Cognition

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Introduction

Long ago, William James (1890/1955) argued that a degree of vagueness can be beneficial to science when attempting new research directions. A strikingly similar opinion was vented by Marvin Minsky a century later: “It often does more harm than good to force definitions on things we don’t understand. Besides, only in logic and mathematics do definitions ever capture concepts perfectly. The things we deal with in practical life are usually too complicated to be represented by neat, compact expressions. Especially when it comes to understand minds, we still know so little that we can’t be sure our ideas about psychology are even aimed in the right directions. In any case, one must not mistake defining things for knowing what they are” (Minsky, 1988). The fact that both opinions were set forth by students of cognition is perhaps no coincidence. As we shall see, different conceptual aspects have come to be crystallized within the current definition of cognition through a convoluted and blurry path, in common usage, in philosophy, as well as in psychological theorizing.

A glimpse of common sense usages may be obtained from dictionary definitions. Consider Webster 's (1913 edition),

> Cog*ni"tion\, n. [L. cognitio, fr. cognoscere, cognitum, to become acquainted with, to know; co- + noscere, gnoscere, to get a knowledge of. See {Know}, v. t.] 1. The act of knowing; knowledge; perception. 2. That which is known.

which underscores a crucial difference between two usages of the same term. The first is a process: cognition as something that humans do (along with several other animals). The second is a product: cognitions as mental representations that surface to consciousness when we perceive, reason, or form mental images. At the very beginning of his Principles, William James (1890/1955, p. 1) used the term

in the second sense: “Psychology is the science of mental life, both of its phenomena and their conditions. The phenomena are such things as we call feelings, desires, cognitions, reasonings, decisions, and the like...”. At the beginning of Cognition and Reality, conversely, Ulrich Neisser (1976, p.1) relied on the first: “cognition is the activity of knowing: the acquisition, organization, and use of knowledge.” The difference is not, as one may suspect, merely a matter of conceptual change after the so called “cognitive” revolution (Neisser, 1967). Consider the American Heritage Dictionary of the English Language (4th edition, published in 2000)

> Cognition\, n. 1. The mental process of knowing, including aspects such as awareness, perception, reasoning, and judgment. 2. That which comes to be known, as through perception, reasoning, or intuition; knowledge.

which reiterates the earlier distinction between process and product, but also adds one (crucial) adjective. Cognition is not merely a process, but a “mental” process. In what is perhaps the most influential definition (Neisser, 1967), cognition indeed refers to the mental process by which external or internal input is transformed, reduced, elaborated, stored, recovered, and used. As such, it involves a variety of functions such as perception, attention, memory coding, retention, and recall, decision-making, reasoning, problem-solving, imaging, planning and executing actions. Such mental processes involve the generation and use of internal representations to varying degrees, and may operate independently (or not) at different stages of processing. Furthermore, these processes can to some extent be observed or at least empirically probed, leading to scientific investigation by means of methods akin to those of the natural sciences.

The duality of the concept of “cognition” and its origins

As a word, *cognition* originates from Latin. Latin philosophers used the word *cognitio* as a translation of the Greek *gnosis*, which the Western philosophical tradition translates as *knowledge* (French: connaissance, Italian: conoscenza, German: Erkenntniss). Technically, knowledge is verifiable description, as distinguished by mere belief, that is, description that is assumed to be true but not verified. Thus, to have knowledge of X is to have a procedure to ascertain that X is true. For the present purposes, we suggest that relevant philosophical doctrines may be broadly classified in two general categories. In the first, the procedure is one that establishes an identity between X and our knowledge of X, or at least between their corresponding structures. We will refer to this as the *mappings* doctrine. In the second, the procedure is simply one of presentation: knowing X is simply an "encounter", an event whereby X becomes present. Borrowing a term from a different context (Quine, 1960) we will refer to this as the *qualia* doctrine.

