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Identifying Gaps – Entering the Path to High-Reliability Organizing (HRO)

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Abstract

The human brain evolved to act against consequences, yet decision-making models rely on information processing. Crises occur in volatile environments, yet organizations rely on plans and planning. The gap between fluctuating events and static concepts and models creates inconsistencies that are solved under pressure at the local level. We identify the more consequential gaps, describing their origins and structure. Some gaps are readily bridged, but some present existential danger, such as between identity or beliefs and the environment.

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Introduction

Computer programmers and digital engineers appreciate 10 kinds of people: those who understand binary and those who do not. For this article, we draw three insights from this joke: 1) people tend to divide and classify, 2) some people do not see the divide, and 3) people often do not understand the other side. We create gaps when we do not bridge divides. Rather than criticize the gaps that endanger people or the organization, we suggest the use of engagement to bridge such gaps. This article describes the gap between cognition and behavior, the types of gaps between the stable and unstable environment, and consequential gaps identified in the academic literature. In subsequent articles, we will discuss the priority of consequences and the function of engagement followed by the human performance in these situations.

Does a gap exist between the brain's ability to process perceptions and information (cognition) and the brain's ability to develop adaptive and survival actions (behavior)? *Time* enhances processing but impairs survival. Perhaps the gap is fictitious or synthesized, a product of how we understand the brain's adaptive functions.

The brain perceives the world, forming its perceptions into a mental model or representation of the world, then subsequently processes new information to find the truth. This firmly held belief of the brain as an analytical computer follows the development of computers for analysis and decision-making, initially proposed by Allen Newell and Herbert Simon (1). Cognition became a mechanical behavior, and computers became models of human thought (2, 3).

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The human brain did not evolve a new brain region for abstract thought or information processing. Instead, evolution builds on existing characteristics that are inheritable. Evolution also conserves inheritable characteristics. All cognitive activity has been built on pre-existing brain structures.

Environmental responsiveness is such an inheritable characteristic. Our cognitive processes can influence what we respond to and how we respond. However, alertness and vigilance circuits are shared by fish and mammals (4), while the correlated *behaviors* of environmental responsiveness (boldness and aggressiveness) are widespread in the animal kingdom, structuring the animal personality kingdom (5, 6) The animal personality characteristics of alertness, vigilance circuits, and environmental responsiveness are inheritable.

The brain has developed to respond to the environment with heritable behavioral traits for alertness, vigilance, and responsiveness to the environment. The brain learns how to "approach or avoid an object, to navigate to feeding sites, and to move among obstacles (some of which might themselves be in motion) (7). The brain "goes into the world," interpreting and understanding the world by taking actions to learn about objects rather than the mind becoming constructed from a blank slate (3).

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The function of the brain is to understand the environment by acting on the environment that fits our experience (8, 9). This also describes the neural basis of sensemaking developed by Karl Weick (10) and correlates with Bertrand Russell's "knowledge by acquaintance" (11). It also supports abstract thought's limited influence or should have during life-threatening situations. Stress and fear drive effective action but can be accompanied by the inherent vice of failing to respond or inordinately focusing on personal survival.

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Engagement is acting upon the environment because we observe a discrepancy or experience a disruption. Such action creates more gaps regarding philosophy, strategy, tactics for choosing actions, and interpretation of responses. Do we first identify the situation, apply an algorithm, or figure out the situation by acting?

Gaps exist that impede our ability to prevent or respond to **consequences**. **Engagement** to prevent these consequences generates feedback while bridging these gaps. We define engagement as actions in response to and modified by **feedback**. Systemic and routine engagement of gaps supports effective, early engagement of the situation by individuals. Consequences, though present, become mitigated, and a more desirable end-state will be reached.

Effective operations in a dangerous context focus on the consequences of the situation. The operator considers the consequences of acting and not acting. This is not a singular decision. Marianne Paget (12) described this well, "from the point of view of an actor; an act often becomes mistaken only late in its development. As it is unfolding, it is not becoming a mistake at all. It is moving and evolving in time." Success and failure are ephemeral. Actions and events fold into each other as the actor responds to feedback.

