WHAT DOES QUANTUM PHYSICS HAVE TO DO WITH BEHAVIOR DISORDERS?

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Abstract

Human agency, as a causal factor in behavior, should be taken into account in any complete model of behavior. Human agency is historically tied to the issue of consciousness and its role in behavior. Thus, to argue that consciousness plays a causal role in behavior requires that a plausible explanation of consciousness be articulated, if the assertion is to be more than mere speculation. This article discusses one line of current hypothesizing about the nature of mind and consciousness. The view examined proposes that consciousness or mind is an emergent property of a biological process that can be explained in physical terms. The process described is the Frohlich-style Bose-Einstein condensate, which appears to be capable of producing a macroquantum effect in a biological system. The process is thought to operate at the level of neurons in the brain. If consciousness can be explained as a natural process with a physical basis in the brain, there are several implications for the study of human behavior in general and children with behavior disorders in particular. The first implication is for a change in our epistemology to a philosophy similar to that of scientific realism. The second implication is for an expansion of our concept of causation in behavior to include consciousness as a potential causal agent. The third implication is for a conceptual change in the framework employed in behavior change efforts to emphasize a cooperative approach rather than a teacher-centered approach.

The answer to the above question is, of necessity, both complex and speculative. One perennial question that virtually all conceptions of behavior must address is that of the role of mind or of consciousness in human behavior. Much of Western thought has been influenced by the Newtonian worldview of classical physics. The successes of classical physics reinforced a materialistic and mechanistic approach to the study of all kinds of phenomena, including behavior. Bergmann (1940) pointed out that at the end of the 19th century psychology was still struggling with its metaphysical heritage from philosophy. At that time, psychologists turned to the logico-positivistic movement that was gaining momentum in the physical sciences. One early example of psychology's adoption of the logico-positivistic approach was Watsonian behaviorism. The most obvious contemporary example of the classical approach to explaining human behavior is the environmental determinism of the radical behaviorists (Skinner, 1972). Radical behaviorists see no role for mind or consciousness in human behavior and assert that it is a mentalistic illusion.

Cognitivists, on the other hand, rooted in the classical tradition, but less radical than the behaviorists, see mind or consciousness as playing an important role in human behavior. Many cognitivists believe that consciousness or mind is a computational process like a computer program or software running in a biological computer, that is, wetware (Johnson-Laird, 1988). These cognitivists appear to be very much in the classical camp since they believe that thinking can be reduced to a set of computational algorithms.

Currently, there are some very sophisticated efforts to provide an explanation of consciousness from a classical approach based on computing models. However, mathematical physicist Roger Penrose (1994) argued convincingly that no amount of computing power is capable of accounting for non-computational effects such as understanding. In Penrose's own words, "I am contending that the faculty of human understanding lies beyond any computational scheme whatever" (p. 367). Chemist Graham Cairns-Smith (1996) suggested that another non-computational faculty is the essential quality of consciousness and says, "It seems to me that it is precisely the element of feeling in conscious thought which makes it conscious" (p. 154). It appears that the two faculties proposed as essential features of consciousness by Cairns-Smith and Penrose may be different aspects of a more complex phenomenon resulting from an interaction of these two faculties. Neurologist Antonio Damasio (1994) offered evidence that both the intellectual process and affective process are linked and dependent upon one another. Damasio demonstrated that when the link between thought and feeling is severed, as happens with some types of brain damage, reasoning and decision-making are impaired.

Philosopher John Searle (1992) offered another perspective on the same issue. Searle argued that a duplication of consciousness and thought based on computational algorithms, such as the attempts being made by artificial intelligence researchers, could not work because conscious thought, like digestion, is a natural process. Computation is a human artifact that is observer-relative and not intrinsic to the natural world. Thus, a computational model would be a mathematical representation of a natural process and, no matter how perfect the model, it would still be just a simulation or representation. Searle proposed this thought experiment about simulations: suppose that you write a computer program that perfectly simulates the process of digestion. Now ask yourself, can this simulation digest a piece of pizza? Likewise, he argued, neither can a computational simulation of thinking think, because thought, like digestion, is a natural process.

