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Point of View
THE EYE RESEARCH INSTITUTE UNIVERSITY OF WISCONSIN–MADISON

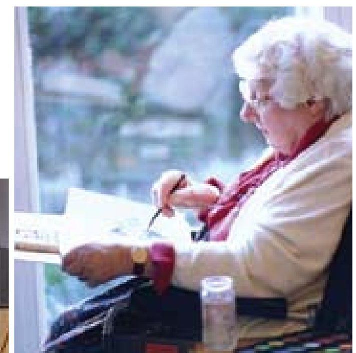
Is the Hand Quicker Than the Eye?

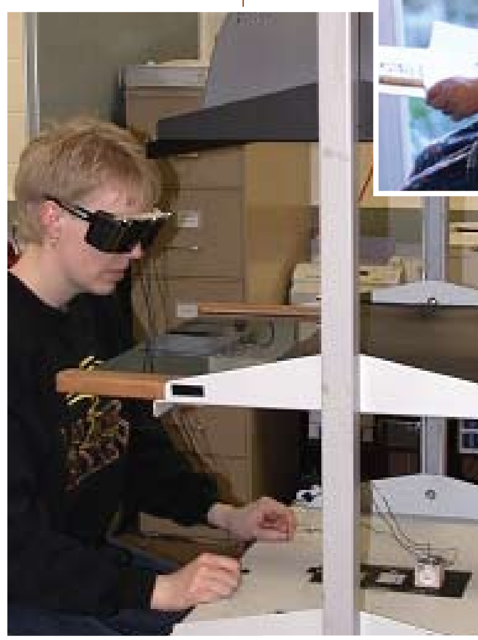
Anyone who has played a video game has had the experience of using hand-eye coordination to guide actions happening in a virtual environment displayed on the computer screen. What can virtual environments such as these teach us about how sensory information – like sight and touch – influence our actions, reactions, and movements?

"We are constantly bombarded with sensory information such as visual and haptic (touch) feedback in our daily lives," says Andrea Mason, PhD, assistant professor of Kinesiology and member of the UW Eye Research Institute. "We use this information when we reach out and grasp objects, when we coordinate movements with another person – like passing an object – or when we use our two hands to catch a ball."

In her laboratory, Mason has created a computerized virtual environment dubbed "The Wisconsin Collaborative Virtual Environment (WiscCVE)" to simulate specific tasks, allowing her to manipulate the type and timing of sensory feedback that a test subject receives. Sitting at a mirror-topped table, the test subject wears polarized stereoscopic goggles, much like sunglasses, that give the subject the sensation of viewing a three-dimensional object that is positioned on the table surface. The subject also wears light emitting diodes (LEDs) on the first finger and thumb of each hand, and when viewed in the virtual environment these LEDs appear as dots that show the placement of the fingers. During testing, Mason can turn on or turn off the subjects' view of the dots, giving them just a glimpse of their fingers or hiding them from view entirely. In a typical experiment, the subjects are shown a cube in the virtual environment, and are asked to move their fingers toward the cube, grasping it when they are able.

"I can alter the point at which the subjects see their fingers or see the cube. We can then assess the importance of the visual feedback on the ability of the subjects to grasp the object," Mason explains. "Is it better to have feedback at the beginning of the task or at the end? Does the feedback need to be continuously present from the start to the end of the task, or can it drop out once the reach is initiated?"





Above: Following a stroke, patients must re-learn basic tasks involving hand-eye coordination, like grasping a pen to write or draw.

Left: A test subject demonstrates the importance of early visual information when attempting to grasp an object in a virtual environment.

Mason expected that knowing where one's fingers were positioned at the beginning of the task would not be as important as the ability to see the hand as it approached the cube. Surprisingly, she found that the opposite was true – when subjects had visual feedback only toward the end of the movement, their performance was as bad as when they got no feedback at all. "It turned out that if feedback about the finger position was given only in the first third of the movement, the speed at which the person performed the task was the same as if they could see their fingers the entire time."

