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Much of a person's knowledgeable interaction with the world concerns the use of visual information. One useful place to expand our knowledge of visual cognition is in the study of what we will call visual symbol systems. These consist of visual domains that are used as sources of information about additional domains – target domains. Examples include the use of telescopes to study astronomy, aerial photographs, and microscopy.

We report here two studies aimed at understanding the use of microscopy in histology. Histology is the microanatomy of biological tissues. It is a core course in both the biology and medical curricula, and it is essential to the study and practice of pathology.

While the target domain in histology consists of three-dimensional structures, the information domain consists of thin sections through the interiors of these structures that have been treated with a variety of stains. The outcome is that: 1) Histology includes a visual information domain and an anatomical target domain that are both very large and complex. 2) The target domain and the information domain are related by a spatial transformation (taking thin slices) that does not generally preserve structure and appearance. 3) There is a one-to-many mapping from the target domain to the information domain. A single type of structure can have a wide variety of looks in a microscope. 4) There is a many-to-one mapping from the target domain to the information domain. Different structures often look alike.

An interview study was conducted with 5 pre-medical or pre-dental graduates of a college histology course. Participants viewed four different microscope slides. In a first phase, participants thought out loud. In a second phase, a structured interview followed up on statements from the verbal protocol. The view through the microscope and everything that was said was recorded with a digital video camera. The four slides varied in their complexity, their familiarity, and in whether the stain was a common one. The audio recordings were transcribed to written form.

This task was clearly challenging for the students. A correct identification of the whole tissue was made 12 times during the verbal protocol out of the possible 20 identifications. One of the slides was identified by everyone -- one was identified by four of the five people. A slide with an unfamiliar stain was identified by just two people, and a tissue that had not previously been seen in a slide was identified by just one person.

Two formal coding systems were developed to help guide exploration of the cognitive processes involved in the interpretation of histological slides. One system was used to characterize the content of the language used to talk about the slides. The second system was used to characterize the manner in which participants worked toward the goal of tissue identification.

The coding of the language revealed that nearly sixty percent of all propositions used by the participants referred to structures on the slide. Fourteen percent of all propositions were associated with reasoning. Almost sixteen percent of all propositions were expressions of prior knowledge.

A second coding system captured high-level goal-directed cognitive processes. First, a master list was composed of the types of elementary cognitive process used across participants to work toward the goal of identification. Second, for each participant and each slide, progress toward identification was diagrammed using the listed processes.

Across all participants and slides, 70 instances of 13 cognitive processes on the master list were recorded. There were 23 attempts at recognition that did not appear to include hypothesis generation. Thirteen of these consisted of a participant listing structures on the slide and then immediately inferring a whole tissue. There were 39 examples of hypothesis testing across all participants and all slides. Interestingly, disconfirming evidence was used more often than confirming evidence.

This investigation demonstrated that identification of histological structures in a microscope is an extremely challenging task, and individual differences among the students are large. In addition, identification of histological structures in a microscope is remarkable for the degree to which it forces an integration of visual knowledge, general (anatomical) knowledge, and reasoning into a single cognitive system. This includes the use of holistic visual information, analytical knowledge about the diagnostic structures in slides, and general knowledge of anatomy. These forms of representation combine to allow recognition and immediate inference when that is available and extensive processes of reasoning when they are needed.