Perspectives

Dynamics and Adaptation

Consciousness, Cognitive Science, and Quantum Mechanics

Jon R Courtney

Abstract
This article examines the status of some explanations of consciousness by comparing and evaluating viewpoints of psychology (e.g. cognition) and physics (e.g. quantum mechanics). It is suggested that the two approaches possess similarities on both a methodological and theoretical level and should benefit from mutual consideration. Attempts to extend and connect explanations of conscious behavior from quantum mechanics and cognition are offered though a phenomenological model. Additionally, the possibility that such phenomenology might someday in fact hold the answer to the "hard problem" of consciousness is also discussed.

Key Words: cognition, consciousness, quantum mechanics, perceptual cycle, perceptual schema

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The relationship of mind and matter is a popular topic for philosophers, psychologists, physicists, many scientists, and even people with no formal scientific training. When searching for answers regarding consciousness researchers often rely on psychology. For at least the past half century, psychologists have been concentrating on study of behavior and the mind. A cognitive psychologist seeks out common mental principles and perhaps one might ultimately build a model based on objective measurements of subjective experience. It seems that cognitive psychology (cognitive neuroscience) is currently the most popular branch of psychology. However, some theorists studying quantum mechanics have also offered potential explanations of conscious behavior from a novel standpoint. It is argued here that progress in examining consciousness though quantum mechanics could be improved by incorporating theoretical considerations from cognition.

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Regarding Methodology: Cognition and Quantum Mechanics

Overall the methodologies employed in quantum physics are similar to cognitive psychology in that each discipline examines behavior. The former relies on the explicit scientific measurement of objectively observable behavior of matter and the latter typically relies on scientific measurement of objectively observable behavior of animals (most often humans) that often describes and communicates subjective experience. Additionally both quantum mechanics and cognitive psychology use indirect methods to study systems whose workings are not directly observable. In quantum mechanics, tracks in a cloud chamber might lead a researcher to infer the existence of elementary particles. In cognition, patterns in reaction times and accuracy rates might lead a researcher to infer the existence of mental structures such as spreading activation networks.

Very recently cognitive psychology has begun to rely on new tools, which allow for measurement of behaviors within the body itself. For example functional magnetic resonance imaging (fMRI) is used to determine localization of function, trans-magnetic stimulation (TMS) is used to create temporary lesions in the brain, and eye tracking, is often incorporated into visual perception studies. Use of these tools in cognitive science typically still involves an introspective aspect or description of qualia, respectively, what subjective experiences and behaviors correlate with brain oxygen flow, a temporary lesion or ocular movement patterns, in essence combining the observation of the physical and mental realms.

Explanations of consciousnesses from both cognitive psychology and quantum mechanics could assist in answering what has been termed as the "hard problem" of consciousness (Chalmers, 1995); specifically how physical processes give rise to subjective experiences. While the problems asked and answered within the discipline of cognitive psychology typically do not attempt to answer the "hard problem" of consciousness head on, it certainly does not mean that researchers are stuck in a quagmire when it comes to attempting to answer questions regarding consciousness. Scientists (knowingly or unknowingly) do attempt to answer the smaller "easy problems" through performing experiments on simple aspects of mind and behavior, perhaps in the hopes that the hard problem will be resolved through many smaller answers.

Regarding such smaller answers, one who studies the activity of particles in quantum mechanics can make probability judgments about quantum material, which would logically seem to lead to an ability to make probability judgments about mental properties. This seems to be accurate for behavioral predictions of material on a micro (or quantum) level and even behavioral predictions of humans on a macro level as in psychology probability judgments are relied on for explanation. However, if quantum mechanics cannot yet be solidly connected to the observable and solidly predictable nature of classical physics and larger matter, it could be problematic to offer a solid connection to the observable or unobservable properties of humans (behavior and consciousness).

