The Proper Role of Know How in Epistemology

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1.) Introduction

From its beginnings western epistemology has concentrated fundamentally, if not exclusively, upon knowledge as conscious or consciously accessible belief. Similarly, contemporary philosophy of cognitive science emphasizes the role of explicitly represented information in computational explanations in cognitive science. I argue that cynosural role of propositional models of knowledge in western epistemology constitutes a significant misapprehension. Research in cognitive psychology, computer science, and neuroscience strongly support the notion that a large percentage of know how is neither consciously represented nor propositional in nature. Furthermore, current theories of neuroevolution demonstrate that know how has a roughly equal evolutionary vintage in human brain development. Finally, computational considerations not only establish that know how proves an equally viable form of knowledge for cognitive tasks, but establish the necessity of know how for knowledge in the form of belief.

2.) Knowledge and Cognitive Science

Despite the rather recent emergence of more eclectic research within cognitive science, cognitive science remains a science of the creation and utilization of knowledge. Cognitive scientists appeal to knowledge in explaining behavior because that behavior systematically and reliably outperforms chance for the mechanism type. For instance, all rocks fall equally well when unrestrained in a gravitational field. Thus, it is not necessary to explain differences in decent between rocks or for a single rock across time. Likewise, billiard balls are no better or worse than one another at engaging in relatively inelastic collisions. However, humans and other animals exhibit striking differences in performance of a wide variety of behaviors both within individuals across time. Humans, for instance, differ widely in their ability to direct the inelastic collisions of billiard balls in order to drive them into pool table pockets. Cognitive scientists explain such differences by appealing to the ability of humans and animals to generate and use knowledge about the environment.

To cognize is to know. To have a cognitive capacity is to have a capacity (ability) which seems to generate or to require knowledge. Cognitive science seeks to explain the cognitive capacities, of humans, animals, and possibly machines. However, the primary thrust of research in cognitive science is directed towards explaining human cognitive abilities. The classic approach to explaining cognitive capacities within cognitive science has two foundational theses; The "Computational Theory of Cognition" (CTC) and the "Representational Theory of Intentionality" (RTI), which together dictate the explanatory structure of cognitive science. The CTC characterizes cognition as the computation of complex functions on representational states, where computation consists in performing operations defined over representational states. These operations can be rule-based manipulations of syntactic strings as in traditional artificial intelligence, or the weighted passing of activation as in connectionist models. The RTI asserts that mental states have intentionality (are about the world/have content) in virtue of a representation relation holding between the world and those states. In three conceptually distinct (though not necessarily temporally distinct) stages, CTC/RTI depicts cognizers acquiring input through sensory organs and/or memory and generating outputs in the form of memories, inputs to other processes, and/or motor response commands.

