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Implementation of High-Reliability Organizing (HRO): The Inherent Vice Characteristics of Stress, Fear, and Threat

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Abstract

High-Reliability Organizations engage threats and adversity to maintain reliable operations. Human stress, fear, and threat responses drive safe and effective engagement of environmental threats. The executive functions integrate perception from opposite ends of the brain, hastily created plans, and motor activity. During a crisis, the hypothalamic-pituitary-adrenal (HPA) axis enables survival behaviors by releasing cortisol to "disarm" the executive functions. Novelty, uncertainty, and uncontrollability, in the domain of the executive functions, cause stress responses. Fear reactions at the subcortical level maintain a safe distance from the threat. Threat reflexes rapidly initiate protective behaviors. However, these same responses, when unmodulated, can harm the individual. The prevalence of unmodulated stress, fear, and threat makes them appear unpreventable, if not normal. This is the inherent vice of stress, fear, and threat. By describing their function and location in the brain, we can identify these behaviors to begin modulation for effective responses to threats.

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Introduction

Stress research and the consequences of stress focus on uncontrollability. Interventions focus on adding a sense of controllability by limiting exposure to uncontrollability or increasing controllability through rules and algorithms. These approaches, almost the foundation of risk management and management science, disregard the function of stress responses and the adaptive neurohormonal responses in the brain. The final product of stress is allostasis. Withdrawing from threat or adversity or seeking external authority such as executives, administrators, or experts also withdraws from experience. We lose the learning and development necessary to extend neonatal care to improve lives or healthcare to improve society (1).

Safer environments relax the selection pressure on behaviors necessary to survive, if not thrive, in a hostile or adverse environment. Suites of behaviors that developed for survival may remain in the repertoire of human behavior but modulate due to social custom. The loss of some behaviors has permanently modified other behavioral suites (2, 3). One residual effect is the transfer of fear from a physical object, such as a predator, to an idea, the fear of the predator. This effect creates the ecology of fear where, for example, the idea has a more destructive effect than the threat itself (4). We need only look at hospital programs for error prevention. The consequences of the criminalization of a medication error and the subsequent conviction of a registered nurse (5) have created a new ecology of fear.

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Stress, fear, and threat prepare the brain for adequate cognition and drive safe and effective engagement with that adversity. Not recognizing these strengths shifts the research and conversation to the unmodulated damage stress, fear, and threat can cause. This lack of acknowledgment is the inherent vice of stress (6). Karl Weick (7) described failure as not acting that the failure is not only invisible but also becomes organizational knowledge. The inherent vices from stress, fear, and threat also lead to not acting, and the behaviors to avoid threats have become organizational knowledge.

Relaxed Selection and Conserved Stress

Survival and defensive behaviors observed in mammals, particularly prey species, can be observed in humans, though in a relaxed form. These are *conserved behaviors;* those behaviors are passed down from ancestral lines. Functionally evolved for imminent physical danger, the stress-fear-threat cascade today reacts to thoughts and perceptions and can be modulated by thoughts and perceptions.

While the conserved stress system inhibits top-down cognitive control and enhances bottom-up reflexive actions, modulation by human executive processes can move mental processes toward effective cognitive flexibility.

Relaxed selection occurs when an environmental demand or threat is removed, relaxing selection pressure and altering the original suites of behavior (8). This concept is similar to animal domestication, which introduced domesticated traits unsuitable for survival in the wild (9). The relaxed selection for stress, fear, and threat alters the need for the motor and somatic components, yet the appraisal and motivational components may remain unaltered.

Viewing stress, fear, and threat responses in light of a relaxed selection of conserved behaviors allows us to discuss maladaptive behaviors objectively. We can identify the distinct effects of stress, fear, and threat. Stress impedes memory recall and working memory. Fear drives conscious self-protective behaviors. Threat reflexes, though not preventable, need not be sustained.

Executive Functions

Effective action responding to a changing environment integrates perception, hastily created plans, and motor activity from opposite ends of the brain. The *executive functions*, acting hierarchically, coordinate temporary behavioral structures and "integrate actions with perceptions in the presence of novelty and complexity" (10).

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The executive functions support motor attention, working memory, and inhibitory control:

- *Motor attention* to preparing for impending motor action – "memory of the future" (10)
- *Working (short-term) memory* for sensory stimuli mediates perception and action toward a goal in real-time (10)
- *Inhibitory control* protects goal-directed behavior from interference, distracting information, and impulsive or reflexive behavior (10); inhibits emotional memories (11, 12), well-established habits, and more easily processed intuitions (13).

Working memory has the attribute of rapidly 'forgetting' information as the motor actions evolve. During the action, we must release memories as we continually bring new things into our memory. Inhibition allows one to inhibit thoughts or prepotent responses, allowing selective attention to task-relevant information and engagement of goal-directed actions. Working memory refers to keeping the information in mind and updating/integrating current content with new information. Cognitive flexibility is the ability to shift between cognitive rules or modes of thought (14).

Anatomic location. The dorsolateral prefrontal cortex (DPFC) and the posterior parietal cortex (PPC) functionally cooperate during time-based contingencies between continuous perception and emerging motor action (10, 15). The DPFC mediates internal and external stimuli for *inhibitory control* (10).