Could a description of an emergent system arising from complex interactions of microscopic systems be a useful explanation of macroscopic systems? There seems to be an underlying theme within physics and psychology in that the larger orderly world arises as a sort of emergent process from the complex and (relatively) unpredictable smaller world. In physics this claim is asserted in the relationship between observations made in quantum mechanics and general relativity. In psychology it comes from the observation of consciousness (along with mental processes and behavior) arising out of a complex (be it biological or multiple draft) activity of the brain. A more popular theory attempting to tie in the physical world (quantum mechanics) with the mental world (consciousness) is offered via some interpretations within quantum mechanics (e.g. Stapp 1993).

To accept a quantum mechanics theory of consciousness, it seems logical that one would have to dismiss a causal role of consciousness. The dismissal of a causal role of consciousness could be due to the unpredictable (supposed random) activity of quantum material, and also due to the offering that quantum material is driven by some sort of "(pseudo) random number generator" or a universal algorithm (Stapp 1993, p.32-33). Would a person's behavior and thinking have to follow any perceived pattern or be dependent on the activity of this random number generator? Furthermore, a causal role of consciousness is often posited by theories of mind from a quantum mechanics perspective. In theories such as that of Stapp, such a random number generator might be the mechanism for determining behavior. However, for consciousness to determine brain activity or behavior would one have to be in control of this random number generator?

Perhaps the randomness that might be well represented by a random number generator is epiphenomenal or is at best a phenomenological representation of quantum material rather than deterministic. Ultimately one might have to rely on the thesis of order (epiphenomenal or not) arising from disorder; however, whether or not such predictions made about orderly systems arising from unpredictable comparatively disorderly smaller parts would aid in providing an explanation of consciousness is debatable. This is not to say that systems should be considered as non interacting static entities or declaring that quantum mechanics does not hold the answers (in fact the uncertainty principle and the possibility of particles almost instantaneously traveling across space and time might be promising for explaining such currently unexplainable and controversial phenomenon as remote viewing). However, the current state of such theories could benefit from incorporation with methodological and theoretical advances from cognition.

Regarding Theory: The Smaller Answers

It seems that a starting point for many questions is phenomenology of activity. How then might a complex system such as a human experiencing consciousness be phenomenologically explained and studied? One interesting unifying framework can be drawn from Gell-Mann's (1994) model of how a complex adaptive system works (Figure 1). A model that consists of a conceptual framework might hold valuable explanatory power regarding how a conscious being is aware of, responds to, and adapts to its environment and how activity is changed by experience. The dynamic transmission of information in humans can be framed very well within complex adaptive systems. Dynamic processes, and subsequent perception and memory, rely on structures called schemata that provide us with reflections and expectations of our environment (Hochberg, 1978, Intraub, 2002). However, what is the nature of the relationship between schemata and complexity? One possibility is that when environmental complexity is communicated to a complex adaptive system via sensory modalities, regularities in the environment are recognized by the system and are incorporated into schemata or conceptual frameworks.

Such regularities might be recognized based on the amount of randomness (or algorithmic information content) inherent in the stimuli. Regularities identifiable by complex adaptive systems are subsequently incorporated in representations of positions, motions, and shapes by a schema. Such regularities might include invariant laws of space and geometry such as path transformation (Shepard & Cooper, 1982) and symmetry (Gell-Mann, 1994), and also could include environmental invariants such as gravity (Hubbard, 2005), and spatial continuity (Intraub, 2002). A complex adaptive system might also identify regularities that are not present in the environment or simply inaccurate, and this is exemplified by the incorporation of incorrect beliefs about physics and causality into their representations of space (Hubbard, Ruppel, & Courtney, 2005). Regardless, once the schema has been activated it influences present and future interactions with the environment, often providing the complex adaptive system with anticipatory information based on regularities and previous experience. What regularities might influence structure on a quantum level? It is possible that even the unpredictable nature of quantum material could influence structure or action of other material (micro or macro). Such a notion is simple to comprehend on a macro level (in cognition) as at times an unpredictable situation is capable of being incorporated into a schema which might influence behavior. Mental structures such as schemata are surely a consequence of biology, prior experience, and expectation. incorporation of regularities into a schema, most notably in this case, the regularity of spatial continuity (Intraub, 1997). Memories (in the form of expectations) for this unseen region are nevertheless quite accurate and include completed forms of objects that were only partially shown (drawing the top of a fence although the top was not shown in the original picture). This could be due