Psychiatrist I.N. Marshall (1989) discussed two properties of consciousness that cannot be explained by classical physics. These two properties are unity and complexity. He asserted that consciousness is a complex phenomenon that cannot be localized to any specific site in the brain. Thus, consciousness must depend upon processes extending over separate areas of the brain. Further, Marshall argued that the unity of consciousness implies that areas of the brain giving rise to consciousness have a single identity. However, the principle of classical locality in physics assumes that spatially separated parts of a process have different identities. Hence, Marshall asserted ". . . states of consciousness are not describable by classical physics" (p. 74). "Therefore the substrate of consciousness is assumed not to be a classical system" (p. 78). Marshall (1989) summarized his analysis in the following statement:

> The general assumption of classical mechanics is that any complex system can be reductively analyzed into smaller parts having separate identities and only local interactions. . . . The classical assumption, which pervades our whole technology and culture, has broken down in quantum mechanics . . . . A kind of "relational holism" pervades quantum mechanics (Teller, 1986). But these discoveries have not been fully assimilated into the prevailing intellectual orthodoxy. (p. 78)

If Marshall's analysis is accepted, the search for a physical basis for consciousness must look for a biological process that can produce a macro-quantum effect. Cairns-Smith (1996) proposed a set of criteria to use in evaluating possible quantum-based theories of consciousness. His proposal consisted of four necessary features:

1. The theory must be able to explain consciousness as a physical effect.

2. The physical effect must meet the requirement of evolutionary accessibility; that is, it has a high probability of arising, in rudimentary form, from natural variations in physical structures.
3. Once available, the effect must be capable of development and specialization, through selection pressures, into a distinct structure or process that serves a new function.
4. The effect produced must have some measure of independence from the structures from which it arose.

Cairns-Smith, employing his four criteria, evaluated several possible explanations of consciousness based on quantum physics. He found the theory proposed by Marshall (1989) as being the theory most congruent with his criteria.

Marshall's model of consciousness depends upon a Frohlich-style Bose-Einstein condensate for the needed macro-quantum process. Frohlich, in the previous sentence, refers to a Frohlich pumped system. This is a biological process described by Herbert Frohlich (1968, 1986). This process appears to be capable of producing a Bose-Einstein condensate. A non-biological example of a Bose-Einstein condensate is a laser. In the proposed biological system, the electrons within atoms comprising individual molecules that make up the cell membranes of living tissue vibrate and emit photons. Photons are actually fundamental particles called bosons. One of the characteristics of bosons is that they tend to aggregate. As the metabolic energy pumped into the system increases, "stimulated" emissions of photons occur. This process involves an already emitted photon stimulating an atom to emit another photon. Stimulated photons are emitted in phase with the photon that stimulated their emission. The more in-phase photons that have been emitted, the easier it is for additional emissions to be stimulated. When a large number of these in-phase photons have been emitted, they attain coherence and form a condensed phase. Specifically, a Bose-Einstein condensate is created, which is the most ordered form of a condensed phase. In such an ordered system, the photons comprising the system function as a unified whole. These photons can be described as being in a wave state, and all of their waves are in phase. This results in a complete sharing and integration of all of their individual properties.

This process occurs in the membrane of the neuronal cells in the brain, according to Marshall (1989). Marshall believes that the electrical firing of the neurons, when the brain is stimulated provides the energy causing the molecules in cell membranes to vibrate and to become a pumped system. Penrose (1994) differed with Marshall about the location of the process. Penrose proposed that the process is located in the microtubles in the cytoskeleton of the cells. Penrose argued that the action of general anesthetics offers some direct evidence for his claim. His evidence is related to what will turn consciousness off. He stated that ". . . general anesthesia can be induced by a large number of completely different substances that seem to have no chemical relationship with one another whatever" (p. 369). He asked, since it is not a common property of the chemicals that is responsible for general anesthesia, what is responsible? He suggested that what these unrelated chemicals have in common is their effect on the functioning of the microtubles in the cytoskeleton of neuronal cells. Specifically, they ". . . exert an immobilizing effect on some part of the cytoskeleton" (p. 370). This effect, he stated, can be experimentally demonstrated even in single-celled organisms. Further, the process suggested as responsible for consciousness requires a functioning cytoskeleton. In short, if the cytoskeleton is immobilized, the necessary vibration and emission of stimulated photons needed for a Bose-Einstein condensate to form cannot occur.

