this nativist syllogism depends on the extent to which P is unique to language, the extent to which it is explicitly represented in the child's experience, and the speed with which the child learns it. These are empirical matters, which will undoubtedly take a long time to resolve. Some current evidence, however, weakens the empirical force of each premise in this syllogism. Many linguistic universals are at least logically derivable from independently motivated cognitive processes and systems. Recent linguistic research has demonstrated that the abstract properties of sentences are directly represented in their apparent structure, and thus has reduced the puzzle of how those abstract properties might be discovered. And careful studies of language acquisition have shown that children may take as much as ten years to master certain universal properties of language.

The complexity of P would seem to be an important feature of the nativist syllogism. The more complex it is, the more plausible the claim that no learning theory adequately accounts for its acquisition. This depends on a particular definition of *learning* as "learning by induction" – that is, by examination of the environment, without any prior structure or hypothesis. Here it is useful to distinguish between two kinds of potentially innate hypotheses: "linguamental" and "modality-specific." An innate structure that is intrinsic to all human mental activity, or one that is a compound of such structures, is linguamental. An innate structure that applies only to a particular kind of mental activity, such as language, is modality-specific. Clearly, since all mental activity involves linguamental universals, language is innate. If those universals themselves can combine to generate structural hypotheses adequate for linguistic structure, then language can be innate without being based on corresponding modality-specific innate structure. The more complex and cognitively unique a linguistic property is, the greater the burden on any theory of linguamental universals – and the more likely it seems that the property results from a modality-specific universal limited to language.

This leads us to formulate a notion of "learning/c," which we propose as a label for the process of acquiring structures by combining basic linguamental structures. This stands in contrast to the usual notion of "learning by induction." If induction fails in general, it fails to account for the acquisition of language in particular. The argument that language is innate is moot, since the acquisition of learning clearly – and by definition of learning/c – involves learning/c, which in turn recruits innate structures. The interest of the current claim that language is innate depends on the extent to which one invokes modality-specific innate structures that cannot be accounted for by the mechanisms of learning/c. In arguing for this, the linguistic nativist has taken the high ground by appearing to lump together "learning by induction" with learning/c, thus placing the linguamental nativist on the defensive. By contrast, the linguamental nativist could construct the following syllogism:

- Language has property P.
- P cannot be transmitted by any known genetic mechanism.
- Therefore P is learned/c.
- Therefore language is learned/c.

As with the nativist argument, the strength of this argument depends on the complexity of P. If P is complex, the burden on genetic theory is high. The linguamental syllogism provides an alternative to the linguistic syllogism without committing us to mindless induction. It also clarifies how the issue of nativism can become empirical.

To decide between these views, we require the deepest possible understanding of language in human beings. For the linguistic nativist, the goal is to determine adequate mechanisms of genetic transmission. For the linguamental nativist, the goal is to determine mechanisms of coordination of linguamental processes that can account for their ability to represent language.

The struggle between the general and the specific nativist is not a hopeless philosophical debate. Current empirical investigations can be expected to clarify the claims and lead to a resolution. Why, then, has the issue generated so much controversy? Part of the reason is its relation to behaviorist restrictions on what count as possible data for a psychological theory.

2. What Can a Psychological Theory Explain?

The science of the mind grew out of efforts to deal with problems in three older disciplines: physics, medicine, and philosophy. In nineteenth-century physics, the problem of the human observer and his relation to the material world became an unavoidable concern of astronomers and physicists. In medicine, it became impossible to explain insanity without referring to mental processes as well as to physiological mechanisms. And philosophy had long set the goal of determining the sources of knowledge. In attempting to deal with problems originally raised in the context of physics and medicine, the new science of psychology seemed to offer an experimental method for studying mental processes, rather than the traditional a priori basis.