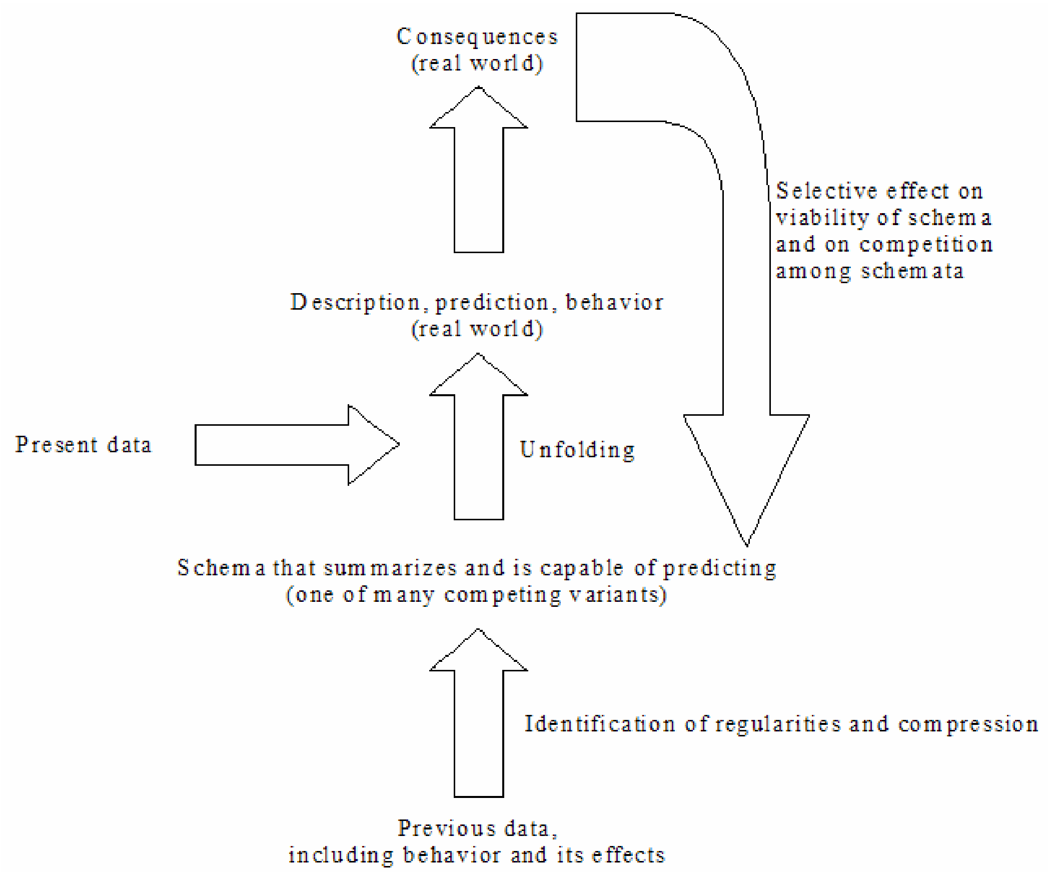


Figure 1. How a complex adaptive system works, adapted from Gell-Mann, 1994.

to the fact that schemata (and subsequently effects such as boundary extension) function as a tool for filling in anticipated information.