The Frohlich-style Bose-Einstein condensate then appears to be a macro-quantum biological state that, when created in the brain, would make possible an ordered and unified state of awareness necessary if the holistic nature of consciousness is to be explained. Thus, this conception of human functioning is one of two interacting systems. One system, the physical body, including the brain, is a system that can be explained in terms of classical physics. The other system, consciousness or mind, is a system arising from a specialized adaptation in the brain that apparently can only be explained in terms of quantum physics.

Accepting then that it may be possible to provide a scientific explanation for consciousness that rests upon the physics of a biological process found in neuronal cells in the brain, there arises the question, why would consciousness have evolved? Cairns-Smith (1996) suggested that consciousness is a control system. In fact, he argued that there are three control systems operating in human beings. The first and oldest system is chemical and employs biological messengers such as hormones. The second is an evolutionary extension of the chemical system that can be characterized as neuronal processing and employs electrical signals. This neuronal processing operates at an unconscious level, and its activities can be compared to the parallel, distributed processing in an electronic computer. Parallel, distributed processing occurs when multiple, but independent, processing of input takes place simultaneously. However, when this parallel processing becomes very complex, a need arises for an executive control system to prevent the neuronal output from overwhelming the organism and producing gridlock. The third system then is the most recent control system. Parallel processing is slow in comparison to the other two systems. However, the system is comprehensive in its ability to access sensory data being processed throughout the brain and to access vast stores of data in memory. The data accessed then becomes subject to something more akin to serial or sequential processing. Serial processing occurs when a single task is focused on and carried to completion. Such an executive-control system must, in order to better solve problems and meet needs, employ goals and priorities to manage the complex output from neuronal processing competing for its attention.

Cairns-Smith (1996) proposed that consciousness is necessitated by the evolving complexity of the nervous system. He argued that increased awareness of the world and the relationships that exist amongst variables in the world gives a definite survival advantage to a problem-solving organism like human beings. He suggested that problem solving is one of the prime responsibilities of consciousness and that both volition and intent are necessary components in such a system.

Campbell (1974), in discussing Karl Popper's evolutionary epistemology, laid out a hierarchy of problem solving with 10 levels. As one moves up through these levels of thought, it is clear that modes higher in the hierarchy give greater evolutionary advantage than those lower in the hierarchy. One reason for this advantage is the increase in the number of variables that can be employed in problem solving. Another and perhaps more important advantage is that it becomes possible to devise and try out courses of action, as well as evaluate their possible consequences without the risk of direct engagement of the environment. Consciousness probably first becomes necessary in this hierarchy at level five, which is characterized as "visually supported thought," and certainly is necessary at level six, which is characterized as "mnemonically supported thought." Consciousness, it appears, provides the "global work space," proposed by Bernard Barrs (cited in Cairns-Smith, p.180), necessary for selectively considering input, devising solutions and selecting from among possible solutions to a problem.

It now appears that one need not regard consciousness as merely an illusion, nor as a computational program, but rather as a natural process with a physical basis in the brain. If one accepts this possibility, there are several implications for the study of human behavior. The first implication relates to the epistemology underlying the study of human behavior. At the turn of the century, psychology parted with it roots in philosophy and began attempting to create a science of behavior. In this attempt to become scientific, it relied, largely, upon a philosophy of science called positivism (Bergmann, 1940). In its most basic form, positivism asserts that observable events and their functional relationships are all that can be known. The philosopher John Dewey characterized this view as, "the spectator theory of knowledge." By way of contrast, some cognitive psychologists have adopted the philosophy of constructivism. In its most radical form, constructivism asserts that everything we know is a social and intellectual construction; that is, there is no objective reality to be observed and understood independent of our ideas about it. It is, therefore, very much in the tradition of idealism, in which all that is believed to exist are ideas. Clearly, for the radical constructivists, the role of consciousness in behavior is primary and self-evident.