Wilhelm Wundt developed several different kinds of experimental psychology. He and his students explored objective methods – such as the measurement of reaction times – and applied them widely. In the study of higher mental processes, they relied most strongly on the use of introspection, itself a methodological inheritor of Cartesian rationalism. The presumption was that internal cognitive states could be directly perceived, once one was adequately trained in self-analysis. This method was ultimately abandoned for several reasons, including its inapplicability to animal behavior and its variability from person to person and from time to time. Clearly, many aspects of our state of mind influence what we perceive it to be. Either a theory of introspection itself must be available, or introspective evidence must be outlawed. The latter alternative was the most salient.

There was a more general reason why psychology, unlike other sciences, required an a priori fiat on the method of choosing relevant data. Because many of the relevant inadequacies of its parent sciences were directly related to the problem of conscious observation, psychology could not avoid confronting that problem in order to establish a firm foundation for itself. The solution was the doctrine of behaviorism, the position that only observable or potentially observable facts may bear on a theory of behavior. At first this doctrine would seem unexceptionable, since one would certainly not want to require that a theory explain only facts that are in principle unobservable. However, strict behaviorism excludes phenomena of obvious psychological importance, such as percepts, beliefs, intentions, and consciousness. This led to the corresponding doctrine of associationism, which limits behavioral operations to one apparently simple kind.

3. What Are Possible Psychological Operations?

It has long been taken for granted that a basic theoretical problem in describing behavior is to specify the relation linking separate psychological units. A change in behavior as a function of experience can be interpreted as the new appearance of a contiguity between hitherto unrelated events. When constructing a theory that accounts for the existence of observable contiguous behaviors in relation only to observable aspects of the environment, one still has a choice of how rich an internal theory of the organism to ascribe. The simplest possible relation between two units specifies only that they are "associated," without ascribing any internal structure to the relation; this position characterizes associationism. On the alternative position, relationalism, relations are wide-ranging, including "precede," "cause," "is greater than," or "sense," "know," and "represent."

Simplicity would seem to dictate that the first step in the description of every phenomenon should be to posit only associations. More elaborate relations would then be described as compounds of associations. The difficulty is that since an association imputes absolutely no structure to the relation between units, no amount of simple combination of them can yield more complex relations: any number of zeros sums (or multiplies) to zero. The theoretical cost of maintaining associationism may be a proliferation of different kinds of rules of combination, or of distinct units that can be combined in only one way.

Many psychologists believe, nevertheless, that some yet unknown laws of combination, which perhaps apply only when very large numbers of associations are at issue, will provide enough descriptive power. There is a separate reason to hold out for this possibility, namely that associations would seem to be understandable in behaviorist and empiricist terms. The naïve child (and the correspondingly naïve theoretical psychologist) can observe that separate units become related in time, so that one regularly occurs with another. He cannot, however, distinguish between associations that differ only internally. Accordingly, if the only association is that of unanalyzed contiguity, the behaviorist and empiricist paradigms can proceed untroubled. There is a further reason to restrict mental relations to association, namely that association can be understood in direct mechanistic terms. This brings us to the next question.

4. What Is Necessary for a Scientific Explanation?

A scientific theory is not accepted as complete until it reaches the status of an explanation. But what qualifies as a true explanation as distinguished from an orderly description? One frequent answer has been based in reductionism: an explanation reduces a phenomenon to a different level of description, with postulated units to which known principles apply. The molecular theory of matter, the atomic theory of the molecule, and the subatomic theory of the atom stand as touchstones for such scientific explanations. Reductionism does not require that a phenomenon be explained only by description of events at a *lower* level. Astrology is as much a reductionist theory as molecular chemistry: it ascribes aspects of our everyday behavior to correspondence laws that interpret the physical relations between planets.

Reductionism sets strong constraints on the form of descriptions of behavior: any postulated behavioral mechanisms must be reducible to a correspondence with some physical description. This constraint binds the practicing psychologist to state his theories in the terms that can be most easily understood mechanistically; hence it applies a further pressure towards the mechanistically transparent formulations of associationism and behaviorism.