A robust method for exploring schema and its effects on complex adaptive systems is to examine errors in perception and memory. Often times our experiences are reflections of what we expect might happen next. One example of anticipatory predictions provided by schemata is seen in the phenomenon known as *boundary extension* (Intraub 2002); if presented with a close-up view of a scene, then people will remember that scene as being more expansive than it actually was when they first perceived the scene. People will remember objects as being smaller, and include a surrounding region not shown in the picture due to the

Neisser (1976) offers a parsimonious schematic theory that operates in a cycle but does not rely on non-linear relationships (Figure 2). Neisser (1976) describes anticipatory schemata as cognitive structures that prepare a perceiver to accept certain kinds of information and control the activity of looking in his perceptual cycle model. These anticipatory schemata are framed in a perceptual cycle by Neisser in which the observer is actively exploring his environment. These explorations are directed by anticipatory schemata which are plans for action and readiness for certain types of information. The observer perceives the outcomes of the explorations, salient events are remembered, and the original schemata are further modified. Thus modified, the schemata direct further exploration and become ready for more information, and of course this model operates as a function of time, allowing for changes to occur in perception and memory and allowing adaptation in response to regularities or changes in the environment.

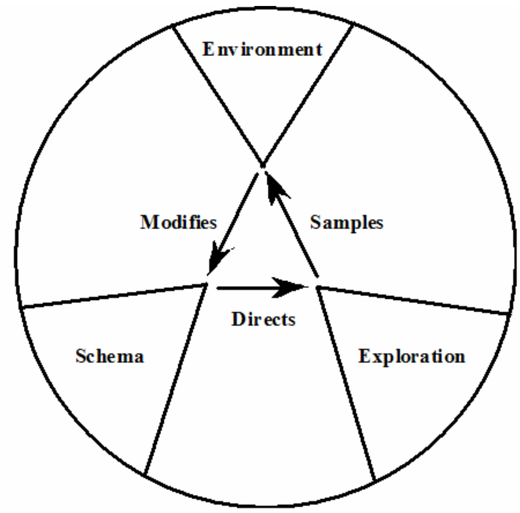


Figure 2. The perceptual cycle, adapted from Neisser (1976). Schema directs exploration which samples the environment modifying schema.

Where might consciousness exist within such a framework? One could assume that awareness could occur during the activation of a schema and direction of exploration, and that awareness could also occur during the sampling of the environment and subsequent modification of a schema. For example, imagine that a child is learning to ride a bicycle. Her parent might give some direction or perhaps the child has observed another child riding a bicycle. Nevertheless, a certain schema is brought into the situation directing the child's action on the bicycle. Some motor actions might be helpful and some might lead to a painful fall. Such experiences are further incorporated into the schema and the child is most likely quite aware of the entire perceptual cycle adjusting her actions based on feedback from the environment that she incorporates into her strategy for staying on the bicycle until, with practice these processes become more automatic and perhaps awareness of this cycle is limited to the exploration and sampling of the environment.

Gell-Mann's (1994) and Neisser's (1976) models might both provide a good phenomenological account of conscious beings interacting with the environment. It is possible that one could characterize consciousness as awareness of such a cycle; in other words, the awareness of the processing of information and interaction with the environment. It is likely that not all information within a given schema (or all schemata for that matter) are available to (or are describable by) the observer. Also, a person need not change their schema with each interaction with the environment; in fact, a change might also come from the introspection of schematic information which would include tools such as memory, imagery, and emotion. Schematic activation will necessarily depend on the data that is available to the observer at any given time. The cues that prompt access to that data, the changes occurring in the environment, and what is consciously available for description could likely direct exploration. The use of these types of tools, which may exist in the schema section of the model, could arguably be what makes conscious beings unique from unconscious beings, because such models could also describe behavior of non-conscious objects. If a schema can be described as a representation (physical or mental) or described as awareness of the surrounding environment (or even influence of the surrounding environment) consciousness might be described as an awareness of that awareness which is most evident in behaviors such as imagery and introspection.