Problems

We work with other people's executive functions. At all levels of operations, we can *identify* what is happening, then *interpret* with *our* expertise for salience and relevance, and *translate* it to give relevance to *their* expertise. We can use concrete words and action verbs for *motor attention*. By "chunking" information, we compress memory elements *working memory* rather than increasing elements by splitting ideas. Observing a person struggling with stress, fear, or threat, we support their *inhibitory control* by decomposing goals into more easily attained objectives and reducing distractions.

The brain's response to stress constrains executive functions and impairs abstract thought. During an emergency, using abstract words sends messages to areas of the brain impaired by stress. Motor attention initiates action – we think by acting. Motor cognition comes from the coupling of perception and action. The *sensorimotor neural network* processes sentences with concrete nouns and words as well as abstract words but with a preference for concrete terms (16). *Motor abstract* words will activate motor areas while visual abstract words elicit higher visual area activity (17). Concrete, active words facilitate action while abstract words tend to generate thinking, a problem in a stressful situation.

What not to do. It is common to hear "Don't do that!" rather than what *to do.* The brain processes verbs faster than nouns. Action verbs affect overt motor performance dependent on timing, interfering with a reaching movement in progress within 200 msec. The same words processed *before* movement will *assist* the movement (18). This action, fortunately, is category-specific. A quick shout to move a hand causes hands to move and not random body parts (19-21).

Descriptions become valuable packets of information that carry information, drive decisions, and frame the situation—*articulate*, *objective*, *succinc*t descriptions package situations for action.

In the first years of the paramedic program, emergency physicians often did not know what equipment paramedics carried, their capabilities, or what actions they were authorized to do (personal experience, DvS). This led to orders such as D5W boluses for hypovolemic shock. The physician who trained the paramedics, Ron Stewart, MD, taught the paramedics to give articulate, objective, succinct descriptions. If the discrepancy continued, we were to increase the accuracy of our description. This becomes a trait, changing disagreements into "dueling descriptions" that, rather than producing tension, produce ever-increasing accuracy. One thoracic surgeon, discussing his fellowship training, described why the surgical attendings did not like late-night calls from one of the fellows. He would obtain all necessary information and give an accurate description. The reason for the apprehension – was that the attendings asked for tests, not because they needed the results, but because it gave them time to think. The author remembered that whenever someone ordered a late-night chest x-ray.

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Stress

Causes. Novelty, uncertainty, and uncontrollability, in the domain of the executive functions, cause stress responses (22, 23). Uncontrollability alone causes minor stress to impair executive functions (24).

Functions. Cortisol inhibits memory recall in select memory systems while enhancing habit memory and learned behaviors. Cortisol also selects memory formation and transforms threat reflexes

into learned behaviors. The stress response functionally inhibits the executive functions.

Anatomic Location

The amygdala activates the sympathetic-adrenal-medullary (SAM) axis for the proverbial "flight-or-fight" response and the hypothalamic-pituitary-adrenal (HPA) axis for the release of peripheral adrenal hormones, including cortisol (25). Cortisol blocks memory retrieval in the prefrontal cortex and hippocampus (memory center), and the amygdala directly inhibits the prefrontal cortex

- Novelty is processed in the right and left cerebral cortex processes familiar perceptions.
- Uncertainty and ambiguity in decision-making occur in the ventromedial prefrontal cortex (vmPFC). The vmPFC is also involved in making decisions in uncertainty (26); see below.
- Uncontrollability or unpredictability is the stimulus for the HPA axis.

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Problems

If unrestrained neurological stress responses develop, then almost pure bottom-up control and self-preserving behaviors occur. Cortisol and the amygdala increasingly suppress the executive functions, and a defense cascade follows (27). Threats that are proximal (static distance) or approaching (changing distance) will mobilize one to move toward safety or fight in self-defense if escape is impossible.

Even though intuitions and scientific thoughts are abstractions, the loss of executive functions means that intuitive thought is not inhibited. Because intuitive responses are mentally faster than scientific responses, childlike misconceptions emerge, and the individual begins thinking in intuitions and superstitions. Without cognitive inhibition by the executive functions, intuitions during a crisis can predominate over scientific thought (28).

Novelty, uncertainty, and uncontrollability have made stress responses a normal part of operations. This unrecognized stress increases staff attrition and costs while compromising reliability and safety.

Novelty. We can find something familiar in any new situation, starting at that point. We can use metaphors for description and analogies for analogical reasoning. Metaphors carry meaning and assist interpretation when the person using the metaphor must experience the word or phrase. Analogies have greater applicability to support interpretation and reasoning when the comparison has plausibility, increased similarities, and correspondences between domains. Without analogical strength, the metaphors and analogies become thought-terminating cliches (29). We cannot describe or argue against a metaphor or cliché.

Becoming a "slippery slope." The authors have traversed, ascended, and descended slippery slopes. This involves a good description of the slope and conditions along with knowledge of the equipment and capabilities of those in the team. Unskilled, unprepared, and ill-equipped people are best advised to leave slippery slopes to those with the necessary experience – whether on a climb or as a cliché. The cliché may be the ultimate slippery slope.