It is not clear that the simple kind of reductionism we have just presented has ever worked for any but isolated phenomena. A complete description at any given level, even in physics, seems usually to have required the invocation of laws not previously known at other levels, as well as special rules on how one level of description corresponds to another. Nor is it clear that human behavior is the same sort of phenomenon as that described in the physical sciences. Certain behavioral phenomena do not seem satisfactorily explained by any conceivable reduction. The reductionist description of ethical, emotional, and mathematical relations might seem adequate but irrelevant. Such phenomena seem best characterized by "functional" descriptions, explaining the properties of an entity by reference to functional relations between that entity and others at the same level of description.

Many phenomena are behavioral but obviously require functional explanation. Consider the concept of "it" in a child's game of tag. Suppose we attempted to explain what "it" is by reference to the behaviors we observe in actual games of tag. No description is adequate. We cannot refer to the child who seems to be running after the other children, since certain children enjoy being "it" so much that once they get tagged they refuse to chase anybody else.

Conversely, we cannot describe "it" as the child from whom all other children run, because the same perverse child who enjoys being "it" will refuse to run away from the incumbent. To see how to deal with this problem, we must turn to the rules for the game of tag.

1. Decide to play a game of tag.
2. Everybody shouts, "Not it."
3. The child who is judged to have shouted "Not it" last is "it."
4. "It" tags another child, who thereupon becomes "it."
5. Repeat (4) until extrinsic circumstances halt the game.

Under these rules, it is not necessary for anybody to run away from anybody else. Children could stand in a big circle and produce a peristaltic cyclic wave of tagging behavior. They would properly be said to be playing a game of tag, although not one that would be much fun.

The point is that many children know the rules of the game, regardless of its physical instantiation. "It" is defined functionally – not in terms of the behavior of anybody in the game but in terms of the states specified by the rules.

A functionalist psychology is liberated from any mechanistic constraints on possible theories. At first this may seem unwise, since all the behavior we see is in fact produced by physical entities. But cognitive psychology can be viewed as the study of the states that underlie behavior as well as the behavior itself. The analogy of L'homme Mâchine provides a useful perspective. As has been known for centuries, human-like behavior can be produced by machines that probably do not have human physical states. The current growth of computational devices brings us closer to machines capable of assuming states that may turn out to be those of human beings. Clearly a computer program could represent the game of tag, and computer-driven bugs could play it. We would then define the bug that is "it" in terms of the stage of the game that had been played through. But the physical manifestation of that stage could differ according to the particular hardware configuration, time-sharing contingencies, and so on. We must define "it" in terms of the stage in the program itself, not in terms of any particular physical manifestation.

The heuristic virtue of functionalist psychology is that it enables us to proceed with the study of cognition without having solved the problem of how human beings actually carry out their cognitive activities. We know from examples such as tag that at least some

human activities involve rule systems, which can be studied independently of their physical manifestation. The limitation of this kind of psychology is that once our theories have been liberated from the reductionist constraint, they may spin off into irrelevant speculation about humanly impossible models. This raises one of the oldest questions in the study of behavior, the nature of the relation between body and mind.

5. What Is the Physical Basis of Mind?

What is the physical basis of knowledge? The answers to this question range between materialism and dualism. According to materialism, for every mental state there is a corresponding physical state of the human brain. According to dualism, mental states and brain states do not necessarily have direct correspondences. Materialism would seem to be the only position compatible with a true science of behavior. Human beings are obviously material objects: the claim that a human being could have a nonmaterial structure uniquely his own is tantamount to the claim that we have bodies and souls. The study of souls might seem to be outside of scientific inquiry, but only if one rejects functionalism. Functionalism imposes no restriction on theories about the computational basis of the behavior of hobbits, gryphons, or angels. The functionalist is concerned solely with the scientific description of the organizational system underlying behavior – not with the discovery of any physical correspondence to that system. Though the world as we understand it scientifically seems to be totally mechanistic, we do not have to commit our psychological theories to such a mechanism in order to pursue them.