Gaps form at various levels of analysis – prevention and response, planning, training, organizing, logistics, prevention, recovery, et cetera. Engagement bridges these gaps. Unrecognized information is lost with increased risk exposure.

The first article (13) in the *Neonatology Today* series about High-Reliability Organizing (HRO) addressed the gap between the normative and pragmatic frames, describing engagement as a bridge. Throughout the HRO series, we have described other gaps having various methods for engagement. These presentations developed from our efforts to articulate the experience of HRO to those who have not effectively experienced operations in dangerous contexts. The elaboration of these various gaps and methods of engagement continued from the feedback of readers, conversations with operators having various levels of understanding and experience, and the continuing extension of our discussions with Karl Weick.

Gaps are not visible without a challenge to the system and, more vital, without acceptance of negative feedback about the system, leaders, executives, and administrators. Long periods without serious incidents reinforce beliefs that a program is effective. The vigilance that identifies errors, mistakes, and near misses can support beliefs about the effectiveness of enforcement measures. Research relying on data that fits a statistically normal distribution and standard deviations creates the science supporting these beliefs. Concepts from models of psychological stress and theories from complexity and chaos emphasize the importance of accepted models and how leadership is used.

These descriptions and beliefs strongly derive from management science, generally with management models borrowing from methods of organizing developed for extreme hazards. This borrowing has been restricted, mostly from the normative frame for preventing system failure. The more salient and relevant principles then become less visible and often unnoticed. The occasion for academic observers to participate in live-or-die operations and become familiar with the more pragmatic frame is severely limited. Identifying characteristics necessary in dangerous and routine operations is absent, and their necessity in routine operations is unnoticed (13).

Not directly addressing these gaps between the normative and pragmatic frames has consequences. Management science focuses on theory and methods to bring theory to the field. Operators rely on the experience that may not sufficiently be informed by science. Leaders in both realms find evidence to reinforce their beliefs, further deepening the divide between the theoretician and the operator. Experience may go "underground" amongst operators more ubiquitously, while managers and leaders support their beliefs with science, alienating operators.

It is June in the hospital, and a new intern stands next to an infant with a decreasing heart and respiratory rate. The capillary refill is prolonged. Staff exposed the infant for examination. What action do we expect from the intern, nurse, or respiratory care practitioner? The discussion would reveal the gaps endemic in healthcare or any domain of operations.

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Aristotle (14) described the five virtues of thought in his book *Nicomachean Ethics*: *technê*, *epistêmê*, *phronêsis*, *sophia*, and *nous*. The more salient gap is between *episteme* and *techne. Episteme* in modern English is "knowledge" (epistemology is the study of the nature of knowledge), and *techne* is translated as "craft," "craftsmanship art," or "skill," this represents practical, context-dependent knowledge, or what we would call the practice. This is also the divide between science and the practice of medicine.

We may not see this gap as clinically relevant until we listen to arguments reliant on evidence-based medicine, protocols, and lab values that reject anecdotes. An extension of this gap is the "common sense" idea that makes it hard to believe something ex-

ists if the person does not know about it. One Author (DvS) had observed clinical deterioration in patients because a healthcare professional was unaware that a certain condition could occur and refused to believe in the possibility when told it could develop. Karl Weick (personal communication) observed and warned, "This is between rationalism and empiricism, but take care to avoid empirical research and the term empirical being hijacked to justify rationalism." Empiricism shifts from sensory experience to prospective, randomized, controlled studies. This gap is formed when knowledge from a white noise environment is applied to red noise forcing functions (15), the gap between formal and emergent structures (13).

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The 'color' of environmental noise describes the effect of periods on the environment. Without feedback, time segments and elements are independent of each other and typically assumed to be independent, hence the Gaussian distribution and calculated statistics and probabilities. The presence of feedback in a system causes autocorrelation and frequency changes. Low-frequency events bring a more significant force into the system [Table 1].

