

To understand and answer the question posed, specifically "What is cognitive science?", it is necessary for us to consider the major developments through the 20th century that led to the birth of the new field in the late 1970's. To this end, I will discuss how developments in psychology, computer science and linguistics merged into what we now call "cognitive science".

Psychology plays a very large role in the formation of cognitive science. In American psychology of the early to mid 1900's, Behaviorism was the dominant viewpoint and methodology. Founded by John Watson, the goal of Behaviorism is the "prediction and control of behavior" and is only concerned with what can be observed [Note 2]. B.F. Skinner took this one step further by considering the organism in question as a black box, thereby rejecting all mental states and processes as being useless in psychology: they were not observable [About Behaviorism]. As a computer scientist, I can sympathize with Skinner's point of view. If I had to understand the underlying processes of a computer in order to write a program, then I would still be working on writing my first program. But of course, I don't outright reject these phenomena as being unimportant.

Around the same time, Tolman's Purposive Behaviorism grew out of Watson's Behaviorism, and in Europe, Gestalt psychology developed as a popular viewpoint and methodology. Tolman took the view of "behavior as an emergent phenomenon of the brain" and it has a purpose. It is not simply a stimulus-response entity, as Watson and Skinner describe it [Note 2]. Tolman's rats in a maze demonstrated the concept of cognitive maps, enforcing that learning, and by extension behavior, is a "transaction between the organism and the environment" [Note 2]. Practitioners of Gestalt psychology evolved along the same lines as

Tolman, in the position that organisms transact with their environment and perceive it in varying ways.

Furthermore are the concepts of the conscious and unconscious. The conscious mind can be divided into two subcategories: objective and subjective. Objective conscious involves an organism being aware of its surroundings, and such awareness is something that can be shared among organisms. Subjective conscious is organism specific and as such, will vary from organism to organism. By definition, to be unconscious of something is to be unaware of its existence. There are three types: preconscious, dynamically unconscious and cognitive unconscious. The former involves latent processes that can become conscious at any time. The dynamically unconscious (the subconscious as coined by Janet [Note 3]) is those processes and desires that are instinctual and repressed. Automatic bodily functions are one example of this. The third involves concepts such as blindsight, implicit memory and a concept I have coined as "autopilot", such as speaking properly without thinking about the rules of the language [Note 3].

The advent of the digital computer and the resulting importance of symbol processing marked a revolution in how humans came to think of cognition. As such, the development of computer science, in particular the field of Artificial Intelligence, plays an important role in cognitive science.

Originally, the computer was viewed as a number crunching apparatus; however, early pioneers such as Von Neumann and Turing saw it as much more than that: they saw it as a general purpose symbol processing machine. Computers are great for algorithmic reasoning,

such as multiplying impossibly large numbers in a time less than that required for a human to even consider the first digit of such a number. But Simon and Newell, with their program Logic Theorist, provided strong evidence that a computer can also reason in a manner similar to that of a human, that is, by heuristic reasoning [Note 7].

Symbols are things which represent other things. For instance, a stop sign is a symbol that represents a concept, that concept being you need to stop and wait until it is clear for you to proceed. Symbols are ubiquitous and used constantly throughout our daily lives, but we rarely consider them in and of themselves. However, Craik, in his book *The Nature of Explanation*, considers how symbols are used in our everyday lives: "...the essential feature [of thought] is ... symbolism, and ... this symbolism is largely of the same kind as that which is familiar to us in mechanical devices which aid thought and calculation." [Note 5]. It is important to note his consideration of mechanical devices, indicating that without the overt use of symbols in such devices, he would not have reached his conclusion about symbolism in thought.

Finally, in regard to developing a historical context for the understanding of "What is cognitive science?", I will discuss Chomsky and the importance of language to the development of cognitive science. Of important note here is Chomsky's concept of a "universal grammar" and its connection to the mind. More specifically, Chomsky stated that "a person who has acquired knowledge of a language has internalized a system of rules" [Note 8]. Combined with the weak linguistic relativity hypothesis, the idea that the language a person speaks influences the way he

thinks [Note 8], "universal grammar" strongly refutes the black box notion of Behaviorism and reinforces the concept of cognition and the tenets of cognitive science.