Uncertainty. Collecting more data and information to reduce variance is counterproductive in a red noise environment. On the contrary, more information increases variance and uncertainty.

Early in his career in the fire rescue ambulance, one of the authors (DvS) learned the safety and strength by saying, "I don't know." As opposed to the thought-terminating cliché, the phrase would initiate investigations and generate learning. In healthcare, the phrase brought doubt about one's abilities. Compared to operations in dangerous contexts, certitude tends to bring more respect (30). One new attending told the author that the attending should always know the answer. Senior attendings would simply say it confidently, giving no opportunity for correction.

Reductionism is another way to address uncertainty. Red noise has long period forcing functions. Interacting frequencies develop autocorrelations. New properties emerge from nonlinear interactions. It is not only uncertainty but uncertainty in flux that we engage. Reverting to the originating elements, reducing events to basic measures, gives the tractability that reduces stress, but at the price of mistranslations.

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Abstractions can be lifted from any situation. We cannot argue with abstractions. We cannot measure or act on abstractions. By design, abstractions fit any situation, misleading and arresting our sensemaking (31). Substituting abstractions into context can be deadly.

Controllability. The sense of control comes from how we choose and interpret our actions. When people used pencils for examinations, one of the authors (DvS) asked the residents why they brought five sharp pencils to the exam when one dull pencil would suffice. The degree of stress experienced by consulting physicians in an ICU room could be observed by how often they turned the display knob on a mechanical ventilator. They would observe the chest, turn the knob, read the numbers, observe the test, and repeat. What they saw on the ventilator was not a new setting but different displays.

Controllability is an inherent vice of command and distinguishes leadership authority from command authority. The leader creates a safe space for subordinates to operate, liberating behavior for effective operations. A firefighter quoted Capt. As they approached a structure fire, Bill Corr said, "OK, men, do your stuff." Uninformed command authority controls the behavior of subordinates, reducing the commander's stress while creating stress for subordinates. Karl Weick (personal communication) defined micromanagement as attending to details but without context.

Constraint on action is an inherent vice of rules and algorithms.

Rules and algorithms can free space in working memory, identify safe actions, and create boundaries for safety. Rules, however, can compete or conflict; a forcing function opens space between rules. The performance of an expert who follows the rules will deteriorate (32-34).

Error management is an inherent vice of risk management programs. Behaviors to reduce risk include "doing everything through channels," "refer all matters to committees," which should be "as large as possible — never less than five," "advocate caution," "urge your fellow conferees to be reasonable and avoid haste," "worry about the propriety of any decision — raise the question of whether such action as is contemplated lies within the jurisdiction of the group or whether it might conflict with the policy of some higher echelon," and "apply all regulations to the last letter."

The recommendations quoted in the previous paragraph exemplify a "type of simple sabotage' that requires "no destructive tools whatsoever and produces physical damage, if any, by highly indirect means." During World War II, the United States Office of Strategic Services (OSS) contributed to undermining industrial efforts by teaching these "simple sabotage" methods to civilian workers in occupied Europe (Office of Strategic Services 1944) (35). Executives and administrators commonly accept these methods as diplomatic means to prevent error and reduce liability (36).

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Predictability. Inference to know if therapy will succeed or the course of a disease commonly follows scientific logic and probability statistics. Modal and paraconsistent logics replace scientific logic (37, 38). We cannot develop probabilities because we do not have a Gaussian distribution in red noise environments. When families and staff asked one of the authors (DvS) the percent chance of survival, he answered, "Our job is to turn a 20% survival into a 30% survival, then into a 50% survival, and do this until it is over."

For an HRO, the prediction comes from what we can influence and the team's capabilities rather than what the circumstances tell us.

Fear

Fear reactions and threat reflexes. We use Joseph LeDoux and Daniel Pine's (39) description of "fear" as a conscious, subjective feeling generated in *cortical regions* of the brain. Therefore, fear is amenable to conscious interpretation, and consequently, the individual can modulate what we call "fear reactions." The objectively observable behavioral and physiological responses involve *subcortical regions*. The initiation of these responses occurs at levels below one's awareness but can be modulated if the individual is sensitive to their presence. While acknowledging the ability for modulation, we call these actions "threat reflexes" because the subcortical generation of the initial behavioral or physiological response cannot be prevented.

Though the initiation of threat reflexes is below the level of awareness, once in progress, the individual has awareness and often control. This distinguishes threat reflex behaviors from emotional fear reaction responses. We recognize that our extensive *in vivo* experiences may differ from academic publications. However, knowing the differences is vital to reaching a safe outcome during such an engagement.

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Causes. Proximity in time or space of a threat or an approaching threat.

Function. Fear motivates a person to act to reduce the potential danger from a threat. While it is common to discuss fear as a predator-prey interaction, it is more beneficial to view fear as a motivating drive that protects one's physical, mental, and emotional self from attack or collision (40).