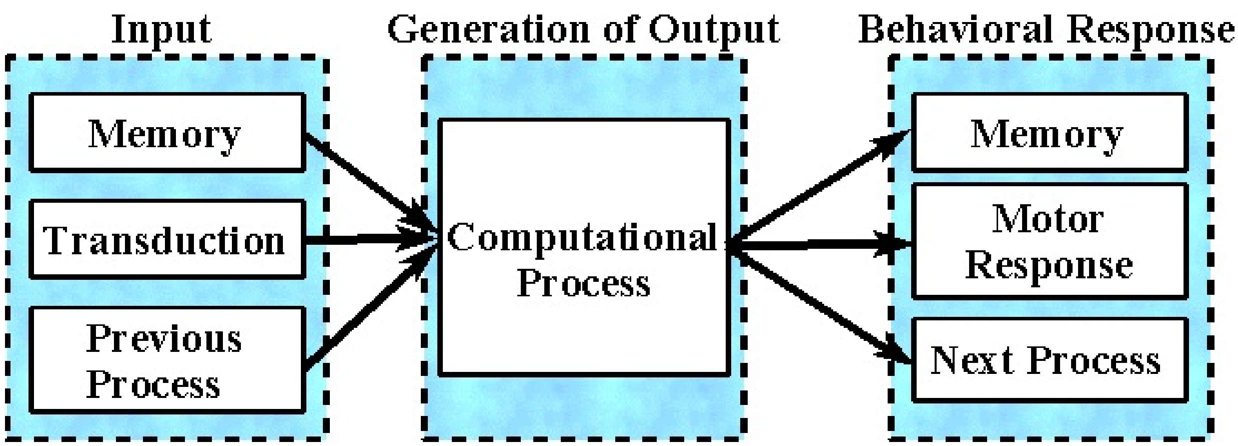

Figure 1: Three Stages

Philosophers of cognitive science accentuate the role of representations in computational explanation in cognitive science. John Haugeland (1981) introduces the notion of a semantic engine in explicating the CTC's explanatory structure: Cognizers instantiate physical engines--dynamic systems operating upon physical principles. One can understand these physical engines as embodying type-individuated, syntactically structured states and evolving through principled interactions between their states. Cognizers instantiate syntactic engines--dynamic systems operating in accordance with syntactic principles to perform syntactic work–in virtue of such nomic interactions between type-individuated states . A semantics for the syntactic engine is provided by an interpretation function that enables the researcher to understand syntactic engines as instantiating semantic engines--dynamic systems operating in accordance with semantic principles to perform semantic work. Moreover, this strategy potentially applies to multiple levels of description of a given machine.

One can depict the general explanatory schema for such explanations with the diagram below (figure 2):

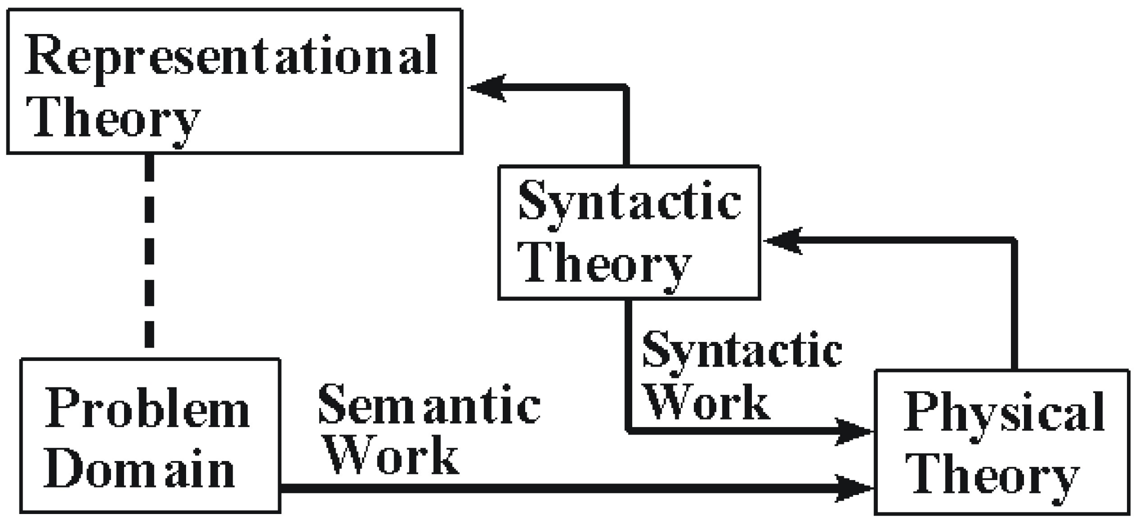

Figure 2: Explanatory Structure

While philosophers of cognitive science have done much to clarify the explanatory structure of cognitive science, I would suggest that they overemphasize the role of explicit representations and the semantics of such representations. Philosophers rarely formulate the explanans and explanada of cognitive science in the epistemic terms often employed by the scientists themselves. Moreover, little attention has been payed by philosophers to the role of know how in computational explanations in cognitive science.