Table 1. Patterns and Characteristics of Noise (15)

Color	Structure	Variance	Distribution
White	No frequencies dominate Flattened spectrum	Data *decreases* variance	Gaussian distribution - Elements fully independent - No autocorrelation
Red	Low frequencies dominate Long-period cycles	Data *increases* variance	Power law distribution - Elements *not* independent - Mutual/reciprocal relations
Pink	The midpoint of red noise Slope lies *exactly* midway between white noise and brown (random) noise	Data *continuously increases* variance Distinguishes pink noise from reddened spectra	Power law distribution - No well-defined long-term mean - No well-defined value at a single point

The intern above is in that gap. The intern is losing context in a space meant for passage, yet they cannot move. The intern must act. Not think – act. Thinking doesn't cause a sick stomach. Acting doesn't cause a sick stomach. Thinking to act causes a sick stomach, impairing thought, and impending action. This is tonic immobility – the bane of the liminal space and the reason programs reduce risk by bringing structure for the intern while other programs engage risk by increasing the capabilities of the intern (16, 17). This is the fundamental gap in reliability. "People need to know how to go on. HRO is a guide for doing so," Karl Weick (personal communication).

Gaps in Theory and Practice

The Particular

Aristotle (18) distinguished between knowledge and wisdom and between the theoretical and the practical. *Epistêmê* (theoretical knowledge) and *technê* (practical knowledge) are familiar to us as science and technology, respectively (19). *Phronêsis* (practical wisdom) describes the capability for rational thinking that accounts for context and contingent facts, thus taking in "the particular." The HRO places value on information that may change with events. Aristotle considered *phronêsis* the first of the four cardinal virtues because ethics guides the individual to place the community's good ahead of the individual's good. Phronesis is acquired through practice and observation: practice creates the experience, while observation of elders who model this virtue leads one to phronesis (20).

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We see Aristotle's focus on the particular with Patricia Benner's description of the development of the moral agency. The individual develops an enhanced ability to read the situation as the limits of planning and prediction become apparent. The individual begins to make a difference – improvement is from the individual's judgment and actions rather than algorithms. With that knowledge comes responsibility for the care provided (21).

Classifications and Standardization

Classifications are influential with a relatively invisible influence on thinking and acting. Consider how the organization's error classification influences whether disruption is engaged as an error, novel, or emergent situation. How one classifies the incident influences actions, communications, and documentation (22).

Concepts are how we access reality, produce mental representations, make sense of the world, and make predictions. We then classify and categorize our concepts as part of knowledge production. Classification as 'categorical work' creates the rules for communication, meanings, conforming actions, and compliance (23) which then become the standards for the rules to classify and produce textual or material objects (24). Keeping our classifications in the abstract makes them more amenable to classification and more tractable to our sense of order (25).

This perspective, however, is outside the flux of events. Within

the flux of events, the operator is personally at risk, and changing contexts necessitates updating less reliable information. For the operator, this is 'articulation work,' the way things are worked out in practice. Articulation work is classification in real-time, managing and anticipating contingencies in the face of the unexpected, and directing efforts to keep the program running (23). In classifying, we lose details due to irrelevance, but what is irrelevant now may become relevant later. Context and meaning, critical for engagement, are lost.

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Leaders, administrators, and regulators may mistranslate the nature of an HRO and try to control or reduce the fluidity necessary for engagement (23). This is usually accomplished with increased standardization and reduced diversity and variability. The dominant group sets the discourse, defines categories and classifications, sets limits of what can be spoken about and what cannot, and who can speak with legitimacy. The dominant account is the privilege of being listened to (26).

Abstractions and Context

Concepts are reality images, but we must not mistake concepts *for* reality. Alfred North Whitehead (27) warns against this "fallacy of misplaced concreteness," mistaking the abstract for the concrete, accepting abstractions as the most concrete rendering of fact. Discrete, abstract concepts, in a reality of continuous perceptions, create gaps subject to misspecification, misidentification, and misunderstanding (28), gaps the pragmatic leadership stance works to close.

