IDEAS & OPINION

CONSCIOUSNESS AND ADAPTIVE BEHAVIOR

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The main problem in explaining consciousness is accounting for its subjectivity from an internal perspective. In addition, subjective systems have adaptive ability to respond to change and self-organize their own behavior. In this context, the nonlinear emergence of internal explicit states might be studied in natural systems to gain insight into the physical principles involved in the production of consciousness. Since intelligence is the ability to consciously create voluntary new or novel intentional action, standardized tests might provide an index of intelligence, as well as the degree of consciousness present, i.e. IQ might also be a measure of degree of consciousness.

Key words: *Consciousness; Adaptive behavior; Nonlinear emergence; Physical principles; Brain states; Intelligence*

INTRODUCTION

For centuries people have been trying to explain consciousness (Chalmers, 2004). The main problem in explaining consciousness is accounting for its subjectivity, i.e. consciousness is an internal perspective or point of view, an internal context built from external input and previous experience or memory (McCrone, 2001). Subjective systems may be adaptive-able to utilize their viewpoints to respond to change, i.e. self-organize to control their own behavior (McCrone, 2001). In this paper, I show how such subjectivity might arise and be utilized.

VOLUNTARY NEW OR NOVEL INTENTIONAL (ADAPTIVE) ACTION

Our production of new or novel adaptive action is essential for our survival. We voluntarily (by choice, free will) produce such action and it is always directed towards some goal (intentional). The creation of this action allows us to respond to our continuously changing environment in a rapid, versatile, and purposeful manner. We are not bound by stereotyped inflexible reflexive or programmed-type responses typical of lower animals and machines; but have a high capacity to create new or different responses as the situation demands.

Our production of voluntary new or novel intentional actions or action sequences has reached its highest development in speech and reasoning (thinking). In communicating with others, we are continually composing new or novel word sequences. In thinking, we are continually modifying and arranging and rearranging thoughts (these may be considered

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reactivated memories of perceived sensory input) in new or novel sequences. The creation of voluntary new or novel intentional actions and action sequences may be seen in our muscular motor action (skeletal and ocular): going to a store, handling a cup, playing a game, fixing something, scanning a crime scene, etc. Such action may also include emotional reactions. Various degrees and composition of emotional reaction are composed depending on the situation. We may be very angry in one situation (shouting, red face, violent gestures, aggressive facial features, etc.), but not so angry in another (firm speech, no red face or gestures, fixed facial features). We may be petrified and cringing with fear in one situation, able to flee in another. We may show love to one person, anger to another. All these actions or action sequences are similar in that they are voluntary new or novel intentional responses. This ability to produce voluntary new or novel intentional action may also be seen to a much more limited extent in lower animals. The production of such responses is very important for survival and may have evolved for such a purpose.

Our ability to produce voluntary new or novel intentional actions and action sequences may have evolved first in the skeletal motor system. This ability may have led to the success of early man and the emergence of *Homo sapiens* as the dominant species (McCrone, 1999). This system is intimately related to perception, as elements of perception are closely tied to specific skeletal motor responses (Allott, 1994). Much of this relationship may be prewired (genetic-Allott, 1994). Speech and thought might have evolved from the basic structure of the muscular motor system (Allott, 1994; McCrone, 1999). Emotional responses are produced by what is often referred to as the third motor system (Holstege et al., 1996). This also might have evolved from the basic skeletal motor system. The evolution of the ability to produce a variety of voluntary new or novel intentional actions would give increased reproductive and survival success.

POINT OF VIEW OR PERSPECTIVE

Voluntary new or novel intentional action is always produced from the subject's own particular point of view or perspective. This point of view or perspective arises from perception. It is unique to that individual at that time. It cannot be known (experienced) by another. It is subjectivity- having or adopting a particular perspective or point of view (Alter, 2002; McClamrock, 1992; McCrone, 2001).

The formation of a particular point of view or perspective is essential for the production of voluntary new or novel intentional (adaptive) action. A point of view or perspective is a particular way of looking at particular information. Perception would directly produce only stereotyped reflexive-type action. In order to produce new or novel action, perception must be reorganized and rerepresented in a new or novel manner (Gershenson & Heyligher, 2004). This rerepresentation represents formation of a new particular point of view or perspective. This new point of view or perspective is not entirely predictable and probably emerges in a nonlinear fashion, typical for complex systems (consisting of interacting elements) like the brain (Gershenson & Heyligher, 2004).

