THE IMPACT OF THE SYMPATHETIC NERVOUS SYSTEM ON USE OF FORCE INVESTIGATIONS

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Executive Overview

Researchers have long recognized that stress is responsible for deteriorating cognitive and physical performance. Reports of tunnel vision, auditory exclusion, time distortions, the loss of fine and complex motor skills, unexplainable accidental discharges and bizarre behavior have been well documented.

Why these phenomena occur has remained elusive until recently. Today, we now know that combat performance is connected to Autonomic Nervous System. This system controls all of the voluntary and involuntary functions of the body, and is divided into parasympathetic and sympathetic systems. The parasympathetic nervous system (PNS) is dominant during nonstress environments where an individual perceives he/she is safe. The PNS controls a number of critical survival functions, such as visual acuity, cognitive processing, and fine or complex motor skill execution. However, anytime the brain perceives an imminent deadly force threat, the sympathetic nervous system (SNS) is activated involuntarily, resulting in an immediate discharge of stress hormones.

The SNS is recognized as the "fight or flight system" and prepares the body for survival by releasing a mass discharge of stress hormones. The release of stress hormones increases arterial pressure and blood flow to large muscle mass (resulting in enhanced gross motor skill and strength capabilities), vasoconstriction of minor blood vessels at the end of the appendages, a multitude of changes to eye physiology, and cessation of the digestive process. The combination of these physiological changes helped early man avoid becoming a meal for another predator. However, combat evolves around fundamental skills based on hand/eye coordination, high levels of acuity or accuracy, and a higher level of cognitive processing. For these functions/skills to work optimally, the PNS must be dominant. Unfortunately, activation of the SNS is automatic and it uncontrollably inhibits the PNS.

The implications of SNS dominance is catastrophic to vision, cognitive processing, as well as fine or complex motor skill performance. For example, SNS excitement will cause the loss of near vision, it disrupts depth perception and collapses the peripheral field. Also consider that vision is the mother of all senses and is the primary sensory source on which the brain relies in combat. However, if the visual system is feeding impaired information back to the brain during combat, threat recognition and processing skills will be flawed.

The SNS is even more devastating on cognitive processing, which is an extremely efficient and lightning fast operation in non stress situations (PNS dominance). It is a process which is normally managed by the cerebral cortex and higher brain functions. But SNS activation inhibits higher brain functions centered in the cerebral cortex, resulting in a deterioration of threat recognition, response selection and the ability to communicate complex thoughts. The result is a dramatic increase in survival reaction time.

The final phase of combat is the execution of a motor skill. Typically, combat skills can be segmented into three categories; gross, fine and complex. Almost one hundred years of research has demonstrated that under SNS excitement, only gross motor skills are performed optimally. Fine motor skills such as precision shooting, and complex motor skills like evasive driving, all deteriorate when the SNS is activated.

The purpose of this paper is to provide administrators, investigators or prosecutors with an overview of the implications of survival stress on use of force actions. This research becomes critical when an agent with an excellent record and history is accused of excessive force. More often than not, we find that the agent was a victim of his SNS which was activated by a subject's threatening actions.

Survival Stress, Vision and Mis-identification of Threats

In the early 1900's, scientists have been studying the effects of stress and fear on the visual system. Cannon (1915) found that SNS triggers pupil dilation, leading to the loss of near vision. The SNS also disrupts the ability to focus, which is a function controlled by the tension on the ciliary muscle. This muscle maintains the convex shape of the lens, which is necessary for clarity and focus. However, when the SNS is activated the ciliary muscle relaxes and the contour of the lens changes from a convex to a flattened state. The actions of the ciliary muscle (combined with several other factors) results in a loss of depth perception and the ability to focus on close objects.

Just as important, is the impact which the SNS has on peripheral vision. Perceptions are delivered to the brain through the basic senses of sight, sound, touch, taste, and smell. Each system provides the brain with a constant source of information about the environment and physical activity through a complex neural receptor network. But when the brain perceives a threat, the brain will "tune into" the system that can provide the most relevant information at that given second. This is referred to as perceptual narrowing.