Gaps generated by theory (abstractions) and practice (context) impair the organization's operations and processes. HRO emerges when our perceptual order is contextual, and we engage the flux of contingencies to make them more orderly. We cannot treat these environments as isolated systems with demarcated boundaries. Instead, the environment is comprised of open, contextual systems always in flux. Contextual systems are those systems where the environment interacts with and changes the problem (29).

> "The misplacing and fixing of abstractions are a big issue. Misplaced concreteness is the problem. Your emphasis [DvS] on moving, flow, trajectory, reduces 'severe concreteness.' I'm studying a disaster that sank the container ship, El Faro. As they are entering the eyewall of hurricane Joaquin, without knowledge of winds and at 4 AM in darkness, the captain says, 'This is a typical winter day in Alaska.' and sticks to his route straight toward the eye. The ship (790 feet long) capsizes 3 1/2 hours later, drowning all 33 crew.
>
> "Typical day" is a severe abstraction."
>
> Karl Weick (personal communication)

The Gap Between Theory and Practice

High-Reliability Theory relies partially on an outside view in its reliance on codifying a framework of guiding principles. However, when those principles are seen as the core to producing reliability, that is where the emphasis gets misplaced. Scientific theory and rationality assume discrete a priori themes and concepts outside the human mind (30, 31). The goal is to represent an "outside" view of the world, a dispassionate, objective representation that is disinterested in personal experience and practical concerns.

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Operators in the field develop their logic of practice built upon contextual relations entwined with people and work (30). For Mike Zundel and Panagiotis Kokkalis (31), the absence of practice within the theory is how theoreticians see theory making as themes in terms of a priori scientific assumptions, the *scientific subject domain*. The theory would move into the practical world by including engagement of practice, closing the gap between theory and practice to create the *practical engagement domain*. The significance of practice engagement derives from attitudes taught to rookies in the military and public safety – always engage, in some way, even if to evacuate the area.

The Skill Acquisition Gap: Competent to Proficient

Patricia Benner (32) described the discontinuity between the competent level of performance obtained in preparatory education and the proficiency necessary for more independent professional functioning. The student moves from what can be taught by precept and what can only be learned through experience. When described as "OJT" (On Job Training) in dangerous contexts, skill acquisition occurs as semi-autonomous engagement under the watchful supervision of veterans, all of whom share the duty to ensure that the novice learns appropriately (16).

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Unfortunately, time and resource limitations lead to standardization and routinization of processes. While this was initially developed in nursing and EMS to prepare novices in a high turnover workforce, it has become perceived as the ideal method for training and maintenance toward a competent level of performance.

The result is the prevention of individualized care (32).

Gaps from Leadership

"Leadership" has become an *ex officio* label for executives, administrators, managers, and supervisors. Such labeling risks washing out the leadership characteristics necessary for liminal events and dangerous contexts. It also distracts from the leadership that expands an organization's frame of reference. The nature of engaging an evolving embedded problem in shared threat does not lend itself to most leadership models.

Leadership models risk creating operational gaps or authority gradients between leader-follower. Models developed in and for stable environments do not fully translate to dynamic, uncertain situations where the leader and followers personally face threats, the type of environment from which the HRO emerged. Leadership from a distance will shift thinking toward decontextualized abstractions, focusing on principles, and relying on discrete concepts.

The pragmatic leadership stance of HRO engages the embedded problem with subordinates, accepting the influence of the environment, monitoring the performance of individuals and the team, and supporting "leader-leader" actions (33). All members of an HRO must immediately engage in any disruption and investigate any discrepancy. People lead in engaging the problem until they are relieved.

HRO leadership has a more pragmatic frame that iteratively supports engagement. Team members and the leader engage in sensemaking/sense-giving as interactive, iterative, recursive, intertwined, and overlapping parts of a single process. Each action, rapid shifts in contingencies, and unexpected disruptions change some of the rules. More than group interaction, it is through shared cognition and visual communication that the team generates a frame that, while dynamically changing, becomes an increasingly accurate representation of events (33, 34). Collaboration makes the team and the HRO stronger (35).