These types of experiments help Mason learn about how sensory feedback affects performance in virtual environments. Mason explains, "If we can discover what type of sensory information is needed and when that information is used, we can make recommendations about how and when to display sensory information to users of virtual environments." The virtual environments that Mason's studies may help to improve are not the entertainment-oriented video games. Instead, she sees potential applications in more "work-related" environments such as robotic surgery or virtual architectural walk-throughs. Mason is currently planning a project that would use findings from her work in both natural and virtual environments to develop an at-home rehabilitation system for survivors of stroke. This at-home "virtual training system" would allow patients to continue rehabilitation in an

The coordinated movement of two hands requires some compartmentalization of sensory and motor information for each hand separately and then the integration by the brain of the individual plans into a final coherent movement as the test subject attempts to place two objects simultaneously either into a tight-fitting or large space (sequences 1-3).

exciting and stimulating computerized environment after traditional clinic rehabilitation has ceased. “Some research has indicated that rehabilitation in virtual environments may be superior to traditional rehabilitation because it is more engaging and may lead to greater adherence. We would like to help patients develop better strategies to manipulate objects in their environment following a stroke. We hope that the results of our work will lead to a cost-effective and engaging training system that people could use in their own homes.”

Mason is also interested in understanding more about how people use sensory information, like vision, to coordinate the movement of the two hands as we grasp separate objects simultaneously. People do tasks like this many times a day in normal life. For example, a writer reaches for a pen with one hand while simultaneously reaching for the paper with the other. In recent studies of adults and children, Mason investigated the timing of the coordination of two simultaneous movements such as these, and assessed how certain sensory demands affected this coordination.

The give-and-take of parenthood: Andrea Mason helps her daughter learn to grasp and exchange objects in the real world.

In this type of experiment, a subject sits at a table – again wearing LEDs on the fingers – and has two cubes placed in front of them. The subject is asked to reach forward with the two hands, grasp one cube in their right hand and another in their left, and then perform one of the following tasks: 1) place both into small, cube-sized target wells, 2) toss both into large open wells, or 3) place the right cube into the right small well while tossing the left cube into the left large well.

These tasks require subjects to acquire visual information about each cube and the location where the cubes must be placed, so subjects must divide their attention between the two tasks in a coordinated way. In planning her experiments, Mason anticipated that the more complex task – placing the cube into the tight-fitting well – would slow down the movement of both hands, because subjects would be forced to divert their visual attention to the more difficult task.

She found that the speed at which the two tasks were accomplished together (placing and tossing at the same time) turned out to be somewhat in between the time required when both hands were placing the cubes (the more difficult, slower task) or when both hands were tossing the cubes (the easier, faster task). Mason thinks that the brain processes the attentional and motor information needed for the tasks by formulating “separate motor plans,” and that these are then executed together in the brain. This seems to imply some neural “cross-talk,” and opens interesting areas of exploration on how the motor system uses sensory information to control one-handed and two-handed movements.

In recent years Mason’s studies have become even more personal. “I was interested in biomedical engineering when I first went to college,” says Mason. “I had a internship in a Kinesiology lab that studied vision and hand movements, and it was so exciting to me that I’ve continued the work ever since. Now, I’m a mother of a three-year-old, and I watch as my daughter learns how to grasp objects – like toys and utensils – and manipulate and pass them more skillfully. These experiences, coupled with an opportunity to help people with disabilities, make my work even more rewarding.”

The UW Eye Research Institute
445 Henry Mall #307
Madison, WI 53706
608/265–0690
email: info@vision.wisc.edu
website: vision.wisc.edu

Retina Research Foundation
Emmett A. Humble Distinguished Director:
Daniel M. Albert, MD, MS
Associate Director:
Arthur S. Polans, PhD
Administrative Director/Editor:
Tracy D. Perkins, MPH