Perceptual narrowing in combat will result in the visual field becoming the dominant source of information about the threat. Keep in mind that the SNS is now activated and the eyes go through automatic changes to enhance survival. One of these changes is the phenomenon of peripheral narrowing (also known as tunnel vision).

There are currently two views why visual narrowing occurs. Research by Sports Optometrist Hal Breedlove, found that SNS excitement causes vasoconstriction to the specific blood vessels of the retina. The retina is comprised of photoreceptors which innervate into the optic nerve, which leads to the visual cortex. The photoreceptors are divided into the rods and cones. The cones provide color reception, resolution and acuity, and are densely populated in the center of the eye. The rods are concentrated on the periphery of the retina and are higher in number than the cones. The rods are responsible for light/dark sensitivity, as well as the detection of subtle and gross movements. Since there are more rods than cones, the optic nerve will receive more information about threats or the environment from the rods.

Breedlove hypothesizes that SNS excitement causes vasoconstriction to the blood vessels on the periphery of the retina. The reduced blood flow inhibits the photoreception of the rods, leading to a collapse of peripheral field by 70%, failing to detect subtle threat movements. This is one of the reasons agents mis-identify quick movements for deadly force threats.

The implications of SNS activation on vision is wide ranging. For example, the loss of near vision will impact an agent's ability to focus on his/her front sights and make precision shots. It could also result in an agent hesitating, which could be especially critical in hostage situations.
The loss of depth perception manifests itself in two forms. First, threats will appear closer than reality and an agent's report of distances will almost always be incorrect. Second, if the threat appears to be closer than reality, an agent will use force quicker if he/she perceives that the threat is imminent. We can also expect agents to often shoot low the first couple of rounds due to the loss of depth perception.

The peripheral vision plays an important role on threat detection and perceiving the location of innocent civilians. Keeping in mind that most of the research indicates the visual field will collapse by 70%, an agent's field of view could be reduced to a "tunnel" of about 24 inches (or smaller) in diameter. A field of view this small will eliminate an agent's ability to see innocent bystanders on either side of the threat or other potential threats. But just as important, an agent's ability to accurately describe a subject in detail will be inhibited if the subject held the weapon low.

Night and color vision can be expected to be dramatically decreased during SNS excitement. This is attributed to the photoreceptors which innervate into the optic nerve. Remember that the photoreceptors are divided into the rods and cones. The cones provide color reception, resolution and acuity, and are densely populated in the center of the eye. The rods are concentrated on the periphery of the retina and are higher in number than the cones. The rods are responsible for light/dark sensitivity, as well as the detection of subtle and gross movements. Since there are more rods than cones, the optic nerve will receive more information about threats or the environment from the rods. Therefore, we can expect that agents will fall victim to their SNS during stress in low light conditions and mis-identify subtle, quick or spontaneous cues as threats and respond with deadly force.

Stress and Motor Skill Performance

The study of skill execution and stress can be traced back to the Civil War. Researchers noted in the late 1800's that as combat/survival stress increased, men lost the ability to perform accuracy skills (precision shooting) and the ability to conduct complex tasks quickly (reloading).

As research methods and technologies have advanced, scientists found that physical or mental stress react differently on different types of motor skills. Researchers began to classify motor skills on a progressive continuum from fine to gross, according to muscle size, task complexity, task effort/fatigue, and how levels of stress affect performance by monitoring escalating heart rates (Cratty, 1973). Scientists continued to refine their research and found that SNS activation triggered the deterioration of fine and complex motor skills. Today, motor skills are divided into the following three basic classifications;

Gross motor skills; are skills which involve the action of large muscle or major muscle groups. An example of a survival gross motor skill would be simple actions such as straight punch, a forward baton strike or the Isosceles shooting stance. Generally, gross motor skills are simple strength skills or skills involving simple symmetrical movements.

