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Image Quiz: Using Principles of Cognitive Psychology to Teach Visual Expertise

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Image Quiz is a cross-platform set of computer programs designed to help users efficiently become visual experts. Unlike novices, visual experts are able to quickly recognize patterns. This allows chess masters to recognize chess configurations and botanists to identify plants from a glimpse out the window of a moving vehicle. The Image Quiz programs help students rapidly achieve this mastery by adapting techniques from cognitive psychology. They are designed to promote holistic processing, the visual processing mode used by experts. This report focuses on the principles behind the Image Quiz programs, and presents some of their major features. The programs can be used in any discipline that depends on visual information. This includes STEM disciplines like chemistry and mathematics.

Introduction

What is hardest of all? That which seems most simple: to see with your eyes what is before your eyes.

—Johann Wolfgang von Goethe

Programs in the Image Quiz family are designed to rapidly and efficiently help users become accomplished visual experts. Unlike novices, visual experts are able to recognize patterns quickly (Bransford et al. 2000). This allows chess masters to recognize meaningful chess configurations and plant systematists to identify species from the window of a moving vehicle. The Image Quiz programs help users achieve this mastery in far less time than is normally required. They do this by adapting learning techniques from areas of cognitive psychology concerned with expertise (Cook, 2006). The programs are designed to promote holistic processing, the visual processing mode used by experts (Bukach et al., 2006; Tanaka et al., 2005). They do so through a series of active learning activities. Active learning engages brain areas associated with visual expertise, while passive learning does not (Rhodes et al., 2004).

In addition to recognizing patterns, visual experts are able to segment their perceptual field and pick out relevant details (Bransford et al., 2000). The Image Quiz programs provide the contextually based experience necessary to develop this skill. They help users segment their visual field into meaningful parts by providing a series of identification tasks based on a classification of the images. For instance, the twenty amino acids can be divided into four functional classes. By learning their functional classification through a series of identification tasks, students learn to identify the functional parts of the molecules without being told to do so. They learn to see the parts by seeing the whole in a specific, functional context. They develop curiosity about how the molecules function, and approach classroom situations with an active interest in learning more.

The programs in the Image Quiz family also help users form accurate visual concepts. Visual concepts are the basis of species recognition, and are important stepping-stones to scientific intuition. The programs accomplish this by exposing users to a greater range of variation than they would normally encounter in classroom situations. Repetitive exposure to this variation is important because concepts encode information not only about the prototype of a category, but also about its variation (Wisniewski, 2002). In an organismal diversity class, a student might be exposed to a few examples of a species, but in order to recognize it accurately in the field he needs to see the range of variation he is likely to encounter. The Image Quiz programs provide exposure to this variation. They are limited only by the number of images in the database, not by the timing of coursework, season, or proximity of the organisms.

Although the Image Quiz family of programs will accomplish all of these goals, they are not intended as replacements for traditional instructional methods. They are supplements that will make traditional methods more effective.

A Blueprint of the Image Quiz Project

In nature we never see anything isolated, but everything in connection with something else which is before it, beside it, under it and over it.

—Johann Wolfgang von Goethe

The Image Quiz Project is about visual literacy, intuition, and expertise. Vision is at the center of much of what we do, yet we spend little time training ourselves to see. Programs in the Image Quiz family provide an easy means of redressing this imbalance. They give users the ability to become quickly familiar with new visual domains; to become visual experts who can rapidly identify patterns, parse complex objects into meaningful parts, and make intuitive leaps based on visual understanding. All of these skills arise from being able to see.

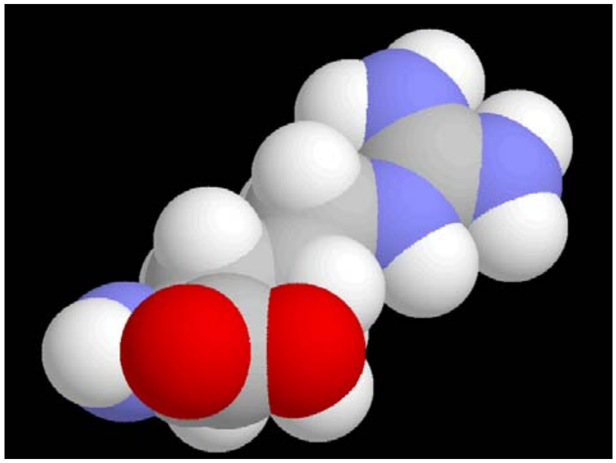

Figure 1: Space-filling representation of the amino acid arginine.