Forms of the mappings doctrine were typical of the Presocratic philosophers, of Plato, of Aristotle, through Thomas Acquinas and the Renaissance natural philosophers, such as Giordano Bruno. The purest form was perhaps the doctrine of eidola set forth by Epicurus, who hypothesized minuscule images detaching from objects to reach the knower's soul, thus preserving the identity with the originating object (Pastore, 1971). Epicurus's idea closely resembles the empiricist notion that objects exert impressions on the sense organs (Hobbes, 1659, 1996; Locke, (1694/1979)). Romantic idealism added, somewhat obscurely, the notion that the mapping is created by a subjective act (Fichte, 1794/1982; Hegel, 1807). The mappings doctrine is explictly present in many modern approaches, such as logical positivism. Wittgenstein, for instance, wrote: "... a proposition is true or false only as an image of reality.." and "... there must be an identity between the image and the object ..." such that "... mutual relations between parts of the object correspond to mutual relations between elements of the image..." (Tractatus Logico-Philosophicus, 1927, p.). Note that mappings imply a dualism of object and representation. The problem posed by such dualism was made explicit by Descartes (1637/1994),

who argued that awareness of an object is no warranty of true knowledge. Kant's "Copernican" revolution (1781/1999) attempted to solve the problem by stressing the subjective, rather than objective, character of the mapping. In his view, the mapping is no longer a relation of identity, objectively describable, but one of production ("synthesis") based on internal constraints ("a priori categories").

Quine (1960) coined the term *qualia* to define the qualitative content of experience. An early form of the qualia doctrine was proposed by the Stoics, who distinguished between knowledge of objects that manifest themselves directly, and knowledge of signs that refer to objects in an indirect fashion. Developments of the Stoic doctrine may be traced, among others, in Berkeley (1710/1988) and in what later came to be known as *phenomenology* (Husserl, 1931/1977). In the qualia approach, direct knowledge is in essence self-validating. The experience of X is our encounter with X, and as such must be taken at face value. In the encounter, the object manifests itself to consciousness, which in turn consists of a "trascending" operation towards to the object (Husserl's term).

On the other hand, the conceptual precursor of cognition as a mental process is not *gnosis* but *nus*, "that whereby the soul reasons and understands" (Aristotle, 350 BC), which the philosophical tradition translates as *understanding* (French: entendement, German: Verstand). The Latin translation, *intellectu*s, has the same root as intelligence, and is preserved in Italian (intelletto). The notion is often reported as corresponding to that of a generic thinking faculty. A quick perusal of some representative definitions, however, clarifies that the notion was in fact limited to cognitive processes that we would today identify with thinking, reasoning, and problem solving, and was therefore more restricted than the modern notion of cognition. Thomas Aquinas (1225/1947), for instance, stressed the internal character of *intellectus*, arguing that the word derived from *intus legere*, to read within, and pertained to cognitive acts aimed at the essence of things, as distinguished by their mere sensible qualities. Kant defined understanding as "the power to know in general". Aristotle proposed a notion of "intuitive"

understanding, defined as the faculty to grasp abstract principles involved in formal reasoning, and Kant argued for a "judging" faculty, operating according to a priori principles. Bergson (1907/1998) proposed a notion of "operative" understanding, which stressed creativity: the faculty of creating varieties of utensils and manufacts. On the other hand, Locke's Essay on Human Understanding (1689) aimed to show "how we come by any knowledge", and to reject any role of innate ideas in such process. The notion implies a larger role for perception or at least sensation in cognition.

Evolution, artificial intelligence, and the naturalization of cognition

As shown briefly in the preceding section, philosopical precurors of the cognition concept reveal an intricate conceptual history, with both senses of the modern concept surfacing and resurfacing either alone or in combination. In general, when considering doctrines of knowledge, the duality of process and product is apparent in the idea of mapping between known objects and the corresponding representations. Interestingly, the nature of the mapping oscillated between a more or less "objective" notion of the relationship between object and knowledge, and a notion stressing a subjective contribution. Debates between stimulus-based and constructivist theories of perception and cognition are strongly reminiscent of these two ways of considering mappings. Stimulus-based theories, such as that championed by Gibson (1979), emphasize similarities between structural properties of the environment and structural properties of perceived or conceived cognitive products, and propose that a sort of objective link is naturally given between them, by the properties that are represented in the spatial-temporal structure of incoming stimuli. Constructivist theories, such as the Gestalt and the neo-Helmholtzian approach, rejected the existence of such objective link and suggested that human cognition requires internal constraints and active reconstruction from incomplete or ambiguous stimulation.