The radical constructivists may have been correct in recognizing that the mechanistic materialism of the classical positivist model was in need of replacement, but in rejecting the positivist model, they took an equally extreme position. On the one side, there is the claim that consciousness is an illusion and reality is independent of human observers, a claim that our knowledge of reality is limited to what can be directly sensed. On the other side, there is the claim that consciousness is primary and reality is wholly dependent on human observers, a claim that we construct reality through our ideas. There appears, however, to be a middle ground related to quantum physics that strikes a balance between these two views. It is a philosophy of science that has arisen within experimental physics to replace positivism as a theory of knowledge, which is called scientific realism (Hacking, 1982).

Scientific realism arose because physics progressed to a point where the variables that it studied could no longer be directly perceived. Initially, this was handled by extending the definition of sensory data to things perceived with the aid of instrumentation, for example, microscopes (Boyd, 1983). However, physicists began to experiment with theoretical variables that could no longer be directly perceived even with the aid of instrumentation. When this occurred, the existence of these variables had to be inferred from their predicted effects. At this point, it was accepted that a new theory of knowledge was needed. Scientific realism accepts the proposition that there is a reality independent of our knowledge of it and that this reality has intrinsic properties that are both observable and unobservable. Scientific realism is, however, a weak form of realism and is not wedded to the physicalism of the classical view. That is, it does not claim that everything is reducible to physical phenomena.

Scientific realism then would appear to allow for both a reality that is, in part, independent of our knowledge of it and one that is, in part, dependent upon human construction. Searle (1992) drew a distinction between aspects of reality that are intrinsic features and those that are observer-relative features. On the one hand, intrinsic features would include such things as the mass or density of an object and the sex or consciousness of an organism. These are aspects of the natural world. On the other hand, observer-relative features would include intellectual constructions such as computational algorithms or scientific theories and social constructions like democracy or art.

Thus, it appears that one implication of accepting an explanation of consciousness based upon quantum physics may be letting go of a philosophy of science that has limited our study of behavior and its causes to the directly observable. Cziko (1989) presented a series of arguments, not all of which depend upon quantum physics, which led to a similar conclusion. Cziko also discussed the implications of that conclusion for educational research. Cziko argued that prediction and control of behavior is not possible and that the proper method for studying human behavior is not experimental but descriptive. Howard, Myers, and Curtin (1991) discussed the issue of human agency and research methodology and suggested that it may be possible to separate agentic and non-agentic influences in experimental results. Howard et al. also proposed a method for studying self-determined behavior and discussed several examples of studies employing this method. The quantum-based explanation of consciousness, outlined in this article, suggests that a philosophy of science should be adopted that permits the study of behavior and its causes, where the causes may not always be observable. If consciousness is a physical but unobservable process that functions as a causal agent in behavior, a theory of knowledge, like scientific realism, that permits the study of unobservable variables is required.

A second implication of a quantum model of consciousness is related to the conception of causation in behavior. If we accept consciousness as an executive control system, then we accept a system that employs goals and priorities to organize input and guide decision-making. Goals can have a biological basis, as in the case of physical needs like reproduction. Goals can also have a social basis, as in the case of goals acquired through socialization, such as getting married. Finally, goals can have a personal basis, as is the case of goals that are the product of unique individual experiences and socialization in interaction with one's biological individuality. An example of this type of goal would be a personal preference about the characteristics of a potential mate. From the perspective of an executive control system, the environment is no longer seen as the principal cause of behavior. Certainly, events in the environment can influence behavior. However, just as important now are the goals that an organism has in the external environment and the decisions it makes about how to best use the external environment to accomplish those goals. This introduces a source of variability into behavior that cannot be explained by studying only observable influences on behavior.

