

Pragmatic High-Reliability Organizations (HRO) Modulate the Functions of Stress and Fear Behaviors During Pandemic COVID-19: The Stress-Fear-Threat Cascade

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moving within the trajectory of events.

Abstract

Stress and fear have biological functions that, when neuromodulated, make adaptive otherwise maladaptive responses. While the concept of a defensive cascade supports cognitive understanding and hypothesis testing, approaching this domain by function using an ecological approach brings the pragmatic stance with methods for prevention and intervention. Stress, fear, and threat have distinct functions to, respectively, constrain cognition, induce cognitive focus, and reflexively respond when in danger. We differentiate reference frames between a fixed-point reference frame that distinguishes the event (stimulus) from the person (responder and response) and an experiential reference frame within cascading events. Unrecognized, the characteristics and actions of an HRO bring modulation to the defense cascade, check the effects of stress, interrupt cascading fear reactions, and abridge threat reflexes.

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Introduction

Stress and fear have biological functions. Stress and fear behavioral responses are integrated collectives of motor and emotive behaviors occurring reflexively, modulated, or used intentionally. When modulated, these behaviors initiate engagement and drive enactment. When entirely reflexive, though, they become destructive to individuals, the system, and the organization. An HRO incorporates stress and fear behaviors into its adaptive response to the unexpected. To better understand how this occurs, we look at stress, fear, and threat from an operational frame of reference supported by science. In this paper, "stress, fear, and threat" refer to stimuli that initiate the defensive cascade, which we differentiate into the functional elements "stress response, fear reactions, and threat reflexes." Further, rather than use a fixed-point reference frame that more easily distinguishes the event (stimulus) from the person (responder and response), the reference frame we use lies within the cascading experiences of the individual

Stress and fear *behaviors* come in suites that contribute to individual temperament and ensembles used when needed. Stress and fear impair information flow, cognition, social interaction and increase staff attrition. These ever-present behavioral suites and ensembles reflect how we will act in a crisis and have unrecognized influences on safety and reliability. Pragmatic HROs have embedded within their characteristics an effective means to diminish these effects. The appearance of maladaptive behavioral suites and ensembles during routine operations are harbingers of failed operations during crises.

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The NICU exists to extend medical care and supportive human contact into an environment of potential or imminent death and dreams on hold. We expect stress, fear, and a threat to life. Humans evolved to survive such environments. But without neuro-modulation, the debilitating effects from stress, fear, and threat become destructive, impair medical care, and drive good people from the field. Understanding the *functions* of stress, fear, and threats and how they appear in the NICU leads to effective means of preventing or modulating maladaptive responses. Understanding how HROs originated in similar environments can lead to effective use of HRO characteristics. Staff then gain meaning from their efforts to help those who cannot help themselves.

Pandemic COVID-19 disrupted healthcare at multiple levels of organization in healthcare, society, and government. Unrecognized were the protean characteristics of HRO that ensure performance at diverse levels of operations, from NICU professionals coalescing around a mother and infant to systems and organizations unaccustomed to jointly working together. During the 1991 eruption of Mt. Pinatubo, the Philippines, ash from the minor initial eruption blew nearby Clark Air Base, and 13,000 personnel were evacuated to the US Naval Facility at Subic Bay. The second, main eruption occurred as winds from a tropical storm blew heavy, wet ash onto Subic Bay, precluding the air evacuation of personnel. HRO characteristics informed the entire response of the US Navy, US

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Air Force, and US Government aid and support to the Philippine people (van Stralen and Mercer 2015). HRO is a powerful method for performance across and within diverse levels of the organization against abrupt overwhelming demands.

Abrupt threats in environments of sufficient magnitude to cause death may require resetting or changing learned behaviors in the moment, if not start over (Doya 2008). Vertebrates have numerous methods for surviving hostile environments, behavior being the most immediately adaptive (Tinbergen 1963). Behaviors come in suites coordinated for various purposes (Fristrup 2001, 20-21; Sih et al. 2004). These suites of behaviors, combining actions and non-actions, create sustained, coordinated defensive responses for survival. The primary defensive and survival functions are 1) reflexive, subcortical actions, 2) hindering memory systems to limit cognition, and 3) volitional behaviors directed toward self-preservation.

“Inhibiting memory recall in select memory systems, enhancing memory recall for habit and learned behaviors, and selected memory formation supports forming threat reflexes into learned behaviors.”