Fear reactions are conscious sensations experienced when exposed to an imminent threat (39, 41). The amygdala sends signals to the brain's unconscious (subcortical) and conscious (prefrontal cortex) regions, accounting for the uncontrolled fear responses and the feeling of fear. The emotional response of fear is to diminish danger (42), creating the drive to avoid or escape, generally focusing on self-interest, self-protection, or protection of others.

Fear-flight is an escape reaction that increases the distance from the threat to maintaining a specific flight distance. Physically, we observe the individual running in a straight line, easily misinterpreted as "fleeing in panic."

In contrast to increasing distance by fear-flight, *fear-fight* is an escape reaction within the 'defense distance.' The individual fights in self-defense to enable escape. There is no further fighting once free of the threat.

Anatomic Location

The initial fear reaction is cortical. With increasing proximity of the threat, fear migrates to the midbrain.

The distant threat within the "flight distance," whether temporal or spatial, increases activity in the ventromedial prefrontal cortex (vmPFC), a region important for decision-making in uncertain, risky, ambiguous, or context-dependent conditions. The vmPFC uses conceptual information about specific outcomes to shape affective responses, such as determining a specific response that is most adaptive given the particular situation (43). The vmPFC connects to the amygdala for the determination of the motivational importance or degree of the threat (26). The amygdala connects to the bed nucleus of the stria terminalis (BNST) to control a repertoire of behavioral defensive states (44, 45).

The additional proximal threat will switch activity from the vmPFC

to the phylogenetically older midbrain periaqueductal gray (PAG) nucleus. The PAG identifies an approaching or receding threat to switch the repertoire of behaviors to fast reflexive behaviors functionally (e.g., fight, flight, or freeze) (40, 44, 46). This continuous switching within the PAG is a blend of the bottom-up responses to threats before they come to our awareness and top-down cortical neuromodulation from the vmPFC and the anterior cingulate cortex.

When the threat becomes proximal, we can observe increased PAG activity. This forebrain-to-midbrain switch is anatomically credible in light of descending connections between the vmPFC/amygdala and PAG

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Problems

Cognitive behaviors directed toward self-protection are organized into offensive and defensive actions. *Offensive protections* include prompt attacks, surprise, concentrated actions, fast tempo, and audacity to stop the spread of the problem. This aggressive projection of force secures the initiative but is pathological when directed toward people. The aggressor uses blame, accusation, and personal attacks.

Defensive protections come about when demands clearly and subjectively exceed a person's capabilities, performance, security, or survival ability. Ad hoc emergency plans will focus on personal survival or the person's sense of safety. The person may withdraw or move to a place of psychological or physical safety (42) – not going near the source of the threat, which could be the leader, an administrator, or a colleague. Whether a leader, administrator, or line worker, the individual keeps a safe distance from the situation, which impairs their ability to identify correlations or causations. As a result, rationalizations, analogies, clichés, metaphors, and abstractions are used to support reasoning, plans, and actions. The person will deflect, excuse, justify, or use prophylactic self-blame. This individual does not help protect others because of the primary focus on reducing their risk.

Intimidation through proximity. Social distance maintains a safe 'flight distance' or creates a sense of control. Social interactions or close physical proximity of a threatening person elicits the same reactions as any threat. Favorable or unfavorable social distance is subjective, but the peripersonal (i.e., near body) space is not. This is measurable space, where intrusion by others elicits discomfort and is encoded in the visual receptive fields of the ventral intraparietal area (VIP) and a polysensory zone in the precentral gyrus. Responses are sensitive to nearby or approaching objects. The VIP connects to the amygdala, then to the PAG for defensive and aggressive behaviors (40, 47).

Intimidation by countenance. The amygdala rapidly recognizes and processes facial expressions for safety. The instrumental use of countenance to intimidate is widely used. Another form of intimidation is to stare at the individual after a request, either by the superior or subordinate. After discussing this with others, one of the authors (DvS) then asked how people responded. One director of nursing answered quite succinctly, "Simple. I'm a woman. I'm used to being stared at. I stare back." Further exploration found this to be an effective response for those who use it.

Fear fight-or-flight. The proximity of the threat drives fear-flight. *Fear-fight* develops during the fear process to enable escape (48). Because humans can separate the motor and affective components of emotion, fear-flight can appear as physically leaving. Fear-fight, the self-defense fight, is a fight to escape and more likely consists of pushing, shoving, and poorly aimed punches. For the affective component, the person appears to avoid, ignore, or distract, perhaps by asking for more information (49). Verbal maneuvers include denial of a problem, dismissiveness of the individual's concerns, or depreciation of disconfirming information. Statements such as "Why wasn't I informed" or "The problem is that you complained wrong" are common. Fear fight for self-defense starts within the defensive distance to help the individual escape.

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Because proximity drives fear, the individual with extreme unmodulated fear has a narrow perceptual focus toward the threat and operates with severely concrete thinking. Concomitant stress from uncertainty and feelings of uncontrollability (hopelessness) generates a cortisol HPA response taking the prefrontal cortex 'off-line,' impairing cognition. The reasoning is not practical. Physically, rather than running from the threat, the person escapes directly *toward* a safe place. There is no time horizon; only the fight focuses on escaping to run straight to a safe place. Once in safety, the affective and motor component is likely to cease.