The distinction between what we have here called the *qualia* and the *mappings* approaches was

voiced explicitly by Gestalt theorist Kurt Koffka (1935), who argued that the starting point in the study of the human mind is the question: “Why do things look as they do?”. Koffka noted that the question has two aspects: a qualitative aspect and a “cognitive” aspect. From the standpoint of the qualitative aspect, he argued, the question applies simply to the appearance of things, as we experience them. As such, it would apply event to a world of pure illusion. From the standpoint of the cognitive aspect, instead, the question is concerned with the problem of how the appearance of things relates to how things actually are. As a student of Husserl, Koffka (and many other Gestaltists) exposed the idea of a methodological primacy of the first aspect over the second. The choice had the merit of reminding psychology, in a period of rampant behaviorism, of the existence of inner conscious contents that remained unexplained by stimulus-response laws, and remained genuine problems. At the same time, however, it eschewed the idea that conscious contents are also always directed toward external objects. Brentano (1874) strongly argued that such “aboutness” is specific of mental phenomena, and modern debates on what is today often called the “symbol grounding” problem (Harnad, 1987) are wary of the difficulty of accounting for the aboutness of mental content.

Current approaches stressing the notion of cognition as perception-action cycle controlled by internal schematas, priors, and decisions (Neisser, 1976) may be construed as one attempt to overcome the opposition between stimulus-based and constructivist theories (see also recent attempts to develop an "embodied" approach to cognitive processes, for instance, as in Clark, 1997). However, links between current theories of cognition and concepts that were used within the philosophical debate should be established with great caution, because current concepts unavoidably include notions that came from two later developments. The first of these, the theory of evolution (Darwin, 1859) provided a radically new criterion for evaluating how organisms learn about their environment. Before evolution, epistemologists struggled with concepts such as Kant's *Ding an sich* (the "thing in itself", as opposed to its phenomenal appearance) and debated whether knowledge was acquired or innate. By

providing a conceptual framework for considering cognition as an adaptive faculty, evolution provided a radically new means for evaluating truth, or at least the degree of efficacy associated with the process of acquiring knowledge – not as access to "reality" (however defined), but as a means to warrant survival by gaining adequate knowledge of one's environment. In addition, evolution provided a powerful framework for understanding how organisms may possess knowledge at birth, and how such knowledge may nonetheless be acquired -- not at the time-scale of the individual, but during the evolutionary history of the species. The second development, the distinction between hardware and software within artificial intelligence, played a crucial role in defining what cognition may be and how it should be studied. Before artificial intelligence, attempts to approach the study of cognition through the methods of the natural sciences (as opposed to philosophical speculation) had to rely on biology, that is, on the idea that cognition may be ultimately explained by understanding the workings of the nervous system. The notion that cognitive processes may be be taken as computational algorithms provided a radically new option. If cognitive processes are the software of the mind, then cognition can be studied using the tools of computer science, and quite independently of their actual implementation in a human nervous system, a non-human animal's, or even in a machine. This notion was critical to the cognitive revolution in psychology, and has now found wide acceptance in philosophical circles (see Block, 1995).