Most philosophers acknowledge both attributions of know how to individuals and the explanatory relevance of such attributions to understanding mentality, despite paying little attention to know how. In contrast, the cognitive science literature bares witness to the pervasiveness and perceived centrality of know how to contemporary cognitive science. Work in cognitive science focuses, not merely upon representations of the world which may be true or false, like beliefs, but on human abilities. Computer scientists more often model the human ability to reason, solve the tower of Hanoi puzzle, play chess, or visually detect and catagorize objects than they model the capacity to have beliefs about reasoning, chess playing or object locations. Computer science research into human abilities produces theories and programmed models of know how--not models of beliefs. These programs consist of sets of condition action rules or connection weights. As such, one best describes these programs as bits of practical reasoning, not to be confused with truth-functional representations of the world. Computer scientists and laypersons alike evaluate such abilities, theories, and programs epistemically. A given chess move is not true or false, but better or worse relative to the goal of winning, more or less justified given the circumstances. The program that generates the move is not true or false, but more or less optimal. Some connectionist claim that in connectionist models of abilities, as in the brain itself, "...almost all knowledge is *implicit* in the structure of the device that carries out the task rather than *explicit* in the states of the units themselves." (Rumelhart, 1989, p.136)

Cognitive psychologists and neuroscientists offer similar acknowledgments of the importance of know how. Stillings *et al*. as well as Cohen and Squire (1980) equate the important declarative/procedural knowledge distinction in psychology to the knowing that/knowing how distinction in philosophy. (Stillings, et al 1987, pp.18-21)

Despite their seeming acceptance of know how and its seeming importance to the scientific study of human cognition, philosophers devote little attention to knowledge how. Ryle's (1949) disposition-based approach garners few supporters, those propounding theories themselves prove even more exiguous. The absence of a systematic and astute theory of know how renders philosophers nescient regarding a fundamental explanatory construct within contemporary cognitive science. Equally lacking is a perspective from which to understand and evaluate the claims of cognitive scientists regarding know how. Development of a theory of know how, therefore, is an ineluctable aspect for the philosophy of mind/cognitive science.

3.) Philosophical Treatment of Knowledge

Long before philosophers of cognitive science began to focus upon explicit representations, epistemologists pondered the nature of knowledge. Like their more scientifically oriented colleagues, epistemologists tend formulate theories of knowledge in terms of consciously represented propositions–beliefs in the case of epistemologists. In the *Theaetetus,* for example*,* Plato suggests that knowledge is true opinion together with an account. Over two centuries later Edmond Gettier entitles his famous paper "Is Justified True Belief Knowledge?". The primary framework for most contemporary epistemology defines knowledge in terms of justified true belief. Even philosophers with a more psychological orientation, such as Hilary Kornblith, causally assert that "the standard account of knowledge is that knowledge is some sort of justified, true belief." (Kornblith 1980 p.598) The most basic questions addressed by epistemology are likewise doxastic in nature. For example, "Do my beliefs about the external world count as knowledge?". In *Epistemology and Cognition* Alvin Goldman asks the central question of his work, "What is knowledge? More Specifically, what is propositional knowledge: what is it to know that something is the case?" (Goldman, 1986, p.42)

In stark relief to the main tradition in epistemology, Ryle proposes a non-propositional, dispositional class of knowledge, captured in the ordinary notion of know how. Ryle's takes as his goal the elimination of belief and other ordinary mental state terms in psychology and ordinary parlance. Ryle sought to use know how, i.e., dispositions to behave intelligently, to replace all such concepts as belief. Indeed, Ryle tells readers that

> In judging that someone's performance is or is not intelligent, we have,...in a certain manner to look beyond the performance itself. For there is no particular overt or inner performance which could not have been accidentally or 'mechanically' executed by an idiot, a sleepwalker, a man in a panic, absence of mind or delirium or even, sometimes, by a parrot. ...in looking beyond the performance itself,.... We are considering his abilities

> and propensities of which his performance was an actualization. Our inquiry is not into causes (and a fortiori not into occult causes), but into capacities,.... (Ryle 1949, p.45)

Ryle's work did generate substantial controversy and debate. Traditionally, philosophers respond to Ryle by recasting know how as practical reasoning involving reasoning using conscious beliefs about effective action. The relatively few resulting treatments of know how in the philosophical literature focus on consciously represented statements about how to carry out a practice. For example, David Carr discusses *know how* as follows:

> Inter alia, knowing how in the strong sense to play football is knowing the rules of the game, but a statement of the rules of the game is not a theoretical statement but a description of a set of rules of *practice*, and mastery of the rules brings with it an understanding of an activity rather than a theory. Statements of the rules of a game are essentially of relations between *prescriptions* rather than descriptions requiring a grasp of practical rather than theoretical discourse. (Carr 1981, pp.60-1)