Fear of decision-making. Fear can lead to more focused consideration for acting versus not acting and create a drive for more relevant information. In the red noise environment, however, more data and information will reduce variance, increasing possibilities. The situation will change, if not deteriorate while obtaining additional information. Avoiding decision-making becomes an inherent vice when it is instrumental for temporal distancing from threat, also discussed above as a method recommended by the OSS to sabotage factories. Reliance on "decision theory" for red noise environments is a form of distancing as the person creates structure (reduces novelty) and increases certainty.

When developing a new PICU, one of the authors (DvS) found resistance to making autonomous decisions from housestaff, nurses, and RCPs. In private discussions, all felt "the pit in their stomach." The author then queried veterans of major fires, riots, and military combat – all had that sensation during their first independent decision. This situation is like the first time an RCP or nurse decides to give a PRN medication without first check-

ing with someone. Physicians go through it. (See tonic immobility below.) The author decided to have staff make their first decision alone, which would be acted on without first reviewing it. However, "alone" meant alone in front of the author as a supporter. He had observed this from his fire captain, William J. Corr, who would ask individuals to give a plan, then he would act on that plan – startling those who had never experienced this approach. He always stood by, ready to comment to the individual if necessary.

One author (DvS) did this during a "low-risk" high-risk delivery, standing outside the delivery room as a hesitant intern received the newborn baby. Afterward, the intern released his anger for the abandonment, then calmed. The author explained he was outside watching and had confidence in the intern. After the episode, the intern began to engage in emergencies earlier with well-considered decisions.

To distinguish if the resistance came from lack of information or knowledge, undeveloped decision skills, or fear of decision-making, he would supply more information and decompose the problem into smaller elements. The decision did not matter at some point – now or in five minutes, 5 or 10.

Ron Stewart, MD, one of the first paramedic educators, trained paramedic students as if they were interns. "We didn't know how to train paramedics, so we trained them as interns" (personal communication and experience, DvS). He thought of sending emergency medicine residents to an EMS incident to model and support paramedic decision-making. He later remarked it was one of the worst decisions he made in EMS – the paramedics would wait for the resident to arrive, letting the resident make the decisions. The decision quality of paramedics had diminished.

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Removing decision-making from staff through comprehensive rules and protocols can decrease decision-making quality. Evaluation shifts from descriptive observation to identifying indicators for a specific rule or protocol. Staff lose cause-and-effect for the action and pay less attention to outcomes since they "did everything right." This is a defense used by executives, administrators, and line staff.

Ecology of fear. Stress and fear can shape an ecology of fear (50) through linkage "to mere thoughts" (51). Fear responses can be generated by the *absence* of a predator (50, 52). In this way, a threat causes more significant damage by its absence than by its presence.

Threat

Causes. Imminent danger and existential threat.

Function. Reflexive action arises from subcortical structures for immediate response to threats before identifying the threat. These unconscious yet objective *threat reflexes* include the well-known fight, flight, and freeze reflexes (39).

Threat-fight is a survival fight; the person engages intending to disable or overcome the threat. Because it is intentional, the individual retains awareness, changes actions and behaviors, and may not stop after the threat is over.

In contrast to situations where the individual physically engages the threat, *threat-flight* rapidly increases the distance between the organism and the threat. The individual is cognizant of events, using reasoned and manipulative offensive and defensive protections.

Attentive freeze is the cessation of movement accompanied by attentive or hypervigilant awareness, allowing the collection of information necessary for effective action. The body is tense and poised to act, and the mind is watchful. Freeze is the brake on fight-or-flight reactions allowing one to learn more, avoid a fight, or prevent any futile flight to failure. Freezing is associated with faster subsequent cue-signaled responses (53).

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Tonic immobility, from the parasympathetic nervous system, is the initial response in many prey species, often accompanied by the evacuation of body contents to mimic carrion. (Predators do not notice immobile objects, nor do they routinely consume rotting flesh.) The person is "frozen" and, despite having muscle tone, *cannot* move (differing from attentive freeze). Full of fear but, despite awareness, consciousness, and emotional arousal, the person cannot call out or respond to pain (27, 54).

Startle reflexes give reflexive protection by rapid body movements to regain balance, change posture to protect vital organs, then quickly become poised for action. A stumble, a quick movement, and a sudden, loud sound cause the reflexive stumble. The common startle action is flexing into the fetal position for protection during a fall [55] or suddenly attending to a "distraction," often with a distinct vocalization. Mentally, one assesses information for the stimulus's salience, meaning, and relevance (55-57). Through convergent evolution, the startle combined the gait and postural balance reflexes with the acoustic startle reflex to protect the soft abdominal organs.

Emotional memory develops from a single, emotionally charged incident, preparing the individual for a similar circumstance. Emotional memory is the only way to learn a life-saving behavior from a single lesson.

Anatomic Location

The amygdala, prefrontal cortex, and the midbrain

The amygdala detects threats and then activates the sympathetic-adrenal-medullary (SAM) axis and the hypothalamic-pituitary-adrenal (HPA) axis, orchestrating the stress, fear, and threat cascade responses in the brain and body (25, 58).

