

# **The Nature of Consciousness**

## **Handout [12]**

**Francis Crick and Christof Koch: *Towards a Neurobiological Theory of Consciousness***

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### **[General Claims]**

- 1. The problem of consciousness can, in the long run, be solved only by explanations at the neural level.**
- 2. Consciousness depends crucially on**
  - (a) some form of rather short-term memory, and also on**
  - (b) some form of serial attentional mechanism.**

**\_\_\_ This attentional mechanism helps sets of the relevant neurons to fire in a coherent semi-oscillatory way, probably at a frequency in the 40-70 Hz range, so that a temporally global unity is imposed on neurons in many different parts of the brain. These oscillations then activate short-term (working) memory.**
- 3. There is general agreement that we are not conscious of all the processes going on in our heads. In fact, some psychologists have argued that we have only very limited introspective access to the origins of even higher order cognitive processes.**
- 4. Assumption: all the different aspects of consciousness, for example, pain and visual awareness, employ a basic common mechanism or perhaps, a few such mechanisms.**
- 5. The problem of qualia may prove to be solvable on the neural level.**

### **[What Consciousness Is]**

- 1. Some species of animals, in particular the higher mammals, possess some of the essential features of consciousness, but not necessarily all.**
- 2. A language system is not essential for consciousness.**
- 3. It is probably that consciousness correlates to some extent with the degree of complexity of any nervous system.**
- 4. Self-consciousness, with is the self-referential aspect of consciousness, is merely a special case of consciousness.**
- 5. Dreams seem to have some of the attributes of consciousness, but people in deep sleep or under deep anesthetic do not.**

[Contemporary Neurobiological Theories]

(1) Johnson-Laird's theory

The brain is a complex hierarchy of largely parallel processors and there is an operation system at the top of the hierarchy. The conscious mind corresponds to this operating system. Thus the mechanism of consciousness expresses the results of some of the computations the brain makes but not the details of how they were done. If there is an operating system of this type it is not easy at the moment to see any particular brain area in which it is located.

(2) Jackendoff's theory

Consciousness is not associated with the highest levels in the hierarchy but with the intermediate levels.

Both views emphasize the intimate relationship between consciousness and  
 \_\_\_ (i) short-term memory [long-term memory is not essential since people without long-term memory seem to be fully conscious.]  
 \_\_\_ (ii) attention

[The Hypothesis]

1. We think it plausible that consciousness in some sense requires neuronal activity.
2. Our basic hypothesis at the neural level is that it is useful to think of consciousness as being correlated with a special type of activity of perhaps a subset of neurons in the cortical system.
3. We hypothesize that there is one basic mechanism (or a few such) underlying them all.
4. The relevant neurons in many cortical areas cooperate together to form some sort of *global activity* and that this global activity corresponds to visual awareness.

[The Binding Problem]

\_\_\_ Because any object will have different characteristics (form, color, notion, orientation) that are processed in several different visual areas, it is highly reasonable to assume that seeing any one object often involves neurons in many different visual areas. The problem of how these neurons temporarily become active as a unit is often described as "the binding problem."

**\_\_\_ As an object seen is often also heard, smelled, or felt, this finding must also occur across different sensory modalities.**

**[The Theory]**

### **1. Oscillations of neurons at 40 - 70 Hz**

It has often been hypothesized,... that in neural terms binding means the temporarily correlated firing of the neurons involved. In other words, neurons in different parts of cortex responding to the currently perceived object fire action potentials at about the same time.

### **2. Attention**

Awareness and attention are intimately bound together. There is a serial attentional mechanism, sometimes called the spotlight of attention.

### **3. Short-term memory**

It has long been argued that awareness is not only associated with attention but also with some form of short-term memory.... No case of a person who is conscious but has lost all forms of short-term memory has been reported.

### **4. Topographic map of the brain**

**This map would derive its input from the individual feature maps and give a very biased view of the visual environment, emphasizing locations where objects differed in some perceptual dimension, i.e., color, motion, depth, from objects at neighboring locations.**

### **5. Feedback pathways**

**Once a particular salient location has been selected, probably by a winner-take-all mechanism, the information associated with it must be activated by referring back to the individual feature maps. The various parts of the visual thalamus are well suited to influence the behavior of neurons in those parts of the neocortex from which they receive information and to which they project back. Some such feedback pathways then activate or synchronize the oscillations at the corresponding locations .... so that a coherent set of features is bound.**

### **6. Selection**

**Of course, this system has to decide, using the categorical knowledge stored in the connections, exactly which neurons must oscillate together to produce a veridical representation of the object being attended to.**

**[Conclusion]**

- 1. The information about a single object is distributed about the brain. There has, therefore, to be a way of imposing a temporary unity on the activities of all the neurons that are relevant at that moment.**
- 2. We suggest that one of the functions of consciousness is to present the result of various underlying computations and that this involves an attentional mechanism that temporarily binds the relevant neurons together by synchronizing their spikes in 40 Hz oscillations.**
- 3. These oscillations do not themselves encode additional information, except in so far as they join together some of the existing information into a coherent percept.**
- 4. We tentatively suggest that this activates the appropriate parts of the working-memory system.**
- 5. There is also much neural activity in the visual system that does not reach full awareness. Much of this corresponds to the computations needed to arrive at the best interpretation of all the incoming information that is compatible with the stored, categorical information acquired in the past. It is this "best interpretation" of which we become aware.**

**[Question: Does this theory support Dennett's Multiple Drafts Model?]**