Reflexive action arises from subcortical structures for immediate response to threats before clearly identifying the threat. These unconscious yet objective *threat reflexes* include the well-known fight, flight, and freeze reflexes (LeDoux 2014; LeDoux and Pine 2016). Inhibiting memory recall in select memory systems, enhancing memory recall for habit and learned behaviors, and selected memory formation supports forming threat reflexes into learned behaviors. Cortisol release during the *stress response*, through the hypothalamic-pituitary-adrenal axis, accomplishes this. Cognitive behaviors directed toward self-protection are organized into offensive and defensive actions. The immediacy and focus of actions and intense feelings identify these conscious yet subjective *fear reactions* (LeDoux 2014; LeDoux and Pine 2016).

Lost in systems and organization thinking is the individual faced with an abrupt threat who experiences natural and expected stress, fear, and threat. In these situations, the individual responds *as an individual* to immediate, local problems relying solely on personal experience. By the time a person asks or calls for assistance or help, actions have already happened. The effects of stress, fear, and threat displace the best plans and systems for support. Individuals at all levels of the organization's hierarchy experience these same effects, which have become incorporated into the culture as expected, if not accepted, behaviors. The ordinary presence of these unrecognized behaviors as stress, fear, and threat behaviors, burdens efforts to achieve safety and reliability (van Stralen, Byrum, and Inozu 2017, 285-7). Unrecognized stress then becomes group stress with loss of individual and organization capability.

The neonatologist can lead staff and the organization through this environment by accepting these behaviors as the expected neurologic response, but one that can be neuromodulated. The physician can recognize these behaviors in patients, staff, colleagues, and senior leaders then support modulating these maladaptive responses for the direct result of increased capability and performance. The use of these characteristics brings adaptability to individual and organization performance *during* unpredictable cir-

cumstances.

In this article, we will describe how pragmatic HRO contains elements to withstand stress, fear, and threat; how we can understand the behavioral responses as conserved defensive and survival behaviors; the adaptive function of stress responses, fear reactions, and threat reflexes; and the specific cases of dissociation, agitation, and posttraumatic stress.

Pragmatic HRO and Stress

HRO emerged from the synthesis of aerial combat decision making, the professionalism of nuclear propulsion crews, and emphasis on aviation operational safety techniques during wartime (van Stralen et al. 2020a). Safety is intrinsic to and inseparable from operations. Safety is not a distinct element, hence the phrase "safety through operations and operations through safety."

The pragmatic stance for HRO is the leadership (van Stralen et al. 2020a and 2020b) necessary to bridge the gap between theory and practice (Zundel and Kokkalis 2010) and discrete concepts and continuous perceptions (Weick 2011), leverages error (van Stralen and Gambino 2020), and informs straightforward decision making for novel medical threats (Eisenberg, Lysouvakon, and Hageman 2020). Perhaps the greatest strength HRO brings to individuals and the organization is the increased capabilities and stress capacity against an abrupt, overwhelming threat. The HRO approach to such incidents also serves for ordinary difficulties, bringing routine situations into the program as impromptu "training" missions. During the Cold War, Soviet threats would approach the USS Carl Vinson. One of the authors (TAM) broke the tension for crew members with the observation, "Remove the 'h' from threat and it becomes a treat;" a "treat" being a real-time training opportunity.

Instrumental for effective implementation and maintenance of high reliability is the leader's actions to modulate stress and fear (van Stralen et al. 2020a) and develop the stress capacity of subordinates (van Stralen et al. 2020b). In these circumstances, maladaptive responses to stress, fear, and threat are deadly and contribute to mission failure.

Authority from a fixed frame of reference outside of the incident follows events as a continuum. Observation at a fixed point detects the emergence of nonlinear patterns and coherent structures not visible locally. Leadership from this fixed point outside of events provides dispassionate direction and support. It might make sense, then, that strong central authority transferred to more experienced leaders would reduce maladaptive responses from stress or fear. This form of directive leadership, however, decreases organizational performance even in routine operations (Pearce and Sims 2002). The environment of a strong central authority can create "mindguards" who protect the leader from disconfirming information (Janis 1989, 279), decreases information flow and cooperation (Westrum 2004), supports simplistic perceptions and decisions by leaders (Tetlock 1979), and can become preoccupied with error and compliance as failure signals (van Stralen and Gambino 2020). Rather than reluctant to simplify, the organization prompts simplification. Subordinates begin to simplify for self-protection.