Common to all post-Rylian accounts of knowing how is the insistence that know how, like knowing that, is really a subset of represented knowledge. Each knowledge set has its own characteristic logic. Knowing that, often called theoretical knowledge, remains propositional, i.e., truth-functional in nature. Know how, often called practical knowledge, is a consciously represented knowledge of procedures. Knowing that, "water freezes at 0^{o} Celsius ," counts a theoretical knowledge. Knowing "to freeze water at sea level, lower its temperature to 0^{o} Celsius or lower" is practical knowledge.

4.) Two Memory Systems of the Brain

Work in cognitive science has revealed multiple memory systems in the brain. One system is referred to as "the basal ganglia system" or "procedural memory system." The basal ganglia are a collection of nuclei deep to the white matter of cerebral cortex. The name includes: caudate, putamen, nucleus accumbens, globus pallidus, substantia nigra, subthalamic nucleus, though there are alternative groupings. Researchers continue to discover new connections, but the major known connectivity within the basal ganglia memory system can be diagramed as follows:

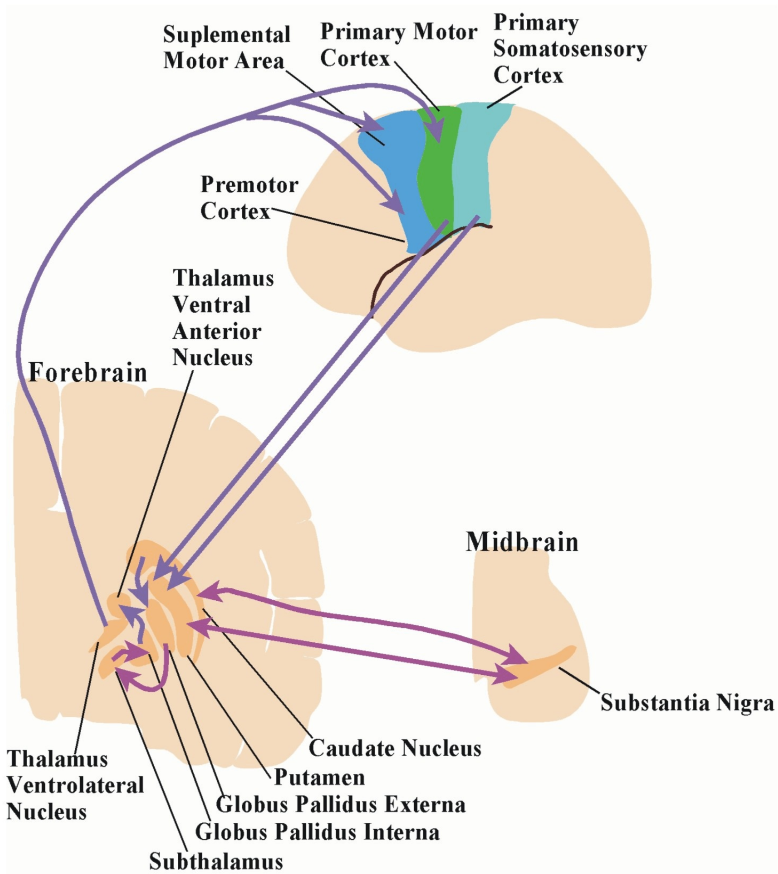

Figure 3: Basal Ganglia Memory System Connections

The basal ganglia memory system has long been recognized as subserving the learning and retention of habits and skills. Riding a bike, for instance, involves procedural memory. However, the basal ganglia system is not limited to motor skill learning. For example, researchers have linked improvements in more seeming contemplative skills such as the ability to solve the tower of Hanoi puzzle or play checkers to the basal ganglia system. In general, cognitive scientists identify motor skills, associations, priming cues, and puzzle solving skills with procedural knowledge. Because the operations of this memory system remain largely inaccessible to consciousness, it has also been described as "tacit knowledge" or "implicit knowledge".