- Cognitive consequences – direct inhibition of the prefrontal cortex and the executive functions
- Endocrine consequences – cause secretion of corticotropin-releasing hormone (CRH) from the periventricular nucleus

of the hypothalamus, CRH releases adrenocorticotropic hormone (ACTH) from the pituitary, ACTH stimulates the secretion of glucocorticoids from the adrenal cortex

- Autonomic consequences – activate the brainstem, which activates the sympathetic nervous system throughout the body

The midbrain periaqueductal gray (PAG) nucleus processes the subjective representation of threat and the degree to which it is felt. The PAG also coordinates behaviors essential to survival, including threat reflexes, rapid changes to subcortical behaviors, and the startle posture corrections (45).

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The vagus nerve mediates many of the features of tonic immobility: bradycardia (slow heart rate), life-threatening arrhythmias, decrease in respiration, nausea and vomiting, urination, and defecation.

Problems

The affective components are unrecognized manifestations of threat reflexes:

- The fight becomes anger or frustration.
- Flight becomes avoidance and distraction.
- Mental freeze becomes confusion, inability to recall knowledge, or loss of working memory.
- Attentive freeze becomes immobility with intense attention, while the mental freeze is the inability to recall knowledge or use working memory
- Tonic immobility prevents physical movement despite awareness of surroundings, but milder presentations are intense aversion, gastric upset, or nausea.
- Startle reflex scream, an involuntary jerk or "start."
- Emotional memory is a severe response independent of and disproportional to the event.

"If you feel your eyes glaze over – slow down," William J. Corr, Capt, LAFD; US Navy veteran, WWII South Pacific

Threat fight-or-flight. Threat fight-or-flight occurs reflexively from a sudden, unexpected, and immediate threat that stimulates the amygdala and SAM survival behavior. The individual retains cognition. As Hediger [48] described, when an enemy enters the critical flight distance, an animal will attack with emergency characteristics beyond self-defense. This is from territoriality, meaning threat fight-or-flight can rapidly emerge from physical proximity and encroachment into a space considered "owned" by the individual, somewhat physical, intellectual, or academic.

The motor component of a threat-fight is the apparent drive for physical harm against the target. Threat-flight contains cognitive, evasive actions as the person maneuvers *away from* the threat.

The prevalence and pervasiveness of the relaxed affective threat-fight responses give the impression that anger is a normal, if not a necessary, behavior in an urgent or emergency environment. The immediate reactions observed by the use of the fear responses of anger and force, for example, reinforce the belief in their effectiveness. The observed effectiveness, however, is the immediate change toward homeostasis at best while impairing allostatic strengthening

Reactive or Instrumental Anger as Fear. One of the authors (DvS), on the surgery service, attended a trauma resuscitation during his first hospital rotation. The chief resident became angry with the team and consulting physicians; voices were raised. This was the author's first experience where professionals became angry during an emergency. Such behavior in a rescue or fire incident would have been quickly curtailed, and the member counseled. For the next 40 years, there has been no change in the presence of affective anger or the use of instrumental anger in healthcare.

The acceptance of anger is such that, when discussed, the initial arguments are to explain it. "Anger is not always a fear response; sometimes it is necessary." After his PICU fellowship, the author spoke with a program director. Upon hearing where the author trained, the director forcefully said, "We don't treat people like [the PICU director] does." Immediately he hung up the phone.

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The Scottish Highland paramedics invited one of the authors (DvS) to speak on decision-making. The lights came on during the presentation, and the group was told the lecture was over. Confused, the paramedics took the author outside and asked him to come to a paramedic station the next morning. Upon arrival, the paramedics told how the author was known overnight throughout the Highlands. When the author began discussing anger as a fear response, the medical director stood up and left the room, stopping the presentation. The medical director was known for frequent outbursts of affective anger and routine use of instrumental anger.

To convince staff of this, the author asks what they do when a superior is angry with them. They work harder. Shifting to anger as a fear reaction or threat reflex, they describe what they would do to reduce the fear. They quickly understand why they cannot reduce the superior's anger – working harder does not diminish the threat.

Misinterpretation of startle. A short yelp may accompany the startle reflex. Such vocalizations in the startle response may be

misinterpreted as "screaming in panic" when they are a singular involuntary reflexive response to regain posture, orient toward a threat, and prepare for voluntary movement.

The startle response, a reflexive behavior, combines the gait and postural balance reflexes with an acoustic startle to protect the soft abdominal organs.

The flexing into the fetal position, a reflex for protection during a fall or to protect soft, internal organs (59), has been misinterpreted as victims surrendering, giving up their chance to escape a threat.

Crossover Responses: Stress, Fear, and Threat

Fight and Flight in the Domains of Fear and Threat

Some people tend to show subtle signs of passive freeze during a crisis. In our experience, this does not predict a person's ability to perform. Instead, those individuals with a tendency to passively freeze are more likely to exhibit fear responses (anxiety), while those with less tendency to freeze are more likely to exhibit anger responses (fight). Discussing this with law enforcement officers and SOCOM operators, they also identified the individual who appears to have no signs of subtle, transient freezing. Anxiety has been associated with freeze and flight tendencies; aggression with reduced freeze but heightened fight tendencies (53). (Noted in the discussion about the freeze, below, we differentiate attentive/orienting freeze from passive freeze and tonic immobility.)