Stress from decision making under centralized authority, a fixed frame of reference, readily leads to maladaptive decision behaviors. Irving Janis (1989, 78-9) described how simple cognitive or emotive rules develop into four identifiable patterns of decision making. With a low level of emotional demand, the individual will depreciate weak signals and not change course, *unconflicted inertia*, or change course by following simple decision rules, *unconflicted change*. If emotional stress becomes intense, the individual escapes by avoiding or ignoring the problem, *defensive*

avoidance, or impulsively takes any option that appears better, *hypervigilance*. While more common to see these patterns of stress and fear in lower echelons, they also occur in "leaders of governments, major business corporations, and other large organizations" (Janis 1989, 3-4). Authority migration and information flow during routine operations in the HRO reduce stress while preparing individuals for consequential decisions, lowering the incidence of these maladaptive decision patterns.

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Authority from a moving reference frame, on the other hand, follows the trajectory of events as local influences, the flux of circumstances, and emergent properties continuously alter the situation. Local leaders then develop as the situation evolves. These emergent leaders are just as likely to be the person with less experience, though with less training and experience actively working under stress, fear, and threat.

In the NICU, neonatologists engage with a flux of contingencies in an effort to treat infants for their illnesses while simultaneously supporting the continued growth and development of the infant. These efforts sometimes succeed, sometimes fail, and most often, they do both. That mixing, along with abrupt changes by happenstance, can threaten the reliable performance of caregivers and the functioning of the NICU through effects on neurological stress and fear systems. Early researchers of HRO focused on the flight deck and "experiences of *not failing*" ("error-free") and somewhat missed "the experiences of failing" (van Stralen 2020), the leader's role in modulating stress and fear (van Stralen et al. 2020a), and how stress capacity strengthens performance through allostatic change (van Stralen et al. 2020b).

These unrecognized HRO traits, however, create some of the commonly known HRO characteristics. Trust from the reciprocity of mutual influence, an element of pragmatic leadership (van Stralen et al. 2020b) and leadership *in extremis* (Baran and Scott 2010; Campbell, Hannah, and Matthews 2010; Dixon et al. 2017), drives *deference to expertise* and contributes to *resilience* through reward processing in the brain (Charney 2003). Leaders *sensitive to local operations* will engender *resilience* by supporting staff during abrupt, error-prone changes (van Stralen and Gambino 2020) and providing the necessary psychological stability to leverage error for learning and effective error management. Staff, then, become more inclined to engage subtle disruptions and discrepancies, an early form of *preoccupation with failure*. HRO researchers have not recognized the incorporation of stress capacity within the construct of HRO; a characteristic lost in the borrowing of HRO by other organizations.

Conserved Stress and Fear Behaviors

The existential threat a person experiences from the mismatch between aspirations and the environment occurs with every ad-

mission of a newborn infant to the NICU, the mismatch of hopes and dreams against the abrupt reality of a critically ill infant. In addition, the abrupt change brought to a family due to premature birth or an ill neonate now interacts with the larger abrupt public health and societal changes due to COVID-19. This existential mismatch precipitates cascading effects in the neurologic stress, fear, and threat systems for everyone involved.

This is not to decontextualize stress, fear, or threat, nor lose the sense of proportion between the death of one's newborn child and the abrupt responsibility a neonatologist assumes when providing care. When not neuromodulated, stress, fear, and threat systems respond to a wide spectrum of stimuli yet have a narrow suite of behavioral responses. Because of their essential survival function, these emergency behavioral responses remain little changed across mammalian species, though conserved within phylogenetic constraints (Katz 2011).

Behaviors have another reason for being conserved. Even when controlled as behaviors, motor patterns are conserved across species (Wainwright and Friel 2001) through conservation of gene function at various levels, from molecular pathways to structure, behavior, and function (Reaume and Sokolowski 2011). Neuronal pathways within the central nervous system are multifunctional; therefore, pathways for an expendable function also serve other adaptive functions (Kavanau 1990). Therefore, behaviors may be conserved to maintain system coherence, constraining complete loss of behavioral traits (Ghyssen 2003; Katz 2009). Of significance, the amygdala, in the highly conserved corticolimbic circuit for stress responsiveness, has conserved a stress-related increase in amygdala-centered structural synchrony paralleled by a decrease in global structural synchrony (Nikolova et al. 2018).

