VISUAL COGNITION IN UNDERGRADUATE BIOLOGY LABS; CAN IT BE CONNECTED TO CONCEPTUAL CHANGE AND OTHER LEARNING THEORIES?

Robert Day, The Ohio State University. day.3@osu.edu.

Synopsis

The author has previously suggested that certain unique cognitive issues may be responsible for the difficulties that some students experience when they try to observe complex biological material during lab, field or microscope exercises (Day, 2001). Although various learning theories, neurological mechanisms and other factors probably influence what students visually perceive, the author suggests that the way that students evaluate, modify and reach conclusions about the meaning of visually complex material in biology labs seems to occur in a way that is very similar to Posner's (1982) conceptual change model. The key to understanding whether this is indeed "conceptual change" seems to be an exploration of exactly what constitutes a "concept". Cognitive psychologists consider that a "concept" is an arbitrarily constructed, human representation of some single, discrete, "real world" phenomenon. Things in the real world are referred to as "categories" and are assumed to have some "real" definition. "Classical categories" are things like mathematic rules (e.g. even numbers are divisible by two). These categories appear, at least superficially, to have a real world definition. "Family resemblance" categories are things like classes of similar objects, e.g chairs. These are philosophically harder to understand because there appear to be no necessary and sufficient conditions that can adequately define them. We all know a chair when we see one but it is hard to precisely define "chair" as a real <u>category</u> and it is likely that different individuals have very different <u>concepts</u> of what a chair is. For most humans then, the act of categorization is actually the act of constructing a personal concept of some real world entity. The nature of categories and concepts is actually a very old philosophical puzzle that has no really good universal explanation. The slippery nature of this problem has confounded cognitive scientists in many fields, because without a good definition of how categories are defined and how they differ from their human-internalized counterpart (concepts) it is extremely hard to understand almost any cognitive function, ranging from language acquisition to perception. (See Pinker, 1984 for a general discussion of this issue)

I suspect that the way that "conceptual change" educational researchers use the word "concept" is actually somewhat inaccurate. What Posner (1982) and his ilk are really talking about when they speak of "conceptual change" is a change in a student's "conceptual schema". It is rare for a student's concept of some basic everyday entity (such as a chair) to change. What more usually changes is the student's ideas about the way that different concepts are related to each other and arranged into some coherent picture of reality It is a change in this picture of reality that Posner calls conceptual change. Nonetheless, if a student's concept of a single isolated object or principle does change (as it often does when observing, say unfamiliar living things) then we should expect that this must inevitably affect any schemas within which the concept is embedded. When an individual recategorizes a single entity (for example when they decide that an animal is not the species that they initially thought it was) , this is not necessarily Posnerian "conceptual change", but it almost always leads to Posnerian conceptual change because any schema that included the changed entity must now be adjusted to take account of the new definition of one of its components. As Posner points out - schemas, like scientific paradigms, can sometimes be resilient to change. When this is the case, we might expect the schema to stabilize or anchor an individual's concept of the discrete entities (on which the schema is built) just as every schema is itself stabilized by other schemas that it connects with (Posners "conceptual ecology"). At times then, if a given schema is robust enough, an individual's categorization of an object may be hard to change, even if the individual is presented with perceptual evidence that the object has been incorrectly categorized. This might explain why students sometimes have a hard time changing the way they perceive something once they have made a decision about its meaning, because to do so would require a complete reconstruction of the entire schema within which it has been placed.

I concede that that an individual's re-evaluation of perceptual data leading to a change in the way they categorize something (such as a type of animal) *may* not be the same as Posner's original idea of conceptual change, however, even if this is the case I think it is inevitable that when such a change does occur, it will often inevitably lead to conceptual change that *is* Posnerian. It should not therefore surprise us that analysis of videotaped observation sessions show us that when students try to make sense of what they see when they look down a microscope, all of the familiar stages of Posner's conceptual change theory (initial stability, dissatisfaction, sometimes assimilation and occasionally accommodation) can be identified.

The problem of defining categories and concepts in biology is especially difficult because the living world is full of "hierarchical gradients" - that is, continuously variable sets of nested categories that defy any attempt by humans to collect them into neat "concepts". I suspect that this special property of living things is one (of several) confounding factors that make visual cognition of biological material difficult and conceptual change common. The problem of how the human brain organizes concepts and determines the relationships between them is such a daunting one that some psychologists have postulated that we must get help from some type of innate ability to discern and organize categories in specific ways that are hard-wired into us. Pinker and others often use examples from the living world whenever they discuss this philosophical problem, yet biology pedagogy specialists have apparently never picked on this fact as an indication that we should <u>expect</u> biology students to have special and unique cognitive problems that occur <u>only</u> in this discipline.

Relatively little educational research has examined the special visual challenges involved with visual learning within the biological sciences. However, research on the human visual system using cognitive and neurological tools is an area of rapid progress that is helping scientists understand how the human brain functions during specific cognitive tasks. For example, functional MRI studies (e.g. Gauthier 1997) with patients suffering from various forms of visual agnosia suggest that specialized parts of the brain may be involved with recognizing sets of similar natural objects. Given the progress being made within the fields visual neurology and psychology, and the apparent special characteristics of biological material that seem to make its human categorization especially difficult and cognitively interesting, it seems strange that educational researchers are not more interested in visual learning mechanisms in biologists because these might offer our best hope of connecting learning theories to actual brain function.

This work may also help to expand or adapt conceptual change learning theory such that it can begin to make useful predictions about new kinds of perceptual learning phenomena. In addition to its theoretical and neurological interest, this research also has immediately practical pedagogic implications for biology instructors, who tend to underestimate their own visual abilities and overlook the visual difficulties of biology students. The instructor's visual skills have been fine tuned by years of experience while the students' visual systems may be easily overwhelmed by complex biological phenomena that they are seeing for the first time. To avoid confusion and frustration on all sides it is important that science teachers be made aware of the visual difficulties that biology students are likely to encounter. Similarly, it is important that teachers reassure their students that these difficulties are a normal part of the learning process. If the author's assertion is correct, then standard conceptual change theory could be used to suggest specific visual learning strategies as well as predict possible cognitive pitfalls for students and instructors working with visually complex material in any discipline.

References

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