Brain Function During Emergencies

Brain Function During Emergencies in High Speed/High Risk Sports:

Implications for Training and Practice

Vic Napier

Walden University

Abstract

Current research is revealing more details about how the brain works during high levels of stress. This paper gives an overview of brain function during times of high stress and arousal. Suggestions for practice strategies based on this knowledge are included at the end of the paper.

Brain Function During Emergencies in High Speed/High Risk Sports:

Implications for Training and Practice

I. Introduction

When I began skydiving in 1980, professional training, and modern equipment was still an aspiration. Square parachutes had caught on with experienced jumpers, but few drop zones were using them for students. I made my student jumps on military surplus equipment and jumped Para Commanders after I earned an A license. I completed student training at a parachute center that opted not to use AADs because of issues around reliability. AADs of the era had a reputation for sometimes firing when the student was standing on the wheel just before exit, occasionally killing the student, and endangering the aircraft and everyone in it.

Fatality rates were high among inexperienced jumpers and frequently resulted from not having a parachute deployed before hitting the ground. Many skydivers died because they spent their entire descent trying to open their main parachute instead of executing emergency procedures and deploying the reserve.

On my 11th jump, I met a young woman named Cathy while boarding the Cessna. Cathy had made a few jumps and graduated to freefall, but had taken some time off. Now she was coming back for a hop and pop. I jumped first but landed off the drop zone and noticed some fluttering fabric in the weeds nearby. Thinking that someone had cut away a malfunctioned main, I walked over to investigate. It was Cathy. It turned out that she jumped on the pass after me, pulled the main ripcord out of its pocket, lost her grip on it, and fumbled around looking for it until deploying her reserve just before impact. Now she was very obviously dead. Neither of us had yet celebrated our 22nd birthday. Such was my initiation to the grim reality of violent and sudden skydiving deaths.

The next summer I met a very nice guy I will call Burt. I only had about 50 jumps and on a good day might fall more or less stable. Burt gave me a few pointers that I remember to this day, but I remember his friendliness and happy nature even more. Two weeks after we met Burt's main malfunctioned, he fought it to less than a thousand feet, then deployed his round reserve without first releasing his main. The reserve wrapped around the main parachute and both streamered all the way to the ground.

Next, a misrouted static line resulted in a student in tow behind the airplane. The Jumpmaster cut the student loose, but he never pulled his reserve ripcord handle. Every time the student reached for the ripcord on his chest reserve, he lost stability and arched to get belly to earth. He did that all the way to the ground. After that, another woman also with the name Cathy steered into power lines carrying 350,000 volts for a lumber mill, even though hundreds of acres of unobstructed wheat fields were nearby.

Why could this happen? Our friends were dying violent and unnecessary deaths when the means of survival was so close and simple. Pulling a couple of handles or making a turn would have saved many lives, but for some reason jumpers fought malfunctioning mains all the way to the ground, or ignored open fields and landed in lakes and power lines and met their deaths.

This was doubly frustrating because of the advances in parachute technology going on about this time. The three-ring system transformed releasing a malfunctioning parachute from a complex time consuming operation to simply pulling a handle. There was no reason for people to mess with malfunctioning mains for more than a second or two, but they did, and for periods far longer than a few seconds.

Hints started emerging, however. Jumpers who burned up too much altitude on malfunctions, yet survived after performing their emergency procedures, reported that they had no idea that so much time had passed. They knew they should have initiated emergency procedures much earlier, but had lost track of time.

However, there had to be more to it than simply losing track of time. These jumpers could have checked an altimeter, or taken a quick glance at the ground. Even if they had not done either of these things they must have been able to see the horizon getting larger in their peripheral vision and realized how low they were getting.

What about those people who died after steering into power lines and lakes surrounded by miles of open landscape? What were they thinking? How could they make such tragic mistakes?

Slowly clues from other sports started coming to light. Skydiving was not the only high-speed activity in which people were making fatal collisions with objects they might have avoided. The Motorcycle Safety Foundation was finding that motorcyclists were dying in collisions also. Rather than simply steering around an object, motorcyclists would often hit them head on. Formal studies have shown that about 60% of single vehicle motorcycle accidents involve impact with a stationary object (Shankar, U. 2001).

Skiers share the same phenomena. Fatal impacts with trees have been the leading cause of skiing fatalities for many years. Even though skis are highly maneuverable, fatal impacts with trees occur with stunning regularity. More than 60% of skiing fatalities result from head injuries after impact with objects, usually trees (Langran 2007).