Consequently, survival and defensive behaviors observed in mammals, particularly prey species, can be observed in humans, though in a relaxed form. *Relaxed selection* occurs when an environmental demand or threat is removed, relaxing selection pressure, and altering the original suites of behavior (Lahti et al. 2009). This is similar to animal domestication that introduced domesticated traits unsuitable for survival in the wild condition (Post 1971).

If we understand stress, fear, and threat as suites of behaviors, part of a person's response to the environment, we can understand the logic in their grouping and how they derive from, and form, a person's temperament. Temperament, as the affective, motivational, and attentional core of a person, represents a person's reactivity (excitability, responsivity, and arousability) and self-regulation (Rothbart and Derryberry 1981; Rothbart and Bates 2007). The limbic system, particularly the amygdala and hypothalamus, regulates these perception-based habits and skills (Cloninger 1994), forming a relationship between behavior patterns from temperament with the environment through perceptual influence and adaptiveness to the situation, further defining temperament (Réale et al. 2007). Temperament, as a tendency or disposition, is situational, the behaviors expressed in response to specific eliciting conditions cognition (Rothbart and Bates 2007).

A *suite of behaviors* is not simply a grouping of behaviors that often appear together but part of a collective within the "executive functions" (Sih et al. 2004). The suite is an integrated set of behavior patterns (Schwenk 2001; Réale et al. 2007), functionally coordinated (Fristrup 2001) to engage some phylogenetic problem (Wainwright and Friel 2001) that stabilizes selection pressures on the organism and population (Schwenk 2001). A suite, therefore, can be treated as a single property (Fristrup 2001), an outcome of the temperament traits operationally defined and ecologically valid (Réale et al. 2007), moving with the organism independent of the environment (Schwenk 2001), individually consistent across multiple contexts (Sih et al. 2004).

Unlike a suite of behaviors, an *ensemble of behaviors* is learned and is selectively activated by specific threat cues. The ensemble functions *for the individual*. The behaviors in an ensemble are considered only in relation to the whole, unlike a suite of behaviors where behaviors are considered as a single property with an ecological function. An ensemble of behaviors serves a social and cultural function (Braica 2014) by maintaining continuity and ongoing social interaction by evoking social support and validating responses from others in ongoing social interaction (Caspi, Bem, and Elder 1989). The social characteristics of an ensemble not only characterize a culture but give some internal coherence to the culture (Braica 2014).

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Viewing stress, fear, and threat responses as conserved behaviors allow us to discuss maladaptive behaviors as more than random or stereotypical actions or a mark of weakness. We are all susceptible to triggered responses, but we also have the ability to neuromodulate the cascading responses. Suites of behaviors explain the similarity of maladaptive patterns. They can help us differentiate the effects of demands that release cortisol to impede memory recall and working memory, the fear that drives conscious self-protection, and threat reflexes that, though not preventable, need not be sustained.

A person may have learned behavioral ensembles in supportive or malignant social environments. The individual may instrumentally use emotion where emotion is not the end in itself but has some other purpose or end, is a means for solving problems, assists in obtaining an objective, for example, instrumental anger (Pascual-Leone et al. 2013). Other individuals gain a feeling of security through provocative statements or actions. In this way, they gain a sense of control over events by forcing others to respond, thus manipulating the social environment similar to Internet trolls.

Neuromodulatory inputs produce adaptive, flexible patterns of activity (Reaume and Sokolowski 2011). In other words, the protective threat reflexes evolved in mammals to fight to the death in the wild can be modulated by humans in the NICU. It is the degree of modulation that makes the difference between enhancement of actions, maladaptive behaviors, mental illness, or criminal activity. The neonatologist can model and support adaptive responses to stress, fear, and threat.

The function of stress and fear

Scientific and lay literature describe stress, fear, and threat in terms of stimulus, response, and purpose. The defense cascade becomes a sequence of mental, emotional, and behavioral responses triggered by a stressor or threat (Kozłowska et al. 2015) that are maladaptive because of negative consequences.

This runs into the problem Niko Tinbergen (1963) identified with animal behavior, we do not notice the behavior until it happens, and we don’t know the mind of the individual. Unknown are the antecedents and cognitive-affective processes. In addition, humans can neuromodulate behaviors, complicating conclusions. We can, however, discuss the *function* of behaviors, described by Niko Tinbergen (1963) as achievements, to better understand the defensive cascade that protects the organism.