Pursuing a psychological theory without some sort of commitment to a mechanistic basis might seem pointless, since the theory would be developed in the absence of methodological constraints that reflect the nature of the human brain. We run the risk of constructing formal models that are computationally adequate to behavior but incompatible with human brains. There is no problem here concerning our description of the initial data – as long as we build our theories on observed behavior only (including introspections). Then we will never propose a theory that initially describes something other than possible behavior.

At issue here are the notions of "natural class" and "natural extension" specified by a theory. That is, in describing data, a theory classifies behaviors according to how they are related. Reductionist materialism requires that the existence of such separate

and overlapping classes be explicable by some form of physical relatedness in their material representations. Given our current understanding of computational devices, such a requirement seems too strong. Often we may not find a constant physical manifestation of the similarity between two particular rules in a computer program, even though we know the rules to be similar or even, in the limiting case, identical. We can maintain only the weak form of materialism sketched above: every mental state corresponds to some physical state. This allows for the possibility that regular organizational laws of behavior exist even though they are not materially represented in any particular way, and even though their formal nature is not explained by their material basis.

If the form of certain organizational laws is not explained in general by their material representation, what is the cause of such laws? This raises the last question we will consider, concerning the ontological status of forms of reason.

6. Why Is What Humans Know the Way It Is?

When an organism is said to "know" a particular thing or to add a skill, we can determine separately what causes that thing or skill to be what it is. We know, for example, that the moon reflects energy from the sun towards the earth. But nothing about human beings or their planetary knowledge causes this state of affairs. The sun would radiate energy, and the moon reflect it, with or without human beings to analyze why. The same may be true for more abstract entities. For example, the fact that five is a prime number is not caused by human knowledge of that fact. It was a prime number before any mathematician recognized the importance of such a category. It will continue to be a prime number after all intelligent species in the universe disappear. Realism, the position that certain formal entities are uncaused, is associated with the views of Plato. It is particularly plausible in dealing with the constancy of formal properties across their physical manifestations. The standard examples involve categorical properties such as triangularity or necessary truth. No accumulation of specific images or contingent truths can account for such categorical concepts.

One could argue that Platonism is an illusion of human cognition: it only seems that truths about numbers are categorical and without material cause. In the view of psychologism, numbers are caused by human cognition: whatever properties they seem to have are the result of how we think, and might well be different if we thought differently. There are various formal arguments against this posi-

tion, but it serves our present purposes to distinguish at least two potential forms of psychologism, corresponding to the two forms of empiricism we discussed above:

- modality-specific psychologism, and
- linguamental psychologism.

Modality-specific psychologism is clearly appropriate for an understanding of a structured capacity such as color vision. Human color vision has certain organizational regularities that may be entirely unique but are clearly rooted in the physiology of the eye and the optical nervous system. Accordingly, the properties of color vision are the result of modality-specific psychological structures.

Numbers, however, are different. Even if their properties were caused by human cognition, the kind of causation would be clearly of a different kind. At the very most we might argue that if such entities are not real, they are the result of deep properties of human cognition, so deep that cognition itself would break down if we perceived number differently. Such linguamental psychologism is in sharp contrast with the claim that there is a modality-specific cognitive cause for numbers, for example, a number sense.

As in the case of empiricism and nativism, the distinction between modality-specific and general cognitive causes of what we know has received greater interest. Recently, in parallel with the linguistic syllogism discussed above, language has been invoked as a structure like color vision, specifically the way it is just because human beings are the way they are. No one can question this, insofar as actually attested languages are concerned. But we can attempt to turn this problem into an empirical one by the distinction between modality-specific and linguamental causation for language and other cognitive capacities. In each case the question becomes,

- How specific is the cause of our knowledge?

and correspondingly,

- How independent of ourselves is the structure of what we know?

Is There a Cognitive Science?

The underlying goal of much of what psychology is taken to be is to ensure that theories are so constructed as to be ultimately amenable to reductionist materialism. The doctrines of empiricism, behaviorism, associationism, reductionism, materialism, and psychologism complement one another in this regard.