Mind, body, and cognitive explanation

The problem of understanding how cognitive processes relate to neural processes may be considered a manifestation of an older, and broader, conceptual issue stemming from the mind/body dichotomy. The issue originates with Cartesian dualism, and permeates approaches to cognition. Are mental and cerebral states two separate entities? Can the mental states be reduced to brain states? And, if so, what is the nature of the interaction between the two? During the centuries, questions such as these have been

the object of heated debate. Fechner (1860/1966) reported that the fundamental idea behind psychophysics came to him when striving to solve the problem of the connection between the body and the mind. By formulating quantitative laws of relations between mental contents ("sensations") and bodily stimuli, he believed that one could prove how mind and body are one aspect of the same unity. Descartes's dualistic position posited an epistemological primacy of mental contents, although he admitted that mind and body had to interact somehow. For this reason, according to Sternberg (1999), Descartes' theory should be considered both mentalistic and interactionistic. In Locke's theory, on the contrary, the body had the major influence on the mind. Humans are born without knowledge, and through the senses (body) they process information which only later will be used by the mind for storage and retrieval. In general, materialist philosophers (for instance, De La Mettrie,1748/1990; Ryle, 1949) denied that the mind was ontologically different from the body, and suggested that it be studied by same methods borrowed from the natural sciences. Other researchers took the opposite position and denied the body a role in influencing human behavior, while others supported the existence of both entities, suggesting an interaction.

Many students of cognition agree that cognitive competence should be explained by coordinating three levels of analysis (Marr, 1982): implementation, algorithm, and computational problem. Explanations at the level of implementation refer to the brain substrate which underlies each cognitive function. For example, it refers to the neurological circuits involved every time we want to retrieve a word from the mental lexicon. Thus implementation refers to the body. Explanations at the level of the algorithm, on the other hand, correspond to the processes required to perform a cognitive activity considered purely as procedures, independently of the substrate carrying them out. For example, in order to correctly produce a word (e.g. to destroy) we need to retrieve information about its meaning (e.g. the act of breaking into pieces), its syntactic properties (the grammatical category and the syntactic complements it selects), its phonological characteristics. In this sense, explanations at the level of the

algorithm refer to the mental operations involved in cognitive function. Explanations at the level of the computational problem, finally, refer to the constraints that apply on both the implementation of cognition and on the implemented algorithms. At this level, crucial to understanding cognition are the biological and environmental context of cognition taken as an adaptive process that subserves specific functions within defined echological niches. Thus, the computational problem refers to the mind but also to the body, as well as to the interaction of both with the environment. Recent speculations about the gene FOXP2 and its relationship with language in the evolutionary history of our species are an excellent example of this level of explanation (see Corballis, this volume).

Not all theorists, however, concur with Marr's three-pronged line of attack. Many researchers, for example, believe that we still know so little about neural circuits that it makes sense to study cognition independently (Simon, 1981). The most important argument for studying the mind independently of the body derives from the computer analogy (Phelps, 1999). In this view, although the relevance of the brain functions as the hardware that actually performs the computation, the nature of cognitive performance is captured by the instructions given in the software (Jonshon-Laird, 1983). In this sense, the actual hardware carrying out the instructions is irrelevant: It could be neuronal circuits, chips, or anything else (Putnam, 1967). Other researchers argue for reductionist explanations, suggesting that in order to understand cognition we first need to discover the neural correlates of it (Crick, 1994). These researchers reject the idea that we can draw a distinction between software and hardware, a position that finds strong support in connectionist models of cognitive processes. According to many authors (Gazzaniga, 2001, Posner, 1989), recent brain imaging techniques now make it possible to study brain activity *in vivo*, revealing the actual structure of connections between brain processes (Hunt, 1999).

Nevertheless, one position is to assume that brain research helps to study human behavior, another is to assume that brain data are sufficient to explain cognition (Phelps, 1999). The way we name colors is an example of this impasse (Tabossi, 1994). According to Tabossi (1994), a simple