VOLUNTARY NEW OR NOVEL INTENTIONAL ACTION AND CONSCIOUSNESS

One interesting thing about our production of voluntary new or novel intentional action is that it is always accompanied by consciousness. Our production of reflex and learned (programmed) action occurs without awareness or consciousness and is said to be automatic. Consciousness is subjective- it is a particular personal perspective or point of view that is somehow created in our brains (Alter, 2002; Byrne, 2001; McClamrock, 1992; Mandik, 2001). Our voluntary new or novel intentional action is created from our particular point of view or perspective at the moment, i.e. our consciousness. Hence consciousness may be responsible

for the composition of voluntary new or novel intentional action and may always be present when such action is composed.

If an animal or machine can produce voluntary new or novel intentional action, then such action may be said to arise from the animal's or machine's own particular point of view or perspective and consciousness may be deemed to be present. If a physical mechanism can be found for the production of voluntary new or novel intentional action, perhaps it also explains how the particular point of view or perspective (consciousness) is produced.

PRODUCTION OF VOLUNTARY NEW OR NOVEL INTENTIONAL ACTION AND CONSCIOUSNESS

Current research indicates that the prefrontal cortex mediates (plans) our ongoing production of voluntary new or novel intentional action through the integration of three cognitive processes: active short-term memory (working memory), motor set (a selection, preparation, and readiness for action), and the inhibition of excess activity (Fuster, 1997, 2000). These three processes may create and implement a particular point of view or perspective for a subject. Active short-term memory is the provisional retention of perceptual information for prospective action, a type of focal attention whereby perception is reorganized and rerepresented, becoming explicit, functional, and conscious (Luck & Vogel, 1997; Todd & Marois, 2004; Vogel & Machizawa, 2004). Specific perceptual activity is selected, rerepresented, and maintained over some interval (delay) so as to produce future action. Such action is thus mediated, deliberated, new or novel, voluntary, and intentional. Active short-term memory may be formed and maintained by positive feedback, a type of reentry (Fuster, 1997). Reentry refers to reciprocal interaction (feedback) between elements and occurs throughout the brain (Tonelli & Edelman, 1998). Positive feedback occurs when this reciprocal feedback is excitatory. Positive feedback leads to exponential growth of activity (Scott, 1996, 1998, 2000). Hence positive feedback between the dissipation and release of perceptual activity (dissipation leads to more release, leading to more dissipation, leading to more release, and so on) may lead to the exponential growth of perceptual activation. However, inhibition is also activated by these dissipation and release events (decay, depletion, change in input, refractory periods, etc.), limiting the growth, producing a balanced (stable) state (Scott, 1996, 1998, 2000). This stable state is a nonlinear emergent, i.e. it depends on, but is entirely different from (is not defined by nor reducible to), its initiating events (Newman, 1997; Scott, 1996, 1998, 2000). It is a rerepresentation of perception. Such nonlinear emergence is responsible for a vast number of natural phenomena [candle flames, waves, nerve impulses, cells, nations, family groups, businesses, stock market, etc.] (Scott, 1996, 1998, 2000; Sieb, 2004). The emergent state is said to be explicit, i.e. it is fully established physically and can be directly utilized to produce other states or effects (intentional character)- O'Brien & Opie, 1999. Since this explicit state is a new internal context built from perception, it may be considered a particular point of view or perspective for that system (subjective or phenomenal character). According to this reasoning, active short-term memory is a particular point of view or perspective for that subject arising from perception. This nonlinear explicit state (point of view) is utilized in the production of action (motor set). Since this state is created anew each time, it is always new or novel, and always produces voluntary new or novel intentional action.

This new or novel internal nonlinear explicit state (active short-term memory) has all the same properties that have been attributed to consciousness (Baars, 1988; Clifton, 2003, 2004a, 2004b; Koch, 1998; Tonelli & Edelman, 1998). It is self generated. It forms rapidly, but does take time to form. It persists. It requires reentry. It requires attention. It has effects on other systems. It has intentional character- is representational, directed. It has subjective character- is a particular first person point of view or perspective. It has content. It is complex, bounded, and has limited capacity. It is variable, flexible, and seamless. It is hard to describe (ineffable). It is transparent (unseen). It is serial in production and prone to interference. It is unified and

coherent (bound, oneness). It is difficult to formally describe (hard to describe scientifically). It is projected outwards. It has intrinsic positive or negative value. It is a tenet of consciousness studies that when two things have all the same properties, they are identical (Velmans, 2002). Hence if the internal explicit states produced in the above manner have all the same properties as consciousness, then they must be identical to consciousness. Thus consciousness arises whenever voluntary new or novel intentional action is produced. Consciousness is essentially part of the mechanism producing voluntary new or novel intentional action. Consciousness is a natural property of such nonlinear explicit states. Subjective consciousness produces physical action because it is a physical state.

