ask the Brains

Is it true that when we drive, walk or reach for something our brain performs calculations? Is this ability learned or innate?

—Helena Larks, San Francisco

Computational neuroscientist **Terry Sejnowski** of the Howard Hughes Medical Institute at the Salk Institute and the University of California, San Diego, answers: OUR BRAIN IS WIRED to perform calculations that let us judge how far away an object is when we walk or jump around or reach for a container of milk. Although this task may seem easy, it turns out that calculating depth is surprisingly complex.

When we look at an object, our eyes project the three-dimensional structure onto a two-dimensional retina. To see the three dimensions, our brain must reconstruct the three-dimensional world from our two-dimensional retinal images. We have learned to judge depth using a variety of visual cues, some involving just one eye (monocular vision) and others involving both eyes (binocular vision).

Binocular vision provides more precise perception of depth, allowing us to judge small differences between the images on both retinas, whereas monocular vision gives us a larger field of view. Occlusion, a monocular cue whereby an object that is closer partly obstructs the faraway one, enables the brain to judge relative distances. When one object occludes another, the observer can rank the relative distances of these objects.

Another monocular cue is motion parallax, which occurs when an observer moves his or her body (or just the head) to provide hints about the relative distance between objects. By moving the head back and forth, the motion allows you to see the objects from slightly different angles. A nearby object will move more quickly along the retina (creating a larger parallax) than a distant object, allowing you to determine which object is closer. When you are driving a car, for instance, nearby things pass more quickly, and faraway objects appear stationary.

Although our brain circuits are genetically programmed to judge depth from such visual cues, it takes experience to calibrate them. Initially children are bad at judging distance, but over time they train their brain to calculate distance. By adulthood we have become experts at judging depth but only with regard to objects in familiar environments. In unfamiliar territory, such as a new mountainous trail, automatic depth judgment fails because our brain has not yet calibrated new clues in the environment. In these new scenarios, we have to retrain our brain to compute distance.

Why do most customers at my bookstore have trouble understanding my instructions to swipe their debit cards with the magnetic stripe "toward me?" Almost everyone positions their card the wrong way, then asks in confusion, "Stripe toward me?"—meaning themselves. What is causing everyone to make the same mistake?

—Michael Manchester, Aylmer, Ontario

Robert O. Duncan, a behavioral scientist at York College, the City University of New York, explains: THIS DEBIT-CARD mystery may seem insignificant (albeit intriguing), but it actually serves as an excellent illustration of how we store memories and why that system sometimes fails us.

In 1974 psychologists Alan Baddeley and Graham Hitch of the University of York in England proposed that we possess working memory, a space where new memories can be accessed and manipulated. According to Baddeley and Hitch's model, we store and alter memories through a phonological loop, which processes sound information, and through a visuospatial scratchpad, which maintains and manipulates spatial and visual information.

When trying to remember a telephone number, you probably rehearse it in your head by repeating the names of the numbers rather than picturing them.

In the case of the debit-card stripe, the phonological loop comes into play because the cashier gives the customer verbal instructions. We use this loop all the time. For example, when trying to remember a telephone number, you probably rehearse the number in your mind by repeating the names of the numbers rather than picturing them.

Your customers are likely rehearsing the words "stripe toward me" so they can remember the command and act on it. A problem occurs, however, when the customer interprets "stripe toward me" literally. This happens because the phonological loop only serves to keep a phrase fresh in your memory—it does not help you intelligently interpret its meaning. Rehearsing the pronoun "me" over and over can alter your interpretation of the instruction, believing the "me" refers to yourself instead of the cashier. M

Have a question? Send it to editors@SciAmMind.com

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