"Functional protective responses to a threat form a gradient – creating distance (escape) to disabling the threat (engagement). We can describe a functional flow for survival responses to a developing danger as apprehension leads to avoidance (flight) and engagement (self-defensive fight)."

Functional protective responses to a threat form a gradient – creating distance (escape) to disabling the threat (engagement). We can describe a functional flow for survival responses to a developing danger as apprehension leads to avoidance (flight) and engagement (self-defensive fight). The shift from contextual decision-making in the cortex (vmPFC) to reflexive decision-making in the more primitive midbrain (PAG) is parallel to increasing proximity. The threat becomes existential as proximity enters territoriality. The amygdala projects to the hypothalamus, midbrain, including the PAG, and lower brainstem for visceral support in the fight-or-flight response.

As a functional approach, the *fear reactions* (PAG) develop from distance-based assessments, while *threat reflexes* (amygdala) come from active danger. Both approaches contain emotional valence from the amygdala. The fight-or-flight of the *fear reactions* can appear to be the same as the fight or flight from *threat reflexes*. Depending on the anatomic site, the PAG functions shift to promote passive freezing, escape, or other active coping behaviors (45). Active coping strategies shift from moderate to the strong threat display, active to aggressive defense, and vigorous escape when the enemy is nearby. When escape from an enemy is impossible, passive coping strategies disengage from the environment, and behaviors shift to freezing, then with increasing proximity, moderate to strong immobility (60, 61).

We recommend a different level of analysis for the different systems (fear, threat) rather than different responses. Appreciating the functional distinctions between fear as escape and threat as attack reduces the response mismatch to the individual involved. Without this appreciation, we risk acceleration of the situation toward loss of control. Fight or flight as offensive and defensive fear responses or threat reflexes have different timelines, stimuli, and purposes. Fear-flight begins more slowly, mediated by the PAG, while the enemy is at a distance from the individual, initiating the movement to regain the "flight distance."

- *Fight-or-flight due to fear is an unengaged fear response.* By lacking neuromodulation, fear drives the individual to escape toward a safe zone, terminating the situation rapidly.
- *Fight-or-fight due to threat (anger)is an engaged threat reflex.* If the individual retains cognition, the person begins evasive actions and maneuvers away from the threat. Without neuromodulation, emotion dominates and drives the action toward what is causing the harm.

Fear Stress Anxiety

Some people are comfortable with novelty, and some are not. Novelty can trigger the HPA system to release cortisol. Decision-making under uncertainty occurs in the vmPFC. Uncertainty can trigger the HPA system to release cortisol. Events in flux can be uncontrollable, another releaser of cortisol from the HPA system. As an enemy comes closer, spatially or temporally, the origin of behaviors moves from the vmPFC to the PAG, where self-defensive behaviors begin to predominate. Cortisol, released due to novelty, uncertainty, or uncontrollability, begins to inhibit memory systems, drawing focus on learned behaviors rather than cognition. At some point, the threat becomes imperiling, and threat reflexes predominate. Cortisol release interferes with cognitive neuromodulating influence. Isolating the brain laterality, the HPA axis, and the SAM axis makes sense for research and developing models but misleads when attempting to understand and observe behaviors during an incident. Confounding factors include perceptions, experience, and social support, whether convergent, local, or from leaders. A vital trait factor influencing the manifestation of defensive reactions is anxiety. Those genetically predisposed to anxiety may show more freezing than those who are non-anxious (53).

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Agitation versus Aggression

A fundamental difference between *agitation* and *aggression* is intent and direction. Agitation consists of spontaneous, non-instrumental actions that may be triggered by, but are not necessarily directed at, external events. Hence, reducing external stimuli can reduce the degree of agitation. On the other hand, aggression has

intent, generally toward self-interest, and is instrumental toward manipulation or control.

Seemingly well-organized people, even leaders, may use instrumental aggression in response to frightening, uncontrollable events. Reducing external stimuli has less effect than engendering a sense of control. Some may respond to the person with faux obedience but more effective is to give the person an easily achieved objective.

"There is some consequence for not distinguishing between agitation and aggression. For example, an agitated person runs toward safety while an aggressive person runs from a threat. The agitated individual becomes increasingly disruptive, unpredictably causing damage while exhausting significant resources but not completely disrupting active, improvised plans."

There is some consequence for not distinguishing between agitation and aggression. For example, an agitated person runs *toward safety* while an aggressive person runs *from a threat*. The agitated individual becomes increasingly disruptive, unpredictably causing damage while exhausting significant resources but not completely disrupting active, improvised plans. The aggressive person engages in the threat or cogently escapes and evades. Aggressive individuals have intent and focus, harming targeted individuals and disrupting plans. Intentional aggression may appear reasonable, rational, and logical, making it insidious and more difficult to identify.