In contrast to the functioning of the basal ganglia memory system, the hippocampal memory system or declarative memory system subserves memory for facts (Tulving & Schater, 1990). Along with several other regional brain structures, researchers traditionally associate the hippocampus with memories for explicit facts (e.g., My car brakes are squealing.) or specific events (e.g., I ate Cornflakes for breakfast this morning), which collectively are referred to as declarative memories. Researchers often further divide declarative memory into episodic memory (memory for past and personally experienced events), and semantic memory (knowledge for the meaning of words and how to apply them). Tulving observes that in cases of episodic memory subjects not only have the memory, but retain some details regarding the setting in which the memory was learned. In semantic memory the subject cannot recall the initial learning context. In all cases of declarative memory subjects retrieve memories into consciousness in such a way that they can declare them. Thus, declarative memory looks very much like the sort of memory envisioned by epistemologists when talking about conscious or consciously accessible beliefs.

In the mammalian brain, one finds the hippocampus and closely interconnected adjacent brain structures almost immediately inside the left and right sides of the brain (temporal lobes) and toward the middle (medial) brain region also called the medial temporal lobe. Researchers continue to refine the anatomical borders of hippocampal memory. Most researchers currently acknowledge a broader hippocampal region, including the hippocampus as well as its overlaying cortical structures. The major structures are the hippocampus, entorhinal cortex, perirhinal cortex, parahippocampal cortex, the unimodal association areas, and the polymodal association areas. The below is a general schematic of hippocampal projections involved in declarative memory. Of special note for this paper are the projections to the inferior temporal lobe thought to subserve the long term storage of factual knowledge.

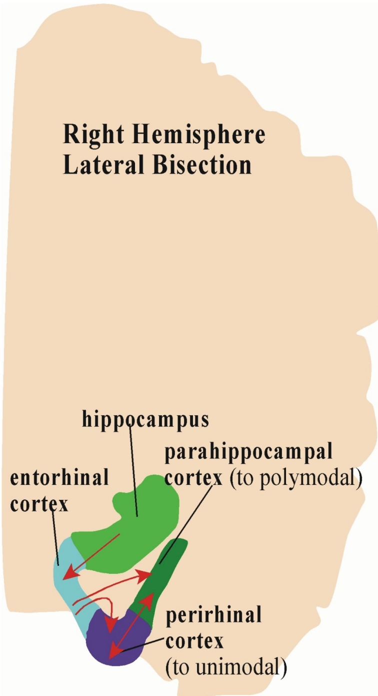

Figure 4: Schematic of Early Hippocampal Projections

The most common form of evidence used to distinguish declarative memory from procedural memory has come from the study of memory dissociations in amnesiacs. Researchers have long known that amnesiacs lack the ability to add to their declarative episodic or semantic memory stores (long-term memory). Perhaps the best known and most extensively studied case involves the patient known as HM, who had the anterior and medial portions his temporal lobes removed to prevent epileptic seizures (Corkin, 1968). Patients with brain damage to the

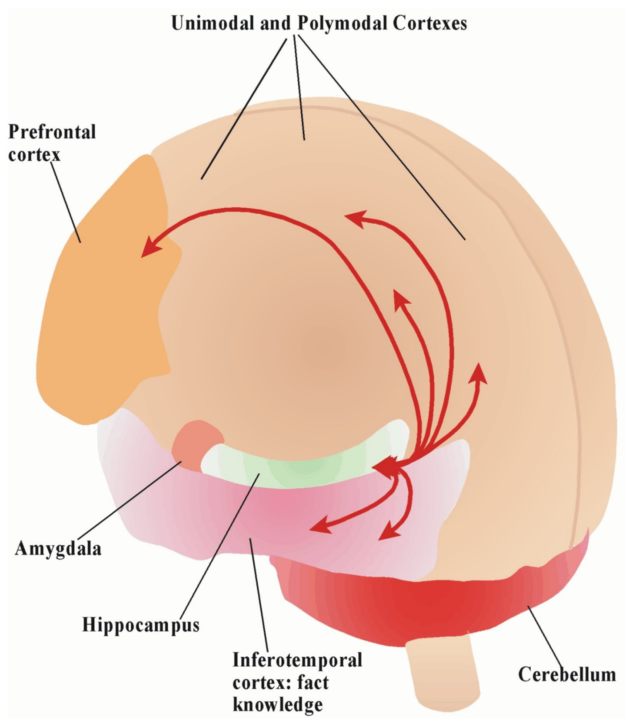

Figure 3: Gross Depiction of Hippocampal Memory Projections

hippocampal memory system like HM have normal or near normal pre-trauma memory for events but have lost the ability to create new long-term memories, suggesting that adding information to declarative memory requires frontal and medial temporal lobe structures. These patients, however, do not lack the ability to form new procedural memories thereby supporting the distinction between declarative and procedural memory pathways.