SUPPORTING EVIDENCE

Consciousness is impaired if reentry mechanisms in the brain are disrupted (Tonelli & Edelman, 1998). Positive feedback is a basic physical mechanism responsible for the production of a large number of natural phenomena. The formation of states via this mechanism shows how information can be bound together in a cohesive and unified whole. Perception and focal attention are essential for consciousness (Rowlands, 2002; Velmans, 1999). Perception is thought to occur in the inferior temporal and inferior parietal cortex (Mattingley, 1999). Pathology of this cortex produces most of the cases of neglect-impaired perception and consciousness (Mattingley, 1999). Active short-term memory has been shown to operate in the posterior parietal cortex (Todd & Marois, 2004; Vogel & Machizawa, 2004). Damage to the prefrontal cortex and/or its connections leads to an impaired general ability to produce voluntary new or novel intentional action (of skeletal movements, oculomotor movements, speech, thought, emotion-psychomotor poverty), but preserves consciousness (Joseph, 1990). Damage to the supplementary motor cortex, frontal eye fields, Broca's Area, temporal cortex, or orbitofrontal cortex impairs the ability to produce voluntary new or novel intentional action in that domain (since the prefrontal cortex generates action via these areas-Fuster, 1997; Pandya & Yeterian, 1990). In this context, standardized intelligence tests depend on how well the subject can integrate information consciously and create voluntary new or novel intentional action.

CONCLUSIONS

Consciousness can be explained as a physical state of the brain. The "gap" between the subjective and the physical (how can the subjective arise from the physical and how can the subjective affect the physical- Velmans, 2002) from this point of view might be removed because the subjective (particular point of view or perspective) is a natural property of nonlinear internal explicit states (Carruthers, 2000, 2002; Clark, 1997; Lazarov, 2003; Nicholson, 2003). Consciousness is natural, material, and functional; not some mysterious, nonmaterial epiphenomenon. It may be studied scientifically. It may occur in animals, machines, and natural systems; any system that has the ability to produce voluntary new or novel intentional action or effects. The production of voluntary new or novel intentional action may be an objective indicator for the presence of consciousness. This is important for the composition, synthesis, and verification of consciousness research.

FUTURE RESEARCH

Future research might include the study of various animal species to determine their ability to compose voluntary new or novel intentional action. If they can, then they may possess some degree of consciousness and may allow study of the neural mechanisms involved in its

production. Human studies of consciousness must involve the production of voluntary new or novel intentional action. Machines may be built that can create true voluntary new or novel intentional action, which could also allow study and manipulation of the physical mechanisms involved. The nonlinear emergence of internal explicit states might be studied in natural systems to gain insight into the physical principles involved in the production of consciousness.

Since intelligence is the ability to consciously create voluntary new or novel intentional action, standardized tests might provide an index of intelligence, as well as the degree of consciousness present, i.e. IQ might also be a measure of degree of consciousness. Hence many of the intelligence tests that exist today may also provide a measure of the degree of consciousness. However, to provide a more accurate measure, they must be broadened to include all types of action. Since consciousness depends on the selection and maintenance of perceptual activity over a delay (of active short-term memory), studies of delayed response tasks might be key to its understanding.

PREDICTIONS

Consciousness likely will be found to be natural, material, and functional. It will be found to be explained by scientific principles. It will be found to function in the creation of voluntary new or novel intentional action and have an evolutionary history. Certain other animals will be found to have a degree of consciousness. Conscious machines will be built. A degree of consciousness will be found in many nonlinear emergent natural systems. It will be possible to construct standardized tests to measure the degree of consciousness (IQ). It will be possible to manipulate and extend our consciousness, perhaps into what is now the paranormal. Our consciousness may persist after death, if we possess an energy that continues to interact with itself after we die.

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