Our frame of reference starts with behaviors during the initial alarm, emergent team formation and emergent leadership, following these behaviors as suites and ensembles through the changing trajectory of events. Ours is a functional view of stress, fear, and threat – what do they achieve?

Stress and abrupt threat initiate behavioral and nonbehavioral responses through the three conserved defensive brain systems: The Hypothalamic-Pituitary-Adrenal System (HPA), the Sympathetic Nervous System (SNS), and the Limbic System. Each system, though, is conserved to different degrees with different contributions to behavioral suites and ensembles. For conceptual purposes, researchers and clinicians may assign orders of magnitude to the stimulus and response while assigning a temporal order to responses. We find “in vivo,” little linkage between the magnitude of stimulus and response, and no temporal order or progression in the defense cascade.

The cause-and-effect has a different meaning from an outside point of reference than within the trajectory. From a fixed reference point, an event is an arbitrary point in the flow of events; *the observable is the effect*. You look backward in time, seeking the cause. From within the trajectory, behaviors are a process, and *the observable is the cause*. You trace the ever-changing effects forward in time. The latter approach, described by Tinbergen (1963), helps identify if the observed process promotes better achievement and survival. The difficulty of finding a cause for an observable effect led Tinbergen to think of the function, or achievement, of behavior. That is, observe an effect, then identify the function.

The ultimate *value* of behavior is this adaptive function, while the immediate *cause* of a behavior is how it is constructed from the animal’s physiological mechanisms (Tinbergen 1963). Adaptive function defines suites and categories of behaviors, while causation deals with genetics, hormonal, and neurological processes. Though function and causation operate on different levels of analysis, they are not mutually exclusive alternatives for descriptions. This allows reciprocity between ultimate functional causes and mechanistic proximal causes in either domain (MacDougall-Shackleton 2011).

Organizing stress responses and the defensive cascade as functions comes from experiencing and witnessing that moment of existential threat when security is lost (van Stralen et al. 2017). Academicians use cognitive processes, scientific logic, and tightly coupled concepts, coherent and congruent with other concepts (van Stralen 2020). Consequently, concepts cannot overlap, have gaps, but must have congruence with existing concepts and have intellectual coherence. Conceptual clarity then comes at the expense of utility and, ultimately, relevance. While a linear progression of states makes sense, this internal logic falls apart when an individual with a unique biography faces exigencies and happenstance, perceptions change, and local social interactions help, hinder, and harm. The systems of stress, fear, and threat have *functions* to achieve defense and survival. We distinguish the de-

fensive and survival functions as 1) reflexive actions, 2) limited cognition, and 3) self-preservation.

The Mechanisms of Stress, Fear, and Threat

We can connect the three functions to the three accepted processes: subcortical reflexive actions are the threat reflexes, cortisol-limited cognition is the stress response, and cognitive self-preservation is the fear reactions. Reflexive actions, immediate subcortical responses before identifying the threat, include the well-known *threat reflexes* fight, flight, and freeze (LeDoux 2014; LeDoux and Daniel 2016). Limited cognition, from cortisol release during the *stress response*, brings behavioral focus to the threat, supporting protective actions by inhibiting memory recall in select systems and enhancing memory recall for habits and learned behaviors. Self-preservation, cognitive offensive, and defensive actions directed toward self-protection give the immediacy and focus of our *fear reactions* (LeDoux 2014; LeDoux and Daniel 2016).

The three systems of stress, fear, and threat increase survival in different ways:

- *Stress systems*, through cortisol, inhibit memory recall except for procedural, or habit, memory. The organism will quickly use learned behaviors without loss of time thinking and developing plans or actions.
- *Fear systems* on the cortical surface drive defensive or offensive actions, dependent on the distance from the threat.
- *Threat reflexes*, below the level of the cortex, rapidly drive behaviors directed at the immediate threat.

Stress responses (memory), fear reactions (cortical), and threat reflexes (subcortical) are repertoires of behaviors for self-preservation. They innately form suites of behaviors, but as learned responses, they become behavioral ensembles; for example, a person may use distraction when under threat or instrumental anger to exert control. We follow the convention that fear is a subjective, cortical feeling and emotions are the labeling of the state of arousal. We also recognize the uncoupling of the motor and emotive components of the stress, fear, and threat responses. For example, the emotive component of the fight reflex is anger, while the flight reflex has an emotive component, plausible avoidance, and a motor component, moving to safety. The movement toward safety and movement away from threats have different characteristics. As a threat reflex, moving toward safety is rapid and direct, focused away from the threat. People running from an active shooting in that manner may be mistakenly described as running in panic. Running from a threat is more fear-based as the individual will monitor the threat and adjust movement accordingly. The first is a subcortical reflex; the second is cognitive.