Similar dissocciative evidence for the prodecural/declarative distinction has been discovered in a wide range of diseases and other organic conditions: including Schizophrenia (Schmand *et al.*1992, Schröder *et al.* 1996), Bipolar Disorder (van Gorp *et al.* 1999), Down Syndrome (Vicari 2001), Williams Syndrome (Vicari S., 2001), and Korsakoff Syndrome (Cermak *et al.* 1973, Cohen and Squire 1980) Further evidence has emerged from priming experiments (Jacoby and Witherspoon 1982) and normal aging (Cole and Rotella 2002) .

5.)Why Neither Philosophical Theory is Correct

At first blush, one may conclude from the cognitive science literature that Ryle's non-conscious notion of knowledge how has been vindicated. For example, Cohen and Squire (1980) seems to suggest such a conclusion. However, I argue that the conclusion one ought draw is more subtle and complex. I claim that neither Ryle nor philosophers who respond to Ryle, such as Carr, give a correct and complete theory of philosophical concept of knowledge how. Ryle correctly asserts that many cases of know how are not mediated by practical reasoning involving conscious beliefs about effective action. Thus, HM can improve on the tower of Hanoi puzzle as a result of practice despite no conscious beliefs about; (1) his having worked on the puzzle before, (2) why his moves are good or bad, and (3) that his moves are good or bad. Likewise, philosophers like Carr correctly suppose that some abilities and skills are mediated by conscious beliefs about how to best perform the task. For example, many people know how to cook particular dishes because they possess declarative knowledge in the form of a memorized recipe. For philosophers all such cases count as know how, though some are declarative in nature and others are procedural in nature.

One response to this observation would discard know how as psychologically uninteresting or unreal. That is, one might argue that know how should be discarded because it is not what one might call a psychological natural kind. Since there is no memory system that subserves all and only cases of know how, know how is not a useful concept.

I would suggest that, in the case of know how, this argument goes awry. It is true that the philosophical concept of know how seems to include instances of two types of memory. Rather than an unwanted discovery, this diversity actually underscores an important insight. Up until this point in the paper I have discussed the basal ganglia and hippocampal memory systems as if they were completely modular (operated independently, without sharing information) with respect to one another. This is not the case. These two memory systems interact with one another constantly. The basal ganglia has indirect connectivity to the hippocampus and amygdala through the nucleus accumbens as well as through its projections to the cortical regions, including the frontal lobe. (Mogenson *et al.* 1980, Doya 2000, Greenberg in press) For example, when I first started using the long nonsense password for my computer I had to form a declarative memory of the password. Now, however, that knowledge has passed to my procedural memory system so that in order to recover an explicit conscious knowledge of my password I have to type it out.

Philosophers have failed to understand know how because their theoretical approaches have been structured by implementational commitments. Ryle is committed to explaining behavior without representational structures like beliefs. Advocates of practical reasoning are committed to explaining skills and abilities using a model of conscious reasoning involving explicitly represented knowledge. The lesson, I suggest, one can learn from the basal ganglia and hippocampal memory systems is that what distinguishes know how from knowledge that is the function that it plays in cognition. One must understand know how functionally, and not in terms specific ways to instantiate such a functionally defined process. The case of human memory provides an elegant example of the familiar fact from computer science (discussed below) that the sort of knowledge to which cognitive scientists appeal in explaining cognitive behaviors, i.e., behaviors that systematically and reliably outperform chance for the mechanism type, can be implemented in explicit representations or implicit in the cognitive operations of a cognizer. What these two forms of know how share is that they guide action and interaction with the world in ways that seem best explained by their embodying information about relevant features of the world.