Thus, it appears that a second implication of accepting an explanation of consciousness based upon quantum physics may be giving up theories of behavior that exclude the possibility of individuals being causal agents in their own behavior. The type of model called for is one that is consistent with the hypothesis about the function of consciousness discussed earlier, that is, as a problem-solving control system. Such a model assumes the agency of consciousness in behavior. Bandura (1989) and Howard (1993), in more conventional analyses than the one presented here, also arrived at the conclusion that human agency must be taken into account as a causal variable in human behavior.

At least two psychological models could be useful for understand the working of consciousness as a causal agent in behavior. One is the control theory model of behavior (McClelland, 1994; Powers, 1973, 1980). In this model, an individual's behavior reflects choices made to maximize adaptation of the environment to one's goals. The second is that of social cognitive theory (Bandura, 1989). Bandura presented an argument for a causal model that depends in part upon self-reflective and self-regulatory processes. In this model, goals and forethought play an important role in determining current behavior. Bandura's model is similar to Power's (1973) model in that both employ a control system based on discrepancy reduction, that is, acting to reduce any discrepancy between one's goal and one's perception of the current status of goal attainment. Bandura's model, however, also employs a discrepancy production component through which one intentionally creates a discrepancy between goals and current circumstances by setting new or revised goals. There is some question concerning whether or not this second feature of Bandura's model is an exclusive feature of his control theory (Powers, 1991). Thus, both models view behavior as the product of a deterministic system, but causation must be recognized and understood to include the agency of consciousness and thought in behavior. Consciousness as an executive control system is a dynamic system in which problem-solving strategies are created. It is a system through which new uses for aspects of the environment are discovered, and a system in which goals are modified to reflect a change in the intentions of the organism.

A third implication of a quantum model of consciousness pertains to a shift in the conception of behavior change. If we accept consciousness as an executive control system, then we accept a system that employs goals and priorities to organize input and guide decision-making. Such a system also suggests an important role for volition and choice. A control system model leads us to think differently about selecting strategies for behavior change.

McClelland (1994) discussed four basic approaches that behavior change strategies are based upon: force, threat, incentive, and persuasion. The first two rely on the use of coercion. Behavioral psychologist Murray Sidman (1989) has extensively discussed the effects of coercive strategies. Clearly, force and threat can change behavior, but there are ethical and logistic reasons for not employing such strategies under most circumstances. However, McClelland proposed that incentive, too, is a form of coercion when it is used to externally manipulate an individual's choices. The effects of such manipulations are the bane of incentive-based interventions, because all too often, as soon as the imposed incentives are reduced or removed, the distortion produced in an individual's behavior by these contrived incentives ends. As a behaviorist would say, there is no generalization. There is also some evidence that reinforcement like punishment can have troublesome negative side effects (Balsam & Bondy, 1983). The last strategy, persuasion, does not have the power to produce quick results, as is the case with force or threat, nor does it have the power of incentives to artificially modify choices. However, persuasion is better suited than the other three techniques for facilitating a long-term change in an individual's goals and priorities. Thus, persuasion also has a better chance for facilitating a relatively permanent change in behavior.

Looked at from the perspective outlined above, one could say that interventions directed at students with behavior disorders should be conceptualized in terms of strategies that affect goals and behavior. Thus, for maximum effect, individuals need to understand and be actively engaged in the change process. Certainly, mechanistic approaches like the behavioral approach can produce change, but the behavioral change needs justification. Thus, change must be integrated into the goal system if it is to be a generalized and lasting change. In other words, a change in behavior that is brought about only through external influence may not be accepted as relevant to one's goals. The author is reminded of a poster from the Vietnam War era that read, "Just because you've shut me up doesn't mean you've changed my mind." This statement clearly implies that while there has been a coercively induced change in behavior, the speaker's goals have not changed. Remove the source of coercion, and behavior will realign with the individual's goals.