example as how we put a chromatic continuum (color) into discrete entities (names) is a good example of the risk we may incur in when we underestimate the importance of a multidisciplinary approach to the cognition problem. Indo-European languages have complex systems to name colors. However, some populations of the New Guinea have just two different terms: one refers to the red and the yellow and is named "bright", one refers to blue, green, black and is named "dark" (discussed in Tabossi, 1994.. According to linguistic relativism (Whorf, 1956), names are given to colors on the basis of cultural factors, and therefore culture (language, values, and so on) deeply influences cognition. For instance, according to this hypothesis, it is easier to recognize a color when a name is available for it. Data collected using a multidisciplinary approach have shown that this is false. In fact, perceptual studies demonstrate that color perception is quite independent from culture. Red, green and blue, for instance, are more discriminable than other colors also when there is no a specific name for them. Quite independently of culture, the primate visual system codes color along three opponent dimensions: red/green; yellow/blue; black/white. In addition, some researches revealed that red and yellow are better instances for "bright" than pink or ochre (Rosch, 1978). These results reveal the complexity of the processes, and strongly remind us of the risks involved in underestimating the utility of a multidimensional approach to cognition (Tabossi, 1994).

Cognition and representation

Most theories of cognition assume that the mind forms internal representations (minority exceptions are ecological and embodied theories). For this reason, an overview of the conceptual history of cognition would not be complete without a survey of different approaches to mental representation. As we have seen, representation was implicit in several "mapping" attempts to account for knowledge formation by philosophers. In modern cognitive research, the notion takes more or less this form: if we want to understand the mental algorithms involved in cognitive processes, we must understand the

nature of the data that these algorithms input, process, and output. Therefore, we need to understand how minds represent features of the world (McNamara, 1999). Nonetheless, the nature and role of representation has been one of the most controversial issues in cognitive research. Research in this area has generated an abundance of theory, together with contrasting positions and heated discussions. The controversial question has mainly concerned the definition of format and organization of knowledge stored in the mind and, as a consequence, the description of how mental representations are formed.

Many theorists have proposed that language represents the central scaffolding for cognition. In this vein, Wittgenstein (1922/1961) observed: "The limits of my language mean the limits of my world" (p. 115) and Sapir (1921) proclaimed: "We see and hear and otherwise experience very largely as we do because the language habits of our community predispose certain choices of interpretation". An equally acclaimed tradition, however, has argued that there are many thoughts that transcend words. So, for example, James (1891, p.255) noted: "Great thinkers have vast premonitory glimpses of schemes of relations between terms, which hardly even as verbal images enter the mind, so rapid is the whole process." Einstein (cited in Schlipp, 1949, p. 228), in a striking fulfillment of James' characterization, reported: "These thoughts did not come in any verbal formulation. I very rarely think in words at all. A thought comes, and I may try to express it in words afterwards." Thus, according to many other theorists, words and phrases appear to cut the world up more coarsely than does thought (Pylyshyn, 1981, 2003). According to Pylyshyn, for example, there are many concepts for which there is no corresponding a word. More seriously, one can have thoughts while perceiving contents that *cannot* be expressed in words, thereby implying that the grain of thoughts is finer than that of a person's *potential* linguistic vocabulary (Pylyshyn, 1984; Fodor, 2001; Pinker, 1994). In *The language instinct* (1994), Stephen Pinker offered several arguments to support his view that natural language is inadequate as a medium for thought and that the primary medium of thought is an innate propositional representation system.

According to the propositional theories of knowledge representations, any well-specified set of data can be represented in a single format, i.e., propositions. A propositional representation is a general formalism for representing human knowledge; it is defined as the smallest unit of knowledge that can stand as an assertion and can be true or false (McNamara, 1999). Propositions are not words. They are thoughts or ideas that *can be* expressed in words, but which are mostly expressed through special notations (see e.g., Kintsch, 1974) that specify the *relation* among words and the *argument* of the proposition (McNamara, 1999, 117). Within the knowledge system, a statement is not a sentence in any natural language, rather, it is a "language of thought", commonly referred to as *mentalese* or *lingua mentis* (Fodor, 1975). More recently, the idea that natural language cannot be the medium of thought because of inherent ambiguity and instability has been proposed by many cognitive scientists (Block, 1995; Fodor, 2001; Sperber & Wilson, 1998) who argue that there must be many more concepts than there are words and that, unlike concepts, the meaning of a particular word may depend on many pragmatic factors.