6.) My View of Know How and The Proper Place of Know How in Epistemology

In formulating a philosophical understanding of know how I try to capture this functional notion of know how. I define knowledge how as follows:

Ψ knows how to Φ iff
(1) Ψ is a system,
(2) Φ is a cognitive task,
(3) Ψ instantiates and exploits a tractable set of processes tokening outputs that reliably satisfy the satisfaction conditions associated with the idealized target function characteristic of the Φ across the task domain, and
(4) the level of reliability of the process in cases where the input given the system satisfies the satisfaction conditions associated with the target function is greater than or equal to the general level of reliability of the process across the task domain.

Striped of its technical aspects, my definition defines know how as the embodiment of a process or set of processes, possibly including processes operating on explicit representations, which together allow the system to reliably, and in appropriate circumstances perform a task within the in the real time constraints of the world. Within the above definition, my concept of a system is a primitive. The notion of a cognitive task is that of an inferentially characterizable capacity. Specifically, one can understand a given Φ as a cognitive task only to the extent that one can generate a well-specificed task description of Φ. Well-specified task descriptions (**WSTD**) include three elements; (1) A **WSTD** includes a specification of input/output types in terms of an idealized target function defining success conditions for performing the task by mapping input sets to sets of acceptable outputs. For instance, planning programs have goal states and initial state descriptions as input and compute plans as output. A system computing the successor function has representations of predecessors as input and representations of successors as output. (2) A **WSTD** delineates nomic correlations (including statistical correlations) that underlie the system's performance of a task. For instance, Marr discusses the "underlying physical assumptions" of human vision. Marr's assumptions are nomic generalizations about the task domain, and include the existence of surfaces and spatial continuity. (Marr 1981, pp. 44-51) (3) A **WSTD** includes a specification of the relevant process by reference to the system's laws of operation within the domain, viewing these operations as a strategy or set of strategies for generating outputs from inputs relying upon certain nomic correlations.

Instantiating a process is to exhibit lawful state transitions between input and output across the task domain. Satisfying the satisfaction conditions associated with the idealized target function requires that the input/output pair generated by the system be elements of the input/output sets mapped by the function. My definition also requires tractability: One can attribute knowledge how to a system only if one can characterize the system's process, its lawful state transitions, as a tractable strategy for performing the task. The system must instantiate a process that can generate outputs from inputs given the constraints inherent to the task. For instance, a program employing an exhaustive search method to play chess (one in which it generates the combinatorial result of the average number of legal moves per turn, 31.6, and the average moves per game, 40: approximately 10^{120} different moves) proves intractable. The strategy is *theoretically* sound, but *practically* unsound.

In addition to articulating and advocating a theory of know how consistent with a functional understanding of know how, I also wish to argue that philosophers (and others) should accord knowledge how a role in epistemology on par with the treatment of propositional knowledge. I offer two arguments for this later thesis. First, I argue that computational theories in cognitive science are committed to such a role for know how as a result of their computational framework. Second, I argue that the memory systems of the human brain that subserve these two forms of memory (declarative and procedural) are of roughly the same evolutionary age and are equally integrated into the human brain.

7.) The Computational Argument for the Primacy of Know How

Those with familiar with modern digital computers might suppose that one might easily eliminate non-representational know how because, ultimately, getting a system to know how to perform some task merely requires that one get the right knowledge explicitly represented in the system. If one exclusively conceives of computational systems as systems operating by means of recursive applications of simple control mechanisms (i.e., simple operations on representations), then this line of thought has great appeal. For example, if a computer programmer wished to get a computer to calculate the successor of a number that a user input, they would write a set of explicitly represented instructions in a computer language. Such a program would essentially tell the computer to do something like: Take input number, add one, present new value to user.