The *cortisol stress system* is triggered by *uncontrollable* stress. This is a critical distinction. Research to understand stress requires removing the sense of controllability from the subject. Uncontrollable stress releases cortisol to produce *stress responses*, generally related to failed memory recall. The primary memory systems affected are declarative memory for what is learned, episodic memory of experiences, and working memory for active problem-solving. Procedural memory – habits may be enhanced, allowing the person to continue acting with practiced behaviors. Even minor stress will impair the executive functions (Arnsten 2009).

Stress impairs working memory, and the ability to regulate thought, behavior, emotion, and flexibility of attention:

- Choke (expectations, being observed)
- Impaired memory recall/enhanced procedural memory
- Loss of abstract thought when prefrontal cortex and executive functions are impaired

- Concrete thinking and reasoning due to loss of abstract abilities (amygdala impairs cortex)
- Rules are abstractions, therefore difficult to recall and use
- Failure of cognitive strategies: *Even quite mild acute uncontrollable stress can cause a rapid and dramatic loss of prefrontal cognitive abilities.* Amy F.T. Arnsten (2009).

Fear reactions are conscious sensations experienced when exposed to an imminent threat (Panksepp et al. 2011; Ledoux and Pine 2016). The amygdala sends signals to the unconscious (subcortical) and conscious (prefrontal cortex) regions of the brain, accounting for the uncontrolled fear responses and the feeling of fear. The emotional response of fear, preceded by a threat to self-preservation, is to diminish danger (Oatley & Johnson-Laird 2014). This creates the drive to avoid or escape, generally focusing on self-interest, self-protection, or the protection of others. We can regulate feelings of fear by reappraising the situation or suppressing behaviors (Ochsner and Gross 2008; Heilman et al. 2010; Cutuli 2014; and Gross 2014).

Actions for *offensive protection*, often developed from a developed plan, take the individual into a prompt attack to stop the spread of the problem. The aggressive projection of force secures the initiative but becomes pathological when directed at people. Individuals use surprise, concentrated actions, fast tempo, and audacity. The person will use blame, accusation, and personal attacks.

Actions for *defensive protection* focus on the individual's safety, often with the person moving to a place of psychological or physical safety (Oatley & Johnson-Laird 2014). Any ad hoc emergency plan is singularly focused on personal survival or a sense of safety. The person enters this defensive mode when demands *clearly* exceed capabilities, and risks become too great for the person to feel they can continue or survive. The person will not go near the problem, the source of the threat, which could be the leader, an administrator, or a colleague. Rationalizations and abstractions (for example, clichés and metaphors) support actions since the individual has not approached the situation sufficiently close to identifying correlations or causations. This individual is less useful to protect others because the focus is primarily to reduce risk to themselves. The person will deflect, excuse, justify, or use prophylactic self-blame.

Threat reflexes (subcortical) are commonly referred to as "fear responses," fight, flight, and freeze. We categorize them as "threat reflexes" to differentiate fear from the actual threat and to underscore the uncontrollable appearance of the reflex. The well-known fear responses, fight, flight, and freeze, are more properly neurological threat reflexes mediated through the amygdala. Threat responses are behaviors for survival against adversity or in a hostile environment. Perceptions of threat trigger the reflexes which operate below the level of consciousness (LeDoux 2014).

- A fight engages with the intention of overcoming the threat.
- Flight rapidly increases the distance between the organism and the threat.
- Freeze is attentive or hypervigilant awareness with the cessation of movement. This allows the collection of information necessary for effective action.
- Tonic immobility from the parasympathetic nervous system, the initial response in many prey species, is often accompanied by the evacuation of body contents to mimic carrion. (Immobility does not bring attention to prey, and rotting flesh, containing high levels of pathogens, is not routinely consumed by predators.)

The emotive components are unrecognized manifestations of

System	Dissociation	Tonic Immobility
Response	Cognitive	Behavioral
Defense cascade	Outside	Within
Awareness	Lost	Intense
Emotion	Hypo-aroused	High arousal
Muscle tone	Immobile Flaccidity	Muscle stiffening No flaccidity or collapse
Memory	Fragmented, disorganized, distorted	Intact, even detailed

threat reflexes:

- The fight is anger or frustration.
- The flight is avoidance and distraction.
- Freeze is confusion; mental freeze is the inability to recall knowledge or use working memory.
- Tonic immobility is an upset stomach under pressure that prevents the decisions.