The fact that seeing is more than just opening one's eyes is attested to by many lines of evidence. Imagine a student looking at a space filling representation of an amino acid for the first time (Fig. 1) or someone first confronted with Ando Hiroshige's *Fuji-jeda* (Fig. 2). What do they see? They certainly do not see a molecule with a complex three-dimensional shape or a station on the Tokaido Road in Japan. More likely, they see colors and shapes arranged on a surface, without a pattern that they can easily interpret. Even when told that the scene on the Tokaido Road shows a minor official recording portage fees, they will likely have difficulty locating him. Getting students to see beyond the unfamiliar pattern of their first impression is one of the frustrations of teaching. No matter how much one says, or how many times one explains it, students do not seem to grasp the pattern (Cook, 2006). What does it take to learn to see, and what are its consequences?

One key to learning to see is that we must be actively engaged in the process of looking. Passive looking or looking only

Figure 2: Ando Hiroshige's Fuji-jeda, from Tokaido Gojusan no Uchi (The Fifty-Three Stations of the Tokaido Road), 1831-1834. Woodblock print.

secondarily while trying to learn concepts impedes the process of seeing. This is why interactive computer graphics are so often ineffective. A student watches an animation full of wonder at its beauty, but if his interactions with it are limited to a few mouse clicks, he gains little from the experience (Bork, 1995). We can click the mouse without paying attention. If supplementary conceptual material is included in the animation, our attention is further divided (Chandler & Sweller, 1991). We need activities that engage our active participation; activities that help us wake up and pay attention (Schroeder & Spannagel, 2006). Functional brain imaging demonstrates that active engagement leads to greater activity in brain regions associated with visual expertise (Rhodes et al., 2004).

Seeing also involves innate classification. We see a glowing object on the horizon and wonder if it is a water tower, a plane, or the moon. Until we can link a concept with our perceptual experience, we cannot make sense of it. This linkage is not immediately given; it must be created through repeated experience. The first time we see something, it confuses us. If we are told its name or a given a meaning to associate with the experience, it becomes less confusing, but we have still not internalized the experience. For the knowledge to be internalized, we need to experience it repeatedly. We need to form a clear mental image of the object and associate this image with the relevant concepts. We gain these competencies through practice and repetition.

Even more surprising is that we learn to identify the parts of an object through experience with its classification (Schyns & Rodet, 1997; Schyns et al., 1998). Take a subject and show him an ambiguous object, an object that can be divided into parts in a number of ways. Ask him to identify its parts. His answer will depend upon his prior experience with similar objects. If experience has shown him that it belongs to a group whose members have clearly defined parts, he will find these parts in the ambiguous object. A second subject, who knows the object in a different context, will find in it parts that are consistent with that context. The sensory experience of the two subjects is the same. They both see the same object, yet they see it as composed of different parts. They recognize its parts not only based only on its structure, but also on its relationship to other objects. They find the parts that make the relationships work. This may seem counterintuitive. Classifications are supposed to be based on similarity of the objects alone, not their context. The problem is that an object's classification influences how it is divided into parts (Schyns & Rodet, 1997; Schyns et al., 1998). If we want someone to learn to see its parts, we must teach him to see the object in the context of a classification that implies these parts. This is one of the inspirations behind the Image Quiz Project.

Annie Dillard describes the experience of learning to see in her wonderful book, *Pilgrim at Tinker Creek*. Quoting the work of cataract surgeon Dr. Marius von Senden, she writes, "When a newly sighted girl saw photographs and paintings she asked, 'Why do they put those dark marks all over them?' 'Those aren't dark marks,' her mother explained, 'those are shadows. That is one of the ways the eye knows that things have shape. If it were not for shadows, many things would look flat.' 'Well, that's how things do look,' Joan answered. 'Everything looks flat with dark patches'" (Dillard, 1974: 25).

We can tell Joan that the pattern is there as much as we like, but until she can see it, our words make no sense. Concepts alone are not enough to transform perception into meaningful visual experience. An image of an amino acid, or a reproduction of a work of art, must fit into some larger visual context, a context that cannot be conveyed conceptually, but must be experienced. This is one of the goals of the Image Quiz Project, to provide the means whereby individuals gain the experience necessary to transform perception into visual experience. It does this though a series of computer-based visual training programs: gymnastics for the eyes and mind.