Sometimes skydivers using docile canopies fly into objects that they cannot help but see. I watched a jumper on a demonstration jump completely miss a huge rodeo arena, and land on the top rung of the bullpen. Luckily, he came to rest outside the bullpen rather than inside, and was able to tell us that he not only saw the bullpen, but also was looking at it all the way down.

II. Threat Responses

These tragic outcomes might arise from how our perception changes when we are under the stress of a threatening event. With the advent of technology like Functional Magnetic Resonance Imaging and Positron Emission Tomography, psychologists can see how the brain processes information. This has led to startling unexpected discoveries, as well as confirmation of what we thought we knew all along.

Threatening objects, such as a car that suddenly veers in the path of a motorcyclist, a tree in the path of a skier, or malfunctioning parachutes above a parachutist seem to be pre-recorded in our brain as threats. As soon as we recognize the threat object, our responses are no longer under the control of higher brain centers as they normally are, but by primitive areas at the base and back of the brain. This makes for quicker reactions and is an important survival feature that has served us well for millions of years. We stop thinking when we face serious threats and our reactions are not under our conscious control. Instead, primitive survival mechanisms take over (Ratey 2001).

For example, several weeks ago I was walking from my apartment to a nearby natural park in the Arizona desert. I was walking along the side of the road, reminding myself, that snake season was in full swing, and that I had to be on the lookout for rattlesnakes when I got to the park. Just as that thought went through my mind a stick at my feet coiled into a snake! I did not think, consider my best course of action, or reflect on the pros and cons of various snakebite avoidance strategies. Before I knew what I was doing or why I was doing it, I yelled, jumped back, danced around a bit, then caught my breath and looked back where I had been. Only then did I realize what had happened. None of this was under my conscious control; the threat avoidance center in my brain had taken control until I had removed myself from the threat.

A. Brain Function and High Speed Sport Threats

So, what happens when we come face to face with a serious threat that we cannot simply jump away from, such as a malfunctioning parachute over our head or a car that pulls in front of our motorcycle?

Under normal conditions, our brain works in what psychologists call top down control – our higher brain areas control where we place our attention and how we react to what we see, hear, and touch. For example, when we are ready to leave for work, we consciously look for our keys, see them on a table, and reach for them with our hand (Pinel 2006).

Ordinarily our eyes scan the environment while our brain evaluates sensory data automatically, without conscious awareness or direction. The thalamus receives raw data from sensory organs, refines it, and passes it along to the sensory cortex, the amygdala, and the motor cortex (Ratey 2001). Scientists who study brain processing tell us that evaluations of visual data occur in only three to five hundred milliseconds. That is about as fast as a fly flaps its wing (Zuckerman 1990).

Our brain works much differently when we encounter a threat. Instead of higher brain functions consciously directing our movements, control comes from lower levels. This is what psychologists call bottom up control.

1. Brain

For reasons not fully understood, highly threatening objects – a malfunctioning parachute, a car pulling in front of our motorcycle, or a tree in our path on the ski slope – are sent directly from the thalamus to the amygdala, which initiates a fear response, then sends signals directly to the motor cortex, bypassing higher brain function. The advantage is speed. Very little processing is happening, but the brain is working very quickly and physical reactions occur incredibly fast (Helmuth 2003). This is what happened when I saw the snake at my feet, and probably also happens to skydivers who look up to see a serious malfunction.

2. Visual

During this time our visual attention shifts from object to object classifying each one in terms of most serious threat. We fixate on the object that seems most threatening to the exclusion of everything else. At the same time, our field of vision actually narrows until the only thing in our visual field is the threat object (Rogers, Alderman, & Landers, 2003; Staal 2004). Skydivers fixated on a malfunctioning canopy do not see the horizon racing to consume them because they have no peripheral vision. Skiers and motorcyclists might have a safe path around a car or tree but their field of vision is so narrow that they never see it.

3. Temporal

To add to the confusion our brain also loses track of time when it is under stress. Very short periods seem to stretch into much longer ones. We are so aware of details that it seems as though time slows down. When we are under stress determining the location of a threat object takes less than 100 milliseconds, and recognizing features such as color, orientation, and shape take less than 200 milliseconds (Staal 2004). Many things may be happening very quickly, and we are able to keep track of all of them, as well as attend to many small details. Under normal circumstances, it takes more time to perceive these small details than it does when we are under stress.