Both models give good explanations of behavior on a macro level; however, might they apply to micro material in quantum physics or even physiology of the brain? It seems most likely that as these microstructures underlie macro behavior the models should be followed in some order and that the determining structure (e.g. schema) could also be represented at the other (e.g. mathematical or physical) levels. It could be argued that physical structures (even non-biological or non-conscious) are influenced in a similar way in that previous data or experience affects physical structure and future interaction. For example, waves crashing on a beach surely influence the shape of sand on the beach, and these changes in sand structure will subsequently change the direction of water rolling over the sand. In this case the force acting on an object shapes that object and influences future interaction between objects.

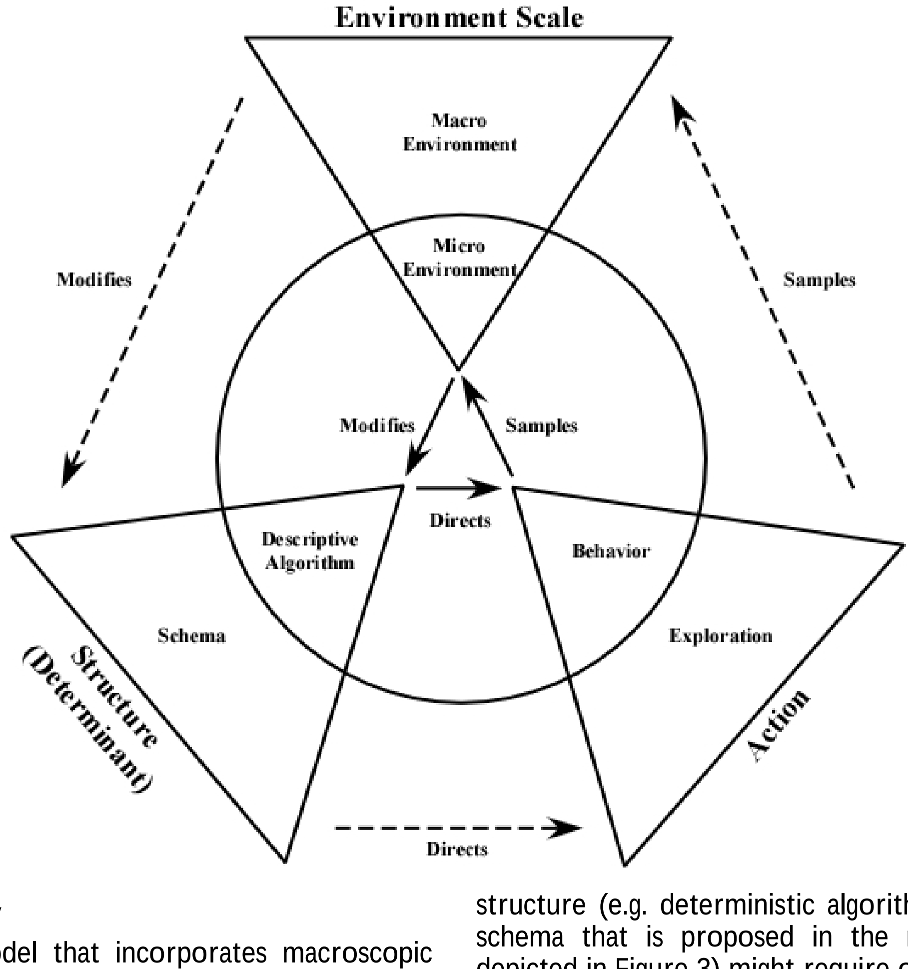
Imagine a somewhat jagged stone that might fit comfortably in your hand is sitting on a hillside above a mountain stream. You pick up the stone and throw it toward the passing water. The rough stone creates a splash as it falls into the stream and quickly sinks to the bottom. Almost immediately a relationship between the stone and the stream should be evident. The stone will influence the direction of the water in the stream and should subsequently slightly alter the stream's structure. Perhaps over time the embankment of the stream will change due to the change in the direction of the water caused by the stone. The structure of the stream is not the only change that will take place. In conjunction with the stone immediately shaping the form of the water around it, over time the stone previously described as somewhat jagged should become smooth as the outside of it erodes away.