Most of our memory for persons, objects, and events from the past is based on non-verbal thinking. The functional role of mental images and of visual-spatial representations in memory has been documented since the time of the ancient Greeks (Yates, 1966). However, the properties of visual-spatial representations and the mechanisms by which they mediate human behavior have been clarified only recently by cognitive research (Cooper & Lang, 1996). The fundamental tenet of analogical theories of knowledge representation is that the properties of human behavior are too rich to be explained by a single form of representation (Kosslyn, 1980; 1994). According to this view, mental states must include sensory contents as well as verbal contents. This is the basic premise of Paivio's dual code view of mental representations, as well as the "perceptual symbol system" concept introduced by Barsalou (1999; 2003). Paivio's (1971) dual coding theory has been one of the most useful theoretical distinction in the field of memory. Given its explanatory value, Paivio's dual coding

theory has remained substantially unchanged up to the present time (Paivio, 1975, 1986, 1991). The theory assumes that cognitive behavior is mediated by two independent but interconnected systems, which are specialized for encoding, organizing, storing, transforming, and retrieving information. The verbal system is regarded as a more abstract, logical mode of representation, while the imagery system is assumed to be a more concrete, analogical mode. The most important assumptions of the theory concern the independence and interconnectedness of the two systems. "Independence" means that either system may work or be influenced in isolation of the other; "interconnectedness" means that information can be transferred from one system to the other. An important corollary of the independence assumption is that the two codes may be additive in their effects (Paivio, 1975, 1986, 1991).

Analogical representations differ markedly from propositional representations (Paivio, 1971, 1986, 1991; Kosslyn, 1980). What distinguishes the analogical aspects of our memories from other aspects, and, more generally, from propositional representations is that analogical representations correspond in non arbitrary ways to the external objects or events that they represent (Cooper & Lang, 1996; Palmer, 1978; Kosslyn, 1980; Shepard & Cooper, 1982). More specifically, there is some degree of "isomorphism" between an object in the world and its analogical representation in the person's mind. This kind of *complementarity* may be schematic, including only salient features of an object or global information about the object's structure, or it may be more concrete, including metric (spatial) information about shape and size (Cooper & Lang, 1996; Kosslyn, 1980; 1994). The evidence consistent with analogical representations and processes is too extensive to be discussed here. To give the reader the flavor of this long and heated debate, we will mention some well-known results, which are commonly considered a milestone in the research on visual imagery, namely, Shepard and Metzler's (1971) experiments on mental rotation. These authors found that the time to judge whether two line drawings represented the same three-dimensional object was a linear function of the angular disparity

between the two figures. This result, which generated ample discussion within the field, was taken as the first and more striking evidence that the mental events and transformations during mental rotation are similar to those occurring during perception of the same real event. The mind, according to this view, passes through intermediate states that correspond to the intermediate states it passes through while perceiving.

During the past twenty years, research in cognition has turned from mere demonstrations of the functional role of visuo-spatial representations in memory to investigations of the properties and format of such representations, of their relationship with working memory and verbal/semantic long-term memory, as well as with abstract non-visual information. Attention has been devoted to the general question of what processes (and related representations) subserve the use of visual-spatial memory. Indeed, there is ample agreement that visuo-spatial memory can neither be investigated in isolation, nor be considered a monolithic structure (Cooper & Laing, 1996, Farah, Hammond, Levine & Calvanio, 1988). To the contrary, the literature offers strong evidence that visuo-spatial memory can both exceed and yet still be influenced by abstract/verbal processes. Although these two depictions of the relationship between language and thought might seem at odds, research in a number of domains of perceptual memory suggests that they may both be accurate. For example, individuals' ability to successfully recognize difficult-to-verbalize colors (Heider, 1972), faces (Polanyi, 1966), and nonverbal forms (Attneave, 1957) reveals the substantial degree to which knowledge can often transcend linguistic skill. Yet these domains are not immune to the influence of language, as revealed by the recognition advantage of easily named colors (Lucy & Schweder, 1979), the impact of post-event verbal information on memory for faces (Greene, Flynn, & Loftus, 1982), and the influence of verbal labels on memory for form (Carmichael, Hogan, & Walter, 1932). In short, cognitive representations can both exceed and yet still be influenced by language (Schooler, Fiore, & Brandimonte, 1997).