Fine motor skills; are skills which require hand/eye coordination and hand dexterity. In the survival skill category, a fine motor skill would include any action that requires precision hand eye coordination, such as precision shooting with a firearm.

Complex motor skills; are skills which involve a series of muscle groups in movements requiring hand/eye coordination, precision, tracking and timing. Survival skills that are complex would include shooting stances that have muscle groups working in different or asymmetrical movements (Weaver), or a takedown that has more than multiple independent components.

By using escalating heart rates as a medium to chart performance, scientists found that high or even moderate levels of stress interfere with fine muscular control and decision-making. In contrast, motor skills dominated by large muscle groups, that have minimal fine motor control and very little decision-making or cognitive complexity, are not effected by high levels of stress. Studies have also found that fine motor skills deteriorate at 115 BPM, complex motor skills deteriorate at 145 BPM, while gross motor skills were performed optimally at higher levels of stress.

The implications of this research focuses on the execution of skills under increasing levels of stress. We find that low level SNS activation results in fine/precision skills, which will effect precision shooting, evasive or pursuit driving, and the execution of subject control techniques or reloading. (This research is consistent with SNS vasoconstriction to the hands and fingers, which deteriorates the dexterity needed for precision shooting skills.)

At high level SNS activation (such as in the case of a SNS mass discharge), investigators can expect to see a complete deterioration of all fine and complex motor skills. Agents actions will be reduced to simple gross movements, such as grappling, clubbing, the use of strangulation techniques, as well as firing an inordinate number of rounds at a perceived threat. All of the latter are typically untrained actions and can be normally traced to the agent being at a heightened state of fear.

Another aspect of stress and motor skill performance is neurological response called "Interlimb Interaction". This response is typically defined as "any action of one limb, real or imagined, having a similar effect of a lesser degree upon another".
Interlimb interaction is most commonly associated with accidental discharges during high stress instances. Generally, an accidental discharge in this category can be divided into three categories; overflow activity, loss of balance and a startle response.

Overflow activity results when an agent highly exerts one muscle group, or a group of muscles, resulting in a neurological impulse overflow that involuntarily activates the opposite muscle groups. An example of overflow activity is often found with an officer who is making a felony arrest with his weapon still in his hand. He tries to direct the subject with his weak hand into a prone position, when the subject suddenly moves into the officer. The officer reflexively pushes the subject back and away with the weak hand. The reflex of the weak hand will overflow into the dominant hand, resulting in an accidental discharge. It is important to remember that most any action that causes the weak hand to flex will cause an overflow to the opposite hand.

Loss of balance is the second category of interlimb interaction. In this case, the action of the body attempting to right itself will invariably cause one hand to reach out and grab an object to stop the fall. This action will involuntarily initiate a contraction in the opposite hand resulting in an accidental discharge.

The final cause of interlimb interaction is the startle response. "Being startled while otherwise physically and/or mentally preoccupied will result in four involuntary actions occurring within 150 milliseconds. First, the eyes blink; second, the head and upper torso move forward; third, the arms bend at the elbow; and lastly, the hands begin to tighten into fists. If a person is under extreme stress and adrenaline has been introduced into the system, resulting startle response contraction can generate as much as 25 pounds of pressure. That amount of force is approximately twice the amount needed to discharge a double action revolver" (FLETC, 1991).

It is important to note that the response as described above focuses on a response in a static environment. However, the research indicates that an agent will become more vulnerable to a startle response accidental discharge when the SNS is already activated. An example would include situations where an agent is in the process of making a high risk/felony arrest with the perception that a deadly force threat was possible.

Stress and Cognitive Processing

The brain's ability to process information and develop responses to environmental stimuli is a highly complex operation. Cognitive processing consists of an interplay between perceptual processing, analyzation, strategy formulation and motor skill initiation. Under nonstressful conditions, this process is conducted in the neocortex which is the higher functioning part of the brain. This process is extremely fast and executed in milliseconds.