Freeze is hypervigilant attention poised to act. Tonic immobility is the alert aware state during behavioral paralysis.

The startle response, also a reflexive behavior, combines the balance reflex with an acoustic startle to protect the soft abdominal organs. A short yelp may accompany the reflex.

Dissociation, Agitation, and Post-Traumatic Stress

Two psychological states frequently encountered during abrupt challenges are peritraumatic dissociation (dissociation in this paper) and agitation, neither of which fit cleanly into functional or anatomic systems.

Dissociation is a loss of cognition, emotional numbing, and muscle flaccidity occurring when the experience is overwhelming, con-

tains intolerable realities, or causes intense emotions, though it can occur in situations that objectively appear innocuous (Frewen and Lanius 2006; Lanius, Paulsen, and Corrigan 2014). This is also our experience; we have observed momentary inactivity with a vacant expression in public safety officers, physicians, surgeons, residents, nurses, respiratory care, families, etc. Dissociation is a psychological process of fragmented awareness with a spectrum of responses from depersonalization, derealization, and amnesia (Schauer and Elbert 2010; Bovine, Ratchford, and Marx 2014). Emotional numbing or detachment reduced awareness, and distortions of reality, even "out-of-body" experience, may offer protection in situations that they would otherwise be unable to cope.

Tonic immobility develops due to the extreme nature of the threat in close physical proximity, almost direct physical contact. The "prey" appears dead, becoming immobile, and may involuntarily expel body contents (gastric, rectal, or bladder) to mimic rotting carrion. Despite maintaining muscle tone, the person is unable to move (described as "waxy" immobility) or call out, scream, or respond to pain. The person is emotionally aroused and full of fear yet maintains full awareness and consciousness with the ability to recall details of the incident (Abrams et al. 2009; Kozłowska et al. 2015).

For some individuals, it may be the first line of response to trauma because of threat proximity, previous experience, or individual differences (Kozłowska et al. 2015). Within the defense cascade,

System	Agitation	Aggression
Intent	Unintentional	Intentional, self-interest May have criminal intent
Instrumentality	None	Control Manipulation, Instrumental aggression.
Behaviors	Vigorous, irregular	Appears rational yet dismisses contextual information
Direction	No target Undirected <i>Directed</i> behaviors appear aggressive, but actions from psychological pain (PTSD)	Targeted individual or object
Affect	Anxiety	Dire consequences of any action
External stimuli	Hyper-responsive May or may not be aware of surroundings, people, or actions	No effect

the function of tonic immobility is to create intact memories of the event in order to later recognize potential predators. Tonic immobility also has a range of presentations, the more common, mild form, in our experience, appears during the first decision a person makes for others, gastric upset forms, and the individual then avoids the decision or continues onward. Either can become a part of their ensemble of behaviors.

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 to *safety* while an aggressive person runs *from a threat*. The agitated individual becomes increasingly disruptive, unpredictably causing damage while exhausting important resources but not completely disrupting active, improvised plans. The aggressive person engages the threat or cogently escapes and evades. The aggressive individual has 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.

Emotional memory and Post-Traumatic Stress

We learn to identify life-threat from a single experience because the amygdala links memory to emotions causing reflexive emotional, visceral, and behavioral responses to threat. Ecologists have also identified the effects of traumatic stress in wild animals as similar to posttraumatic stress in humans (Boonstra 2013). Because the neural circuitry to identify subtle danger is adaptive, it is conserved in animals through predator-prey interactions.

Everyone has memories of some emotionally charged experience, which is a product of life in general, but those who consistently work in a high-risk environment may develop sensitivity to the environment for these cues. A benign but similar cue may elicit a response to a past danger. That is, *the trigger is from the past, but the response is in the present*.

Conclusion: Regulated threat reflexes

The common occurrence of maladaptive responses to stress, fear, and threat, have a greater influence on safety and reliability than the more commonly appreciated problems we encounter in healthcare. In the intensive care environment, we must appreciate and accept the prevalence of stress, fear, and a threat to human executive functions and cognitive processes. In effect, we may best achieve safety through individual capability and stress capacity.

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