The Image Quiz Family of Programs

At present, there are two programs in the Image Quiz Family. The first is a simple prototype with one study mode and one quiz mode. This program was designed to show "proof of concept." The study mode allows users to become familiar with the objects through viewing the images in the database. The images, with their names superimposed, are displayed until the user presses a key to advance to the next image. This is passive learning. It is not the most effective way to learn, but a basic familiarity with the image domain is necessary before active learning can be used effectively. The quiz mode is where the majority of the learning takes place. In it, the user sees an image for a short period, the screen is cleared, and he is asked to identify the image by typing its name. If he is correct, he receives positive feedback and the program proceeds to the next image. If he is wrong, he is informed of the correct answer and given another chance to name the image.

The second program is more sophisticated. A version published by Missouri Botanical Garden Press, is available under the title *Woody Plants of* *the Southeastern United States: A Field Botany Course on CD* (Fig. 3). The program contains a flexible study mode, four quiz modes, and three test modes. The study mode allows for user-controlled or automatic image advance, and allows an image to be displayed alone or with its name. The four quiz modes are drawn from the cognitive psychology literature (Gauthier & Tarr, 1997; Gauthier et al., 1998), and are designed to help users become visual experts. The modes are “Image Naming with Prompt,” “Image Naming without Prompt,” “Image Comparison,” and “Image Verification.” These quiz routines were used in experiments that explored the relationship of visual training to holistic visual processing. The main difference between the quiz and test modes is that the user does not get a second chance to respond in the test modes, while in the quiz modes the user has the chance to repeat the question if their first answer is incorrect. The test modes can be used in classroom situations, or to check a user’s progress after confidence builds in his ability to recognize the images.

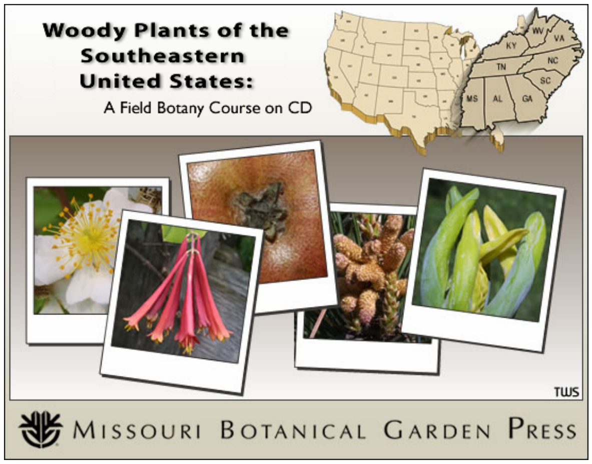

Figure 3: Splash screen from *Woody Plants of the Southeastern United States: A Field Botany Course on CD.*

In “Image Naming with Prompt,” the user gains recognition and spelling practice with the images. An image is displayed along with its name. After the user-defined display period, a response box appears and the user enters the name of the taxon.

“Image Naming without Prompt” is identical to “Image Naming with Prompt,” except that the response box is displayed *after* the screen is cleared. “Image Naming without Prompt” is the most powerful of the four routines, because it is the most difficult and requires the most attention.

In “Image Comparison,” two randomly chosen images from the study set are displayed side by side. The screen is cleared, and the user is asked if the images belong to the same group. The nature of the groups depends on the image set being studied. In *Woody Plants of the Southeastern US*, the groups can be selected from the species, genera, and families of woody plants in the Southeast. If the user’s answer is incorrect, he is asked if he would like to try again. Trials can be repeated until he is successful.

The final quiz mode is “Image Verification.” In it, a single image is displayed followed by the name of one of the image groups. A response box appears and asks the user if the image and name match. If his response is incorrect, he can repeat the exercise.

Future work will add functionality to the Image Quiz engine and will adapt it to different image sets. At present, the user must set all program parameters and determine which images to study. This works well for home use, but it is less effective in classroom situations. We will create a new program with the working name of “Script Creator” to give instructors the ability to create and distribute customized image study sets. The scripts will lock the program into a defined sequence of study and quiz events. Instructors will be able to specify which images to study, in what sequence, and with what study and quiz routines. Students' responses will be output to a password-protected file that will contain summary statistics. Students' progress can be easily monitored, and grades can be assigned with the data in these files.

We expect that these programs, and the methodology on which they are based, will find a place in every discipline that depends on visual expertise. Artists will learn to recognize artistic styles, geographers will learn to interpret maps, mathematicians will teach their students to read equations, and chemists will learn chemical structures. All of this will be accomplished with simple but effective image drills, the essence of the Image Quiz Project.

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