- Empiricism is consistent with this goal by ensuring that what the child learns is limited to what is physically observable and quantifiable. This would seem to guarantee that any theory of knowledge would also be limited to such physically realizable mechanisms.
- Behaviorism rigidly ensures this characteristic in the scientific theories of knowledge.
- Associationism guarantees that the postulated mental operations will be limited to a particular kind – contiguity – which itself is transparently modeled physically.
- Materialism guarantees the relevance of mechanistically constrained reductionist explanations.
- Psychologism is the complementary position to behaviorism for the nativist functionalist. That is, it presupposes that the child creates, on the basis of internally structured mechanisms, any mental structures not accounted for in the external physical world.

Modality-specific psychologism, though not strictly compatible with behaviorism and empiricism, can serve as a redoubt for the behaviorist and empiricist faced with the alternative possibility that certain aspects of knowledge might be Platonically uncaused.

Acceptance of certain internal structures has always been a part of empiricism and behaviorism, in general restricted to obviously inherited physiological sensory systems. Modality-specific psychologism can expand the number of such systems that are inherited with minimal compromise of the basic empiricist and behaviorist position about the inductive basis for learning. Further, strict empiricism is entirely compatible with Platonic realism: if the child can learn only about actual events and properties in the world, then discovering mental categories is at least possible, if they are real. It is not possible, however, if one maintains that the only available learning principle is induction.

The reader can apply the matrix of positions on these issues while reading through this book. Each chapter grapples with one or more of these issues. We think that each of the disciplines represented – psychology, linguistics, and computer science – has a contribution to make towards an integrated solution. We expect

- from psychology a richer theory of learning as it applies to formal knowledge;
- from linguistics a better understanding of the nature of language;
- from computer science the development of physical models that can deal in part with the kinds of knowledge that human beings exhibit.

The form this integrated solution may take, however, seems entirely unclear at the moment. Periodically in behavioral science a

movement emerges that presupposes an integrated solution to be implicit in the correct combination of contemporary disciplines. The current instantiation of that position is "cognitive science," a superset of the disciplines represented in this book. One program for this enterprise is clear: cognition should be pursued in the image of linguistics. Unlike traditional psychologists, many adherents to this position are nativist, mentalist, and relationalist, although none of these positions is necessary for them. It could be that everything turns out to be learned by induction, to be directly observable, and to be a compounding of associations, without invalidating the program of current cognitive science. Materialism is an innocuous hope that pervades all scientific positions without having any particular theoretical implications for the description of behavior. But current cognitive science does appear to presuppose explanatory reductionism and psychologism concerning the basis of mental processes and structures. This is a considerable commitment: it presupposes that each of the separate disciplines is necessarily about human knowledge rather than about what is known.

At one time it was thought that logic was the scientific inquiry of human reason – that a correct theory would account for errors in reasoning and would not lead to counterintuitive results. Yet logic flourished only after Frege tersely, and Husserl exhaustively, destroyed the connection between logic and thought. Today we see similar potential in linguistics. Artificial intelligence and cognitive science may be holding back the discovery of the real properties of language by requiring linguistics to account for all observed grammars and barring it from exploring grammars unlearnable by human beings. Suppose that computational laws are real in the Platonic sense. Then we are similarly hampering what may be the true potential of artificial intelligence: the explanation of laws governing intelligent systems. Finally, as functionalism implies, there may be real laws of thought, independent of the ability of human beings to master them. (Perhaps these would turn out to be a naturally definable subset of the hypothetical computational laws, but not necessarily.) Restricting ourselves to human thinking may obscure the nature of thought, and therefore make a true understanding of thought all the more difficult.

Of course, cognitive science can allow for these possibilities while pursuing its own goal: the achievement of an integrated picture of language, thought, and behavior in human beings. Cognitive science, however, is coherent only because there is a common descriptive target: human knowledge and behavior. It is not necessarily a monolithic science in itself. We expect that each of the component

disciplines has much to learn from the others. But if past developments are any indication, it seems most likely that the fruitful interactions are impossible to predict or to legislate by scientific fiat.

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