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For example, the fire service is quickly reduced to firefighting. William J. Corr, Captain, LAFD, and WWII US Navy veteran, South Pacific, viewed the fire service uniquely as a way of thinking and acting. By modeling motor cognition (thinking *by* acting) and expanding the frame of reference for firefighters from specialists to specialist-generalists, he made the fire service larger than firefighting. Corr often counseled, "We don't fight fires; we solve problems the public cannot or will not solve themselves." These were not simple but ill-structured problems that might be embedded in dangerous situations.

Pediatrics can also expand its frame of reference to become larger than pediatrics. John Mace, MD, former Chairman of the Department of Pediatrics, Loma Linda University, supported the expansion of the Pediatric Critical Care Division as the two Pediatric Intensivists (one of the authors, DvS, and Ronald M. Perkin) began the PICU. Within its first year, the division became influential in adult and pediatric EMS. It expanded into Home Mechanical Ventilation and trauma care, later participating in the national aviation safety program. In the hospital, new procedures were introduced, such as using helium, hand ventilating breathing patients, and intubating for epiglottitis in referring Emergency Departments (EDs). Out of the hospital, new procedures included paramedics intubating infants and children, initiating and managing mechanical ventilation in a free-standing subacute facility without blood gas monitoring, and managing mechanically ventilated children using *smile* as the management goal. Mace provided protective support to the intensivists for this expansion of pediatric critical care and the introduction of methods that were and still are, met with strong disapproval by influential physicians. These respiratory techniques continue in one pediatric subacute facility and a special group in SOCOM – the military's Special Operations Command.

What is more notable than the successes were the failures: development of a pediatric subacute unit within the medical center, full integration of the department into pediatric and adult EMS and trauma systems, pediatric outreach to EDs, creation of a center for pediatric prehospital care, and pediatric intubation by paramedics. (The first two children intubated had apnea with rapidly decreasing heart rates despite mask ventilation. Both were intubated in the field and discharged neurologically intact from the PICU after 24 hours. One of the last infants intubated was an infant in breech birth with only the head visible and cyanotic. The paramedic intubated the infant, who was then delivered to the hospital.) The failures demonstrate that Mace supported programs to serve the community rather than the limited selection of programs within the domain of pediatrics that had a guarantee of success. His was a unique method of HRO leadership.

The pragmatic leadership stance takes place *within* the situation, taking advantage of natural internal processes that self-organize people and situations. Self-organization with intention creates adaptive improvisation and immediate responsiveness, driving engagement and action. Individuals sense and respond to weak signals, subtle and nuanced feedback, and misinterpreted noise to bring order and generate structure (36).

Military veterans describe the importance of mutual influence on performance *in extremis*, the mutual influence acting as a multidirectional pattern of reciprocal leadership enabling team members to lead each other to achieve common objectives (37). For polar explorers, this reciprocal influence makes the team highly effective while the leader maintains a strong influence (38). The leader seeks perspectives, encourages information sharing, and models how to engage in ambiguous situations (39). Through reciprocal influence, the leader gains a sense of how members think and their motivation (38).

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Values

Values are more strongly held and are more permanent beliefs compared to attitudes. Two of the authors (DvS and TAM) identified five values of HROs (33):

- *Duty.* Acknowledge the value of everybody's contribution. We will not let others down; we have a duty to our larger community.
- *Empathy.* We can all make mistakes at any time; HROs work in tough situations where people will fail.
- *Dignity.* Acknowledge the value of everybody's contribution; every job, every task, is important
- *Honesty* What someone says represents the circumstances. Our descriptions represent what we see without effort to persuade. Freely accept disconfirming evidence..
- *Humility.* The unexpected can happen to any of us; we can all fail.