This might be why we perceive time passing far more slowly than it actually is (Carson 1982). It is not a matter of losing track of time, as in a daydream, but rather losing the ability to accurately gauge the passage of time. Skydivers who survive low reserve deployments often are stunned to see video showing how close they are to the ground at line stretch. To them the deployment and canopy ride seem to take much longer.

III. Application

Now that we know a little about how the brain processes threats during an emergency, we can look at training and emergency procedures a little differently.

It is not so much a matter of learning emergency procedures as much as it is teaching your brain different responses to different kinds of emergencies. For example, I do not want my brain responding to a parachute malfunction in the same way it does to a snake and I do not what my brain to respond to a landing obstacle the same way that it responds to a canopy malfunction.

So how do we train our brain to deal with different kinds of emergencies? First, let us talk a little about how we learn.

A. How the Brain Learns

In spite of all we have about "muscle memory", it does not really exist. Muscles have no way to remember anything, and are under control of the brain. It is not muscles that remember, but the brain, and in a very interesting way. The areas of the brain that control movement are called motor areas and work so closely with sensory input that psychologists consider them a single package and call them sensorimotor centers.

When we start learning a new task that involves movement of muscles, it takes quite a bit of conscious effort. Think about learning how to drive a manual transmission. Three pedals, only two feet, and you have to steer with one hand, shift with the other, and follow traffic rules, signals and signs while doing all that shifting and pedal pushing. Let out the clutch too quickly and the engine dies; too much gas as the car lurches like a dragster. Eventually, though drivers learn how to coordinate everything and are shifting, driving, eating a doughnut, and talking on their cell phone all at the same time. How does that happen?

The first thing to remember about how the brain learns new motor tasks – that is movement – is that it is a hierarchal system. The more sophisticated parts of the brain give general orders to lower parts, leaving the more sophisticated parts free to process information that is more complex. Like a company president, the higher parts of the brain issue orders to lower level divisions and departments (Pinel 2006).

Internal sensory organs send information about things like balance, motion and direction, while external sensory organs like the eyes, skin and ears send information about what the environment looks like, how it feels, and sounds that are occurring while the muscles are moving body parts.

When you learn a new task, muscle control originates at the higher levels of the brain with conscious awareness. You are consciously aware of how things look, feel, and sound while you slowly learn the new task. As a sequence of movements is learned, lower sensorimotor levels take over control and conscious attention can be directed elsewhere. Soon the lowest levels of the brains motor centers control movement in a fluid and coordinated way.

This is what we think of as “muscle memory”. The muscles are not remembering anything, but the portions of the brain that carry the memories and direct the muscles are buried so deeply that we have no conscious awareness of them, and it seems as if memory is vested in the muscles (Pinel 2006).

Psychologists speculate that motor learning results in the sequential firing of a specific number and series of neurons in the brain. Once that series of neurons has “learned” a task it never really forgets, and can automatically instruct the muscles to contract in a predetermined pattern. With enough practice, very complex and sophisticated behaviors become automatic. That is why we can relearn complex activities, such as riding a bicycle, even though many years may have passed since we last performed the activity (Weinberg & Gould 1999).

IV. Threat Responses and Machines

Learning new skills is one thing, but knowing when to apply them is another. Now it is time to talk about how to avoid fixating on a threat object, and setting up mechanisms that signal our motor cortex to perform actions that are appropriate for the threat we are experiencing.

We have to train the lower levels of the sensorimotor system to react without conscious control. An interesting statistic that came out of the 1980’s was that the more jumps skydivers made, the safer they became. A corollary is that skydivers who are also very active instructors made up a smaller portion of annual fatalities than skydivers who were not active instructors.

The reason for this is obvious now that we know a little about sensorimotor learning. Every time the instructors physically demonstrated emergency procedures, they were reinforcing what they had already taught their own sensorimotor systems.

In addition, active instructors are usually also active skydivers, and skydiving instructors tend to go through the motions of emergency procedures on every airplane ride to altitude. They go through the same gross sensorimotor sequence that they would during a real emergency, looking at handles, actually touching them, initiating the pull, and extending their arms. They make their practice as realistic as they can, including textual sensations such as the feel of the handles, and even the sound of Velcro starting to peel.