During low to moderate stress (referred to as low level SNS activation), this process becomes impaired and response time begins to slow down. Research (Weltman and Egstrom, 1966) and contemporaries have found that response time will increase by 400%. However, the neocortex operations become inhibited and all rational decision making stops when a SNS mass discharge occurs.

It is under these conditions where agents are the most susceptible to hypervigilance, poor decision making, accidental discharges or actions that are initially construed as excessive. For example, a mass discharge SNS response is usually the result of a deadly force threat perception combined with a perception that the threat is within close proximity and the reaction time is minimal.

This combination normally leads to a state called hypervigilance. Hypervigilance typically manifests into one of five forms; flight, fight (with untrained gross motor skill behavior), fixation, submissive behavior (surrender to death without a fight) and the feedback loop (repetitive actions). But it also occurs during states of hypervigilance where an agent's decision making becomes the most impaired and accidental discharges are the most prominent.

Critical Incident Amnesia

Critical Incident Amnesia (Siddle and Grossman, 1997) is a neurological phenomenon that is gaining widespread attention among use of force investigators. It is a result of an intense critical incident which for criminal justice officers, is almost always associated with a deadly force encounter. More specifically, it is directly linked to SNS excitement and the high level secretion of cortisol into the synapses of the brain. The aftermath is a temporary loss of detailed memory about the events of a critical incident. Unfortunately, investigators and prosecutors often misinterpret the agents lack of candor about an incident and assume (mistakenly) that the agent is untruthful about his/her lack of memory.

Most memory results from when we "attend" to information. Every waking second of every day, our five senses flood the brain with data. But, we only attend to (that is, pay attention to) a tiny percentage of what comes in. If we do not attend to something it is generally lost to memory (Cherry, 1953; Moray, 1959). Intense fixation of attention on a particular aspect of a critical incident can cause vivid memories in some areas, but by definition this focused attending in one area will cause a reduction in attending (and thus to memory) in all other areas.

Sometimes this fixation results in a kind of "flashbulb" effect. Brown & Kulik (1977) originated the term and others (Neisser, Winograd, & Weldon, 1991; Palmer, Schrieber & Fox, 1991) have done significant follow-up work. In critical incidents a "flashbulb memory" is often seen when an initial image or aspect of the critical incident will be all that is remembered. (Other research (Haber, 1969, 1979; & Stromeyer, 1970) refers to a similar process, which has similar effect, as "eidetic" memory.)

This is similar to the process that would occur if you were moving down a familiar hallway or street, saw something new, and thought intently about that new stimulus as you continued to walk. At the end of the walk it is likely that you would have a vivid memory of this one new stimulus, but could not remember anything else that you saw or did, even though you looked at and moved around things in your path. Most of us have experienced something similar many times. In critical incidents this common process can be greatly amplified by the surprise and intensity of the initial shock. The individual essentially functions on autopilot during the critical incident, while the mind continues to dwell on and try to make sense out of that initial image. Immediately afterwards, that image may be all that is remembered.

In addition to the failure to attend which results from fixation and sensory overload, there is a body of research which indicates that intense stress will result in a failure to recall anything learned in a situation (Khalsa, 1997) indicate that this effect is due to the flood of stress hormones (specifically cortisol) in the brain which occurs during intense trauma. The combination of these factors will very often result in "post-incident amnesia" in which, immediately after a critical incident, the majority of information will not be remembered.

The greater the trauma, the greater the impact of post-incident amnesia is likely to be. Key factors which will increase the stress include: the perception of threat or danger, the suddenness of the threat and the available time to respond or prepare, the amount of sensory input needing to be processed, and the degree of physical effort (aerobic and anaerobic output) that was engaged in during the incident. If the individual is physically wounded or injured the effect will be even greater, and the effects of post-incident amnesia will be greatest if the wound or injury results in unconsciousness.