Some values oppose each other such as obedience versus initiative and conformity versus creativity (40). We do not expect to find opposing values in the same culture except that HROs work in structured environments preventing system failure and the unstructured environments of an emergency response. The structured environment favors conformity to standards and obedience to authority, while the initiative to engage and improvise in the unstructured environment is necessary (33). This creates a gap between values and the necessity to, at times, act from opposing values.

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This ability to rapidly develop initiative and creativity in an unstructured situation creates the "leader-leader" construct. A "leader-follower" construct too quickly creates a docile member who awaits instructions. We rely on the leader-leader approach for members to keep their sense of duty toward the community (phronesis) and the organization.

Technical Design versus Self-Organization

The security of *structure* too readily drives people to create or conjure structure through technical design. This is the gap between designed order and emergent order. By organizing structure from outside the flow of events, designed order from human intentions creates structure without context (41), disregarding local forcing functions of the red noise environment (15).

Before events of a forcing function become visible, local nonlinear interactions and self-organizing have occurred. "Natural systems become structured by their internal processes: these are self-organizing systems, and the emergence of order within them is a complex phenomenon" Eugene F. Yates (42). Improvisation is self-organizing with human intention but from *within* the flow of events (43, 44).

Spectating leaders and administrators unable to engage the gap may fear improvisation as a weakness. The weakness is not from non-compliant staff. The weakness emerges from the experience of individual staff facing a confusing situation. Staff always act in a way that makes sense to them…locally. This may not make sense to a spectator (13).

Socio-Technical System (STS)

Introducing "longwall" mining technology into British mining created a gap between technology and social structure. Technology has disrupted the social balance of two men working face-to-face in the "room-and-pillar" technique. Mechanization decreased adaptability and responsible autonomy. Some mines showed increased productivity, while others did not (45).

Technology in the latter group of miners had created a socially ineffective structure. Management disregarded the dangers and human shortcomings that followed the introduction of the technology. Individuals isolated by the longwall technology felt socially isolated and vulnerable, and local disturbances became magnified. The resentment and hostility led the miners to self-organize for group defense.

Technical management gave miners the security necessary for undertaking new developments in productive mines. Technology was treated as an engineering system that interacted with the longwall, which was regarded as a social structure with occupational roles. By treating new technology as two technological and social systems, management developed close interaction with the staff and gained far better results.

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Gaps from Experience

The Flow of Events

We readily understand the different experiences of an event between an observer and participant. However, a gap will develop when we do not acknowledge the different functions of the measures.

We can describe the temporal flow of events in two equivalent ways:

- Observation and measurement at a fixed point as events flow by, observing the rate of change and measuring the velocity and gradients of events
- Experience the effects on a single element of the organization within the flux of events, comparing it to its neighboring elements and evaluating the element's rate of change in the flux of events.

These methods are equivalent to the eulerian and lagrangian specifications from hydrodynamics (46) [Table 2]. The different specifications for events will influence practical descriptions of what to expect, such as the nature of the increase in demand,

the appearance of novel demands, and the decrease in resource availability (47).

The eulerian specification describes the organization's motion without reference to the forces which cause the motion. This generates state variables and demands on the system and organization independent of causation. The lagrangian specification describes the velocity and gradients of events, enabling descriptions

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of demands on individual elements at specific points.

Table 2: Eulerian and Lagrangian Specifications (46)

Eulerian, quantitative	Langrangian, qualitative
Decontextualized	Contextual
External, fixed point Focus on a specific location	Within flow Focus on the individual moving parcel
Flow	Trajectory
Multiple, fixed positions	Continuous measure with position and pressure
Rate of change of system	Individual parcels

VUCA-2T and Liminality

"We modified the US Army concept VUCA (48, 49) for the civilian environment because the military assumes operations under threat. Hence, VUCA-2T describes the HRO environment (Volatility, Uncertainty, Complexity, Ambiguity-Threat, and Time Compression, Table 3) (16)."

VUCA-2T. We modified the US Army concept VUCA (48, 49) for the civilian environment because the military assumes operations under threat. Hence, VUCA-2T describes