Over time, the structure of the environment that the stone is in (the water and bed of the stream) will change the stone's shape. If you come back to the stream after many years have passed and should happen upon this stone again you might not recognize it as it would now appear quite smooth and probably smaller than you remembered it being. As the stone changes shape its influence on the water surrounding it will also change. Thus the relationship between the stone and the stream is ever changing and the forces acting on each are actively shaping the structure of the other and influencing future interaction. The smooth surface of the stone tells you something about its history. Quite early on in life you probably learned that smooth round stones have at some point been shaped by years of erosion and are most often found in riverbeds or near a lake shore. The stones carry with them evidence in their structure of the forces that have formed their current state.

One possibility that could potentially mesh ideas of cognitive science and quantum mechanics is to rely on a "cognitive model" such as that of Neisser as controlling or shaping the design of the determining structures that are well represented as a (pseudo) random number generator, schema, or universal algorithm; in this case, such determinants (whether at a micro or macro level) necessarily depend on one another for their own structure and interaction with the environment. More specifically perhaps a universal algorithm explaining behavior is not so random after all, but also incorporates regularities and certain environmental constraints along with history from the structural properties within the form of material. Using Neisser's (1976) basic framework the determinant (universal algorithm/schema) might be akin to consciousness, although such a determinant could also include data not readily available to the organism or data at any level of the perceptual cycle. Current structure determines activity with the environment, which shapes future structure, and future activity. Some might criticize models such as Neisser's as being circular due to the reliance of previous structure or activity determining future structure or activity. However, the phenomenological explanation is not circular, rather it is cyclical. Such an explanation depicts a dynamic active system that is subject to change based on experience. In essence information breeds information. Not only is such a regress desirable for explanation, but it might be a requirement for those who wish to avoid the presumption of a mystical mathematical determinant or a dualistic account of consciousness or causality (see Figure 3).

The perceptual cycle account could be extended to describe how the structure (determinant) directs behavior in the current environment, and this account includes information and material at both microscopic and macroscopic levels. This leads one to ask the question of if such a model does accurately explain behavior on the micro and macro level of a physical system, should not such a model be obviously observable and testable. Assuming such a model is an accurate depiction of behavior, there are two possibilities why the existence of such a model might not be so obvious. The first and more likely is that behavior has not been thought of in terms of such a model and so when experiments are designed they do not test such a model. The latter is that all of the determining factors in the environment cannot be accounted for or observed and so behavior is only defined and predicted in terms of probability rather than certainty (which include an accurate depiction of how quantum and classical physics relate).

Figure 3. Adaptation of Neisser's (1976) perceptual cycle model. The above model incorporates structure and action of matter at the macroscopic and microscopic levels.



Finally

A model that incorporates macroscopic and microscopic behavior along with views from quantum mechanics and cognition should be helpful. Perhaps the easy problems will someday add up to equal an explanation of the hard problem. Let us say that one wants to know how a red light becomes consciously available to an observer, and how that information influences behavior. To calculate the structure (e.g. deterministic algorithm or schema that is proposed in the model depicted in Figure 3) might require one to answer specific “easy” questions about how light is perceived at the micro and macro levels to answer the “hard problem”. In other words there could be meta-levels of structure in the form of algorithms/schemata that exist and rely on one another. Such meta-levels could at some point combine to create a schematic cycle that is phenomenologically akin to consciousness. Such a phenomenological threshold should also be subject to an organized structure that most likely exists based on interaction with the environment.

The thought that answering questions regarding the easy problems of consciousness can solve the hard problem of consciousness might also be logically possible. For example, when solving a theorem in mathematics it is often necessary to perform various (and sometimes elementary by comparison) sub-calculations for the problem to be answered successfully. However, does this example prove that incorporating quantum mechanics and cognitive science viewpoints into a single testable model would eventually answer the hard problem of consciousness? If an answer is to be found one must continue to ask questions and attempt to answer them.

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