The discussion on mental representations is strictly related to modern cognitive theory, but it may be

open to critical considerations that are present in the history of thinking (see Barsalou, 1992; Cornoldi & Logie, 1996, Kaufmann, 1996). Recently, researchers have argued that the value of representations in cognitive science has been exaggerated (e.g., Brooks, 1991; Thelen & Smith, 1994; van Gelder & Port, 1995). Many of these researchers have suggested that we should eliminate representations from cognitive models and focus instead on the relationship between the cognitive system and the environment or on the sub-representational dynamics of cognitive systems. However, in defense of the concept of “representation”, other authors (Markman & Dietrich, 1998; 2000) have proposed a different interpretation by introducing the notion of a "mediating state” as a common ground in the study of cognition.

In analyzing the use of mental representations in psychological theories and computer models, Markman and Dietrich (1998) suggested two central issues that in their view a defense of representation should deal with. First, a defense of representation should clarify the core notion of representation that seems to be common to most approaches to cognitive processing, in order to provide the philosophical foundation for the use of representation in cognitive models. Second, a defense of representation should analyze how the concept is used in cognitive models in practice, that is, the pragmatic aspects of representation.

As defined by Markman and Dietrich (1998) “mediating states are internal states of a cognitive system that carry information about the environment external to the system and are used by the system in cognitive processing”. Mediating states form a common ground in the study of cognition in that all cognitive theories posit the existence of mediating states. Markman and Dietrich (1998; 2000) specify the characteristics of a mediating state in terms of the following four necessary and jointly sufficient conditions: (a) There is some entity with internal states that undergo changes. (b) There is an environment external to the system which also changes states. (c) There is a set of informational relations between states in the environment and the states internal to the system. The information must

flow both ways, from the environment into the system, and from the system out to the environment. (d) The system must have internal processes that act on and are influenced by the internal states and their changes. In this perspective, the label "representation" can be restricted to a particular subset of mediating states. For example, one may refer to representations as only those mediating states with a particular *type of content* (e.g., propositional). Markman and Dietrich (1998; 2000) argue that this way of restricting mediating states to particular subsets may not be critical for most cognitive explanations but rather has a role in a *theory of content*. Given that all cognitive scientists (even anti-representationalists) agree that cognitive systems include some kind of internal states that carry content (i.e., they accept the existence of mediating states), this definition, according to these authors, provides a good *ouverture* to the discussion on representations and processes in cognition.

From the point of view of mediating states, one may reconcile the apparent disagreement between representationalists and anti-representationalists. Markman and Dietrich (1998) argue that disagreements over whether there are representations are better understood in terms of mediating states, as different researchers focusing on different aspects of cognition and using different kinds of mediating states will be able to explain what they are observing. According to the authors, this definition of a mediating state is quite general. It is intended to capture the general notion that there is *internal* information used by organisms or systems that mediates between environmental information coming in and behavior going out. As a consequence, this notion might be one that all cognitive scientists can agree to. However, the current debate reveals that not all cognitive scientists agree on the concept of mediating states as proposed by Markman and Dietrich (1998). For example, Clapin (1998) argues that not all internal representational states carry information about their contents and that being a mediating state is not essential to being a representation. In fact, they argue, although many people think that information is the basis for a theory of representational content they do not suggest that *every* representational state is information-carrying (e.g., Fodor, 1987). Therefore, Markman & Dietrich's

notion of a mediating state is not one that can form the basis of all accounts of representation (Clapin, 1998). As an alternative approach, Clapin (1998) suggests a careful taxonomy of which representational properties are required for which cognitive processes, without assuming that all representations share all the same properties.

In sum, the current state of the art indeed reveals that the debate about the nature of cognition is still lively and productive, and it will probably push forward our knowledge of the human mind for a long time to come.

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