Nevertheless, one's reduction of knowledge how to something akin to knowledge that remains a strategy only, one that is largely a side effect of the sort of computational systems with which most people are familiar. Moreover, no such reduction can be complete--even in the strongest cases for reduction. Not all computational systems operate using a small set of simple control mechanisms. Some systems implement an algorithm by instantiating a complex set of control mechanisms and *absolutely no represented instructions*. These systems lack explicitly represented knowledge, yet manifest the same know how to the same degree as systems that explicitly represent knowledge of a practice. Such is arguably the case for many connectionist systems, and is clearly the case for Turing machines not implemented on universal Turing machines. Specialized Turing machines employ physics to control the inferences by disciplining the state transitions. For example, the state transitions of a Turing machine that computes the successor function without explicitly represented instructions can be diagramed as follows:

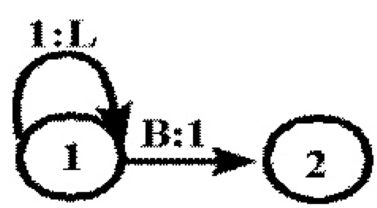

Figure 3

Moreover, systems lacking representations of procedural knowledge are not a mere theoretic possibility. Cognitive scientists theorize that humans operate with few representations and complex control mechanisms in many cases. Although vision researchers claim that the human visual system knows how to, for instance, infer edges from intensity values in retinal arrays, they do not suppose that that ability manifests itself as the result of knowledge that explicitly represented in the brain. Rather, they claim that the visual system instantiates the algorithm without representing it as instructions: The visual system's law-like behavior constitutes the exclusive basis for the ascription of knowledge how. Recall that connectionists like Rumelhart claim that "...almost all knowledge is *implicit* in the structure of the device that carries out the task rather than explicit in the states of the units themselves." (Rumelhart 1989, p.136)

Likewise, not all computational systems operate using the same control mechanisms. Production systems operate by means of a simple matching algorithm and backtracking. Theorem provers might compute the same function using resolution and a unification algorithm. Therefore, even cases where a system has relatively few control mechanisms and explicitly represents its knowledge as complex instructions, the efficacy of those instructions depends directly upon the basic control mechanisms. Altering basic control mechanisms while keeping the representations fixed can have a dramatic negative effect upon performance.

I conclude, therefore, that while one cannot ignore representations of complex instructions in understanding a system's know how, explicitly representing knowledge is insufficient as well as unnecessary for manifesting know how. Moreover, from a computational standpoint, knowledge in the form of explicitly represented knowledge seems to require or presuppose the non-representational knowledge of how to exploit explicitly represented knowledge. An adequate theory of know how must, like my own, be consistent with both possible implementations of know how, and an adequate epistemology must recognize knowledge how as being of equal epistemic import to knowledge that.

8.) The Evolutionary Argument for the Primacy of Know How

Current views of neuroevolution also support the hypothesis that knowledge how and knowledge that are significant and roughly equally ancient components of human brain structure. The two memory systems, hippocampal and basal ganglia, constitute structures that compose a significant portion of non-cortical brain mass. Further, these two systems are directly or indirectly connected to nearly every brain structure. Likewise, the brain areas thought to be involved in procedural knowledge and declarative knowledge clearly represent a structural plan that has remained present and largely unchanged from amphibians through reptiles, birds, and mammals. The hippocampus and basal ganglia appear to be approximately the same neurological age. Likewise, the hippocampus and basal ganglia appear to be relatively homologous in the above-mentioned diverse species. (Marín *et al.*1998, 2000 and Rodriguez *et al.* 2002, and Greeburg forthcoming) These facts strongly suggest that something akin to each memory system and each type of memory has played an integral role in cognition throughout a relatively long period of evolution. Therefore, the almost exclusive philosophical treatment of knowledge that and the heavy priority given to knowledge that in understanding knowledge and the mind seems at odds with evolutionary evidence regarding the relative importance of knowledge how.

9.) Conclusion

In this paper I have argued that considerations form neuroscience, cognitive psychology, computational theory, and neuroevolution belief the narrow traditional empistemological focus on knowledge that in the form of conscious or consciously accessible belief. Knowledge how clearly has an equal or greater role to play in our understanding of mind and knowledge. Furthermore, neither view of the largely neglected notion of knowledge how can withstand scientifically informed scrutiny. I offer an alternative conception of knowledge how which I claim, by understanding know how functionally and not implementationally, captures the valid insights of traditional views of knowledge how without falling victim to their shortcomings.

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