The success of programs for students with behavior disorders is all too often determined by their ability to "shut-up" students. A model that takes into account the role of consciousness in behavior suggests that changing behavior, at least in intellectually adequate human beings, needs also to be about changing minds. Ultimately, changing minds depends upon both persuasion and a cooperative effort. The general strategy for change that is implied is recognition of and involvement by an individual in the process of self-change through modification of goals, where those goals are dysfunctional. It is also a better strategy for finding more appropriate ways of meeting acceptable goals when the means of achieving them are not. Such a strategy must also grapple with the issue of how to define what is acceptable and unacceptable relative to both goals and behavior. Ultimately, such a definition must take into account both the interests of the individual and of society. The most important use of persuasion should be to convince a student to engage in a cooperative alliance. Persuasion should focus on rationales for changes in goals, priorities, or behaviors. Persuasion should also attempt to convince a student of the importance of his or her choices in creating a control system that functions as the foundation for his or her interaction with the world.

There are a number of existing approaches that have possibilities for persuasion-based interventions to facilitate self-directed change in behavior disordered students. One is the Perceptual Control Theory (PCT) approach to behavior change (Ford, 1994), based on the theory of Powers (1973). The PCT approach of Ford emphasizes self-directed change in one's goals and the behaviors employed in meeting those goals. Adlerian psychologists (Adler, 1964; Stein & Edwards, 1997) recognize the role of self-direction in the change process and employ Socratic questioning as a way of helping clients understand and change their goals and behavior. Narrative psychologists (McAdams, 1993; Wood, 1996) describe an approach emphasizing self-direction through the identification and modification of the life-stories or personal myths that one uses to organize and guide behavior. Personal myths can be thought of as a narrative description of one's control system and the goals implicit in the system. Rational-Emotive psychologists (Bernard & Joyce, 1984) employ the concept of underlying or root beliefs as the basic organizing principle for guiding behavior. In this model, one can think of root beliefs as representing the most fundamental goals in one's control system. Interventions that are directed at changing these beliefs require a cooperative effort between a teacher and a student. There are no doubt other possibilities; however, the point is that it is not necessary to invent new strategies in order to implement the approach implied by a model emphasizing the role of consciousness in behavior. The model does not invalidate all existing strategies, but rather suggests a different conceptual framework within which to employ and adapt existing strategies, as well as to create new strategies.

Thus, it appears that a third implication of accepting an explanation of consciousness based upon quantum physics may be de-emphasizing manipulative strategies of behavior change. A focus on externally directed strategies should be replaced by a focus on persuasive strategies that emphasize self-directed change. There probably are some circumstances where persuasion-based and self-directed change may not be possible, for example, in individuals suffering from conditions, in which biological factors play a dominant role, for example, schizophrenia. However, once the biological component of such a disease has been medically managed, the proposed intervention philosophy would be apropos. Medical management of such diseases may still leave such individuals with serious psychological problems that are the by-product of their experiences before successful medical treatment. Mental health problems that are diseases, in the medical sense, probably account only for a small percentage of the children and youth in need of help (Albee, 1968).

With students, the author makes a distinction between agent-directed, reactive methods versus client-directed, persuasive methods (Center, 1999). Agent-directed methods are methods that are suitable for reacting to an immediate presenting problem to prevent injury and to prevent disruption of an instructional program. Behavior modification is an example of such a method. Client-directed methods are often not suitable for dealing with an immediate presenting problem but rather are best suited to avoiding future problems. Rational-Emotive problem solving is an example of a client-directed method. It should also be clear that permanent, long-term change probably requires focusing on client-directed methods. Reactive methods largely rely upon manipulation, for example, contrived reinforcement and coercion, e.g., response cost. Persuasive methods largely rely upon cooperation, for example, an alliance between a student and a teacher to identify and change irrational thinking that is causing a student difficulties.

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