This is not unnecessary or overblown practice. At times of high stress, our brain is hyper-vigilant, and unexpected sensations might divert our attention and create confusion. Making practice as realistic as possible and repeating it often plants a series of physical movements solidly in the motor complex and lessens the ability of unexpected sensory input to confuse a jumper during an emergency. The best rehearsals are as realistic as possible, making use of every sense we have.

It may seem like mental rehearsals are superficial or poor substitutes for hanging in a harness and actually pulling handles. In fact, imagery is a very powerful method of practice that is far more effective that it might seem.

A. Visualization

Psychologists have determined that as far as the brain is concerned simply thinking about performing a physical task is very similar to actually doing it. Vividly imagining a physical act actually uses the same neural pathways that doing the act for real uses. Although muscles do not move when we imagine performing a task, minute electrical impulses travel to the muscles, just as they do when we actually perform the task. You do not have to perform a task to train your brain to do it. Simply imagining that you are performing the task is almost as good as actually doing it (Weinberg & Gould 1999).

This means that imagining different reactions to different events is valuable practice. For example, imagining looking up at a canopy after opening, seeing a steering line malfunction and envisioning releasing brakes and pulling twice on steering handles, then initiating emergency procedures will increase the likelihood of doing just that when a steering line malfunction is encountered.

V. Matching Threats to Responses

The goal is to replace a threat object that initiates fixation, time distortion and a narrowing field of vision with a signal to initiate a particular emergency procedure. We can train our brains to react to a high-speed malfunction by performing emergency procedures, rather than falling into the natural threat response, with the attendant narrowing of visual field, fixation, and time distortion.

The major lesson from brain research is to include the particular kind of emergency in our practice. Instead of simply practicing pulling handles we would best practice imagining the situation in which pulling handles is proper. High-speed malfunctions are treated a little differently than steering line malfunctions, for example, we need to include the type of emergency in our practice.

This lesson can be applied to situations other than dramatic canopy malfunctions. While imagining confronting an obstacle, and practicing the self discipline of focusing on the intended path around it instead of fixating on the threat itself.

The idea behind emergency procedures is to eliminate the need to think. If you teach your sensorimotor system how to respond to various situations there is no reason to waste time thinking about what to do or choosing the right procedure. Practicing different responses to different situations will ensure that when the time comes you will perform the right procedure to meet the particular emergency.

References

Busey, T. A., & Loftus, G. R. (1998). Binocular information acquisition and visual memory. *Journal Of Experimental Psychology. Human Perception And Performance*, *24*(4), 1188-1214.

Carson, D. (1982). Temporal distortion and the ejection decision. *Flying Safet*, March 1982

Celsi, R. (1992). Transcendent benefits of high-risk sports. *Advances in Consumer Research, 19*(1), 636.

Helmuth, L. (2003). Fear and trembling in the amygdala. *Science*, *300*(5619), 568.

Johnson, S., (2004). Mind Wide Open. New York, NY: Schreiber and Sons.

Langran. M. (2007) www.ski-injury.com. Overview of alpine snow sports injuries. Available from: http://www.ski-injury.com/intro.htm#Fatalities

Pinel, J. (2006). *Biopsychology with "beyond the brain and behavior" CD-ROM (6th ed.).* Boston: Allyn and Bacon.

Ratey, J., (2001). A Users Guide to the Brain. New York, NY: Random House.

Rogers, T. J., Alderman, B. L., & Landers, D. M. (2003). Effects of life-event stress and hardiness on peripheral vision in a real-life stress situation. *Behavioral Medicine*, *29*(1), 21-26.

Sapolsky, R., (1994). Why Zebras Don't Get Ulcers. New York, NY: W. H. Freeman.

Shankar, U. (2001). *Fatal single vehicle motorcycle crashes*. Retrieved. from http://www.webbikeworld.com/Motorcycle-Safety/809-360.pdf.

Staal, M. (August 2004). Stress, cognition, and human performance: A literature review and conceptual framework. *NASA Center for AeroSpace Information, NASA/TM—2004–212824*.

Tsai, Y.-F., Viirre, E., Strychacz, C., Chase, B., & Jung, T.-P. (2007). Task performance and eye activity: Predicting behavior relating to cognitive workload. *Aviation, Space, And Environmental Medicine, 78*(5 Suppl), B176-185.

Weinberg, R. & Gould, D. (1999). Foundations of Sport and Exercise Psychology. Champaign IL: Human Kinetics.

Zuckerman, M. (1990). The psychophysiology of sensation seeking. *Journal of Personality, 58*(1), 313-345.