With a solid historical context providing the foundations of cognitive science, we can now address the question of "What is cognitive science?" I will address this in four steps. First, the idea of what exactly a "science" is must be considered. Next, the concept of "cognition" will be considered. Finally, I will conclude with a descriptive explanation of cognitive science followed by a prescriptive explanation.

"Science" is a word that gets thrown around often, but I believe it is poorly understood, even by scientists. Of course they know what it is to "do" science, but what exactly "is" science? Kuhn, in his *Structure of Scientific Revolutions*, addresses this question in two parts: the concepts of normal science and paradigm. In Kuhn's words, normal science is "research firmly based upon one or more past scientific achievements ... that some particular scientific community acknowledges for a time as supplying the foundations of its practice" [Note 1]. Normal science is the "doing" of science, while a paradigm "is" the science and can be described as "a network of facts, theories, models, examples, techniques, methods, philosophical beliefs, worldview and values that are shared by a particular scientific community" [Note 1]. As an example, Behaviorism in the early to mid 1900's was the paradigm of American psychology. According to Kuhn, a science can only be defined by a single dominant paradigm, an assertion which Laudan (and I) disagree with, offering instead that co-paradigms can exist together [Note 1]. Behaviorism and Gestalt psychology existed together, though geographically separate, as co-paradigms defining the field of psychology.

As suggested by the name of the field, cognition is the focus of cognitive science, and again, we run into the question of "what exactly is it?" Before offering a definition of cognition, I will explain the concept behind Bartlett's schema and the concept of culture; these are necessary in understanding cognition in the mind. Bartlett defined schema as an "organization of past reactions or past experiences" [Note 4]. The concept of schema is fairly straightforward: it is a "pattern or template that serves to represent in a person's mind some stereotypical experience or concept" [Note 4]. Minsky adopted the idea of a schema and transformed it into a computational data structure he called a "frame". The importance of schema theory in cognition is expressed by Arbib and Hesse: it "seeks to show that all human mental phenomena reduce to ... patterns of schema activation" [Note 4]. This statement is important when considering cognition.

Culture, like science, is another word that I believe is used often but not really understood, especially in a general sense. For instance, consider the concept of "American culture". Some ideas that compose this complex concept are ideas such as the "American Dream" and "the melting pot" (the diversity of cultures in the US). These are only specific constituents of a specific culture, so what are the broad generalizations that tie varying cultures together? They are as follows: customs, traditions, morals, environment, language, signs and symbols and their meanings and entire belief systems (such as religion) and are, in the words of Bruner, constitutive of mind [Culture].

Tying schema and culture together, along with the previous historical discussion, gives us a definition of cognition, "the processes by which a living being constructs meaning out of

her experiences ... the outcome of the interaction of brain and culture" [Note 1]. In the words of Bruner, "meaning-making" [Acts of Meaning]. To this definition, I would like to add a few points. First, considering Arbib and Hesse, cognition would be impossible without some organizing framework, which is found in Bartlett's schema and of course the symbols to define individual schema.

Second, I will expand upon the concept of "processes", specifically with the ideas of the conscious and unconscious mind. Conscious processes are straightforward: you are aware of the stuff around you and are constantly giving meaning to those things. Unconscious processes are harder to pinpoint, but we know they exist. For instance, humans generally have an subconscious fear of snakes, even if we have never had a bad experience with one in our lives. Also, as mentioned previously, we are able to speak properly without considering the rules of the spoken language. Third, though this definition doesn't explicitly discount it, is the concept of machine cognition. Turing's imitation game (later called Turing test) posits that if a machine can answer questions often enough to fool an interrogator into thinking that it is human, then it can think [Comp. Mach. and Int.]. I agree with Turing and I will sum up my position with an old saying: "if it walks like a duck and quacks like a duck, then it must be a duck." It can also be other things as well, but if it can interact with humans on the level that humans interact with each other, then it is a human, at the very least, culturally speaking.