

It Just Takes Practice: Train Your Mind And You Can Train Your Body – To Hop Or Dance Or Even Perform A Balancing Act Like This

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Special to *The Washington Post*

Tuesday, October 23, 2007; HE01

The photograph, even today, arrests the eye and titillates the mind. It's from the early 20th century, and the young man it shows -- tipping back on the rear legs of his chair -- is using his own legs, splayed in front of him, as a counterbalance.

The feat itself isn't that impressive. It's his location, perched high over a cityscape of tall buildings. A wobble would be fatal.

What strikes me most about the photo is what it suggests about the extraordinary adaptability of our sense of balance.

Here's what I mean: Suppose the photographer grabbed a guy off the street and forced him to change places with the unnamed acrobat in the chair. The results would be predictable: Without a safety net, the new guy would almost certainly fall to his death.

That's because his balance system wouldn't have had time to adjust to the specific demands of balancing on two legs of a chair while perched on the edge of a tall building. But if that guy off the street had gone through the same training as the acrobat, chances are he might well eventually become adroit enough to perform the trick.

Recent research shows that the same is true for any kind of balance challenge, even the ones you see in circuses and on sports fields. Men and women with seemingly superhuman capabilities are, in truth, no different from you and me. They've just had much more training, more exposure to novel balance situations, such as walking on a tightrope, standing on a giant ball or skating around a hockey rink. Their brains have adapted, over time, to these usually destabilizing environments.

This intriguing attribute of our balance system helps explain a great many things about the sense: how it changes with age and disease, but more important, how it can be restored; how it is affected by unusual motion such as undulating in a storm-tossed boat; and how scientists are able to employ high-tech machines to boost the brain's ability to recalibrate the balance system.

Adaptability is central to how the balance system works. Consider it a sort of intricate dance your body does with the Earth's gravitational force, as your brain orchestrates sensory input from three separate systems.

The first of those is the body's dedicated motion sensors, the vestibular apparatus. There are two organs, each about the size of a pencil eraser, one behind each ear. A series of fluid-filled canals

and microscopic hairs measure body movement and gravity. The vestibular apparatus provides a stable base around which your arms and legs can move in all sorts of complex ways.

Think of a cheetah running across the savannah in pursuit of an antelope; his legs are a blur of motion while his head remains still. That stability of the head is made possible by the vestibular apparatus.

The second input is from proprioception -- the output of specialized cells in muscles and joints that tell the brain where your arms and legs are in relation to the rest of your body. A good example is a policeman's sobriety test. The only way you can touch your finger to your nose with your eyes closed is by means of proprioception. When you've had a few too many drinks, your brain has a hard time reading proprioceptive signals.

The third input is from vision. It keeps track primarily of vertical cues in your environment that the brain uses to fine-tune balance. You can get an idea of vision's role by standing on one leg, first with eyes open and then with eyes closed, the latter being far more difficult.

Getting Your Sea Legs

When we're walking or standing on a firm, well-lit, level surface, information from all three sensory inputs is roughly equal. But when the environment becomes more challenging -- in rocky, uneven terrain; when the surface consists of mud or gravel; or if you attempt to balance on, say, a log floating on water; or if the light is poor -- the ratio of sensory input changes.

The brain immediately adapts to the new environment by switching to the most reliable of the three sensory inputs -- in a situation where balance is challenged, vision and proprioception become less useful in maintaining balance. Because gravity is the only steady, unchanging reference point the body has, vestibular information then dominates. All this takes place in the blink of an eye, without conscious thought.

Besides adapting to changes in the environment, the brain can also compensate for weakness or dysfunction in the balance system. This principle is used by physical therapists to rehabilitate people with compromised balance caused by disease or old age. If, say, proprioception in the feet is diminished, perhaps due to diabetes or aging, then special exercises, administered by a physical therapist trained to help people with balance disorders, can help. These help the brain adjust by focusing more on vision and vestibular inputs.

This process is akin to the way muscles get stronger: by being challenged. But to challenge the balance system, it's usually necessary to expose oneself to a stimulus that creates imbalance or even dizziness, whether that be catching a ball while standing on a balance beam or walking across a room while swiveling your head back and forth. Such situations can be extraordinarily uncomfortable, which is why the encouragement and guidance of a trained physical therapist becomes crucial.

Another scenario where balance needs to be challenged to function properly is after someone

takes a fall, perhaps after a stroll outside. The inclination for many people, especially the elderly, is to remain indoors to avoid falling again. But experts say this is a mistake. Better to resist the fear of falling and go out, perhaps with canes or a walker at first, and continue to walk. This allows the brain to adapt to whatever dysfunction or weakness in the balance system led to the fall in the first place.

When riding in a car, boat or plane, many people succumb to a balance system disorder known as motion sickness. Typically this happens when there's a disagreement between the signals coming from two of the sensory inputs for balance, vision and the vestibular apparatus. A good example would be a child reading in the back seat of a car. The bouncing and turning motions that her vestibular apparatus senses don't conform to what her eyes see -- the pages of the book against the stationary interior of the car. This disconnect can cause nausea and vomiting.

But given time, the brain adapts to the unusual sensory signals, and the motion sickness subsides. Sailors, for example, succumb to seasickness for the first several days aboard ship before finally getting their sea legs.

Sense and Sensibility

One of the most mind-boggling examples of adaptability in the balance system that I have come across involved a woman named Cheryl Schiltz. In 1997, at the age of 38, the Wisconsin woman lost most of the function of her vestibular apparatus after taking a common antibiotic for an infection. At first, she couldn't even stand up. Then she learned to walk with canes. But a few years later, she was recruited as the first test subject for a bizarre-looking machine called a BrainPort, designed by scientists at the University of Wisconsin to substitute for a person's vestibular apparatus.

Mounted inside a helmet were instruments that measured the tilt of Schiltz's head. These sent signals to a computer and then to a pad with 144 electric stimulators that sat on her tongue. The device gave Schiltz instant sensory feedback about the position of her body: Seated in a chair, Schiltz would tilt her head to the left, activating the stimulators on the left side of her tongue.

"What we noticed," she told me by phone, "was that with my eyes closed, without the system in my mouth, I had great difficulty keeping my body still. But when we put the tongue display in, and I had that sensation to maintain and to concentrate on, I didn't move."

Weeks later, Schiltz began testing the BrainPort in a standing position. Again, Schiltz said she felt stabilized while wearing the device. But what surprised everyone was that when she later took the tongue pad out of her mouth, she continued to feel stable enough to walk without her canes, to run, skip, dance and even ride a bicycle.

At first these residual effects lasted less than a day. But the more time Schiltz spent using the BrainPort, the longer she could maintain her stability without it -- ultimately for four months.

Although scientists still aren't sure what was going on inside Schiltz's brain, the BrainPort's

inventor, the late Paul Bach-y-Rita, a professor of rehabilitative medicine at the University of Wisconsin, offered a possible explanation: "When a person loses function in the vestibular system, there's never a 100 percent loss," he explained. "Let's say it's a 50 percent loss or a 90 percent loss, but that remaining tissue can be reorganized, totally, to take over the functions of whatever has been lost." The BrainPort somehow allows the brain to recalibrate itself to make use of these faint sensory signals.

Why is the human balance system so adaptable? Perhaps because life would be nearly impossible without this most complex and vital of all the body's senses. Without the ability to know up from down, without an accurate orientation to the Earth, at all times, under all conditions, we'd all be as vulnerable as a neophyte trying to balance a chair on two legs at the top of a tall building.

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