Cognitive Freeze, Attentive Freeze, Tonic Immobility

Information can have more than one meaning, and actions can have more than one effect, contributing to the hypervigilant freeze. This pause can be misinterpreted as denial, indecision, confusion, or waiting for leadership. With thousands of encounters in liminal states, the authors have become familiar with freeze reactions – the inability to think yet can act, the inability to act yet can think, and the inability to act and think. From the academic literature, we find our experiences described as cortisol-impaired cognition, attentive or passive freeze, and tonic immobility.

Cognitive Freeze. Excessive circulating levels of corticosteroids are associated with cognitive impairment and impair the acquisition and consolidation of information. Corticosteroids impair memory retrieval for working memory and declarative memory – the conscious or voluntary recollection of information. Declarative memory includes semantic memory for acquired knowledge, and episodic memory is the memory of experiences. Spared from corticosteroid impairment is procedural memory – the capacity to perform tasks (62).

As resuscitation began, one of the authors (DvS) needed an additional nurse. A nurse had just left an adjacent patient's room. In response to the author's request for assistance, the nurse described their patient's need for vital signs. The author asked if the nurse would mix a dopamine drip for infusion. The nurse brought the prepared infusion into the room, asking about beginning the infusion. Instead, the author asked the nurse for assistance with more pressing physical needs. Immediately, an effective, improvised team had formed, with the nurse demonstrating needed initiative. The author used physical activity to break the "cortisol freeze."

Attentive Freeze. Intimate discussions with those operating in dangerous contexts reveal the shared experience that feels like a freezing episode. Inquiry reveals that the individual had focused awareness and rapidly broke out of the freeze at the proper time. Invariably, they believe they have experienced fear and toxic immobility. They had experienced an attentive freeze.

Attentive freeze stops the excessive acceleration of the fight-or-flight responses to prepare the individual for an effective response to an uncertain situation. The PAG, vmPFC, anterior cingulate cortex, and amygdala facilitate the rapid shifting between attentive freezing and active defensive modes. Attentive freeze increases startle responses; alters perceptual sensitivity; facilitates processing coarse, rather than detailed, information; and accelerates subsequent cue-signaled responses.

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Tonic Immobility. Attentive freeze and tonic immobility responses appear similar to an observer but have distinct survival purposes. A person in the frozen state maintains attentiveness while remaining motionless, poised for action, whether to initiate fight or flight. A person in tonic immobility maintains awareness and will create memories during this phase but cannot respond to stimulation. Freeze is hypervigilant, attention poised to act. Tonic immobility is the alert, aware state during behavioral paralysis.

Tonic immobility, like freezing, is manifested by the absence of movement in response to severe threats. Importantly, however, while freezing can take place early in the defense cascade, tonic immobility occurs later when fight, flight, and freezing are not effective. In traffic accidents, a portion of victims will have experienced a small urine discharge from tonic immobility. Generally, bradycardia develops compared to tachycardia in attentive freeze. PAG is implicated in tonic immobility, the heart rate deceleration, and analgesia during freezing (53).

Without the behavioral component, tonic immobility appears as the feeling of nausea when faced with a difficult decision, the "pit of my stomach" feeling. For novices, nausea accompanies their first independent decision and, if not resolved, will inhibit future decision-making. The individual does not necessarily become

trapped in tonic immobility. Kozlowska et al. (27) described actions a Second World War Flying Officer would take when training pilots: he used a "firm voice devoid of fear to issue simple orders that the men had already learned and that was automatic: 'flaps,' 'raise the stick,' 'rudder.'

Vasovagal Syncope. The "common faint" occurs in an emotional context when the vagus nerve rapidly decreases blood pressure (63). Complete loss of consciousness distinguishes vasovagal syncope from tonic immobility, where the person remains fully aware. Vasovagal syncope could, like tonic immobility, be an adaptation to mimic death (64) or as a response to the sight of blood, injury, or injection. Syncope from seeing one's blood may have adaptive value in reducing blood loss by rapidly decreasing blood pressure through vagus nerve activation (65).

"Threat reflexes rapidly initiate protective behaviors. Modulating these behaviors brings the individual safely within the operational distance of a threat. Organizations that routinely operate in dangerous contexts recognize the utility of stress, fear, and threat while taking measures against their inherent vice."

Conclusion

We too readily view stress, fear, and threat behaviors as unfavorable – indicators of poor performance if not a disease. Human stress, fear, and threat responses drive safe and effective engagement of environmental threats. High-Reliability Organizations must engage in threats and adversity to maintain reliable operations. During a crisis, the hypothalamic-pituitary-adrenal (HPA) axis enables survival behaviors by releasing cortisol to "disarm" the executive functions. Novelty, uncertainty, and uncontrollability, in the domain of the executive functions, cause stress responses. Fear reactions at the subcortical level maintain a safe distance from the threat. Threat reflexes rapidly initiate protective behaviors. Modulating these behaviors brings the individual safely within the operational distance of a threat. Organizations that routinely operate in dangerous contexts recognize the utility of stress, fear, and threat while taking measures against their inherent vice.

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