The implications of critical incident amnesia on law enforcement are profound, and it is vital that procedures be established which will ensure that the most accurate and most complete memories are protected and preserved as a part of standard procedures. The following procedures are recommended:

1. Educate all officers on the effects of stress on memory, in order to ensure that they understand and apply the procedures outlined below. This education process is also vital to reduce guilt and confusion over memory loss, and to reduce the potential for post-traumatic stress disorder. Administrators, internal affairs personnel and prosecutors should also be educated so that all individuals are working together to ensure that the most accurate possible information is being retained.
2. An initial post-incident interview (debriefing, or report) should be conducted as soon as reasonably possible after a critical incident. This should be a quick narrative review of what occurred, and it should be remembered that it is very likely a subject (officer, victim or bystander) will not remember the majority of events that occurred in the incident. The subject can generally be expected to recall:
   a. Type of weapon (handgun, knife) but not the characteristics of the weapon.
   b. General information about the suspect.
   c. General details about the encounter.

These interviews should probably be tape recorded and transcribed, since the residual sympathetic nervous system effects on fine motor control will often make hand written reports illegible. Of course, during this and all other interviews, the interviewer should make a conscious effort not to contaminate the process by suggesting ideas about the crime or the suspect to any witnesses.

The interviews should be conducted on an individual basis, and reasonable efforts should be made to ensure that the subject is isolated from other sources of information (such as news reports or other witnesses) until the next interview, which will take place after a good night's sleep. Every effort should be made to ensure that the subject receives a healthy night's sleep after the incident. Drugs which are administered to the subject (sleeping pills, anesthesia, etc.) should be held to a minimum and should be screened by a physician for potential impact on memory retention.

3. After the first sleep period (generally 24 hours later) the subject should be interviewed again, and the subject can be expected to remember the majority of the details regarding the incident and to refine many of the fine points. In the case of law enforcement officers a written report at this time may be appropriate, and it should be understood that the officer may add significantly to his or her earlier statements.
4. A group interview or group debriefing should then be conducted as soon as reasonably possible after completion of the second set of individual interviews. The memories related in the second interview may be the most pure, but the subject will almost certainly not recover all available memory of the incident until exposed to the retrieval cues that can be provided by other witnesses.

Perhaps the most important aspect of this group debriefing is that it is considered to be the single most powerful therapeutic tool in preventing post-traumatic stress disorder. The moral requirement to provide the therapeutic aspects of this vital group debriefing has been essentially acknowledged by the U.S. military, and law enforcement agencies are probably under increasing legal liability for any post-traumatic responses which would occur among law enforcement officers who have not been given this opportunity.

Summary

The role of the sympathetic nervous system during high stress deadly force situations can not be overstated when attempting to judge an agent's actions with 20/20 hindsight. We must remember that SNS excitement narrows and distorts perceptions, inhibits rational decision making, deteriorates motor skill performance, and great reduces memory immediately after a critical incident. We must remember that the agent is a victim to the SNS's dominance is automatic and uncontrollable. However, it is more important to remember that SNS is activated by a threat perception, or an action by suspect who the agent believes is threatening his/her life.

About the Author

Bruce Siddle is a 19 year law enforcement veteran, the Executive Director of PPCT Management Systems, one of the largest research based use of force training organizations in the world.

Mr. Siddle has been an active consultant for hundreds of criminal justice agencies, including special operations/warfare units for the U.S. Dept. of Navy, U.S. Dept. of Army, U.S. Air Force, the U. S. Department of Defense, the Bureau of Alcohol, Tobacco and Firearm's training division, the FBI's Hostage Rescue Unit, the U. S. Secret Service, the 22nd Special Air Service, and the Queen of England's personal protection unit (Royal Protection Group). Mr. Siddle is also the author of Sharpening the Warrior's Edge, the first text to provide a scientific explanation into survival stress responses, such as visual narrowing, auditory exclusion, hypervigilance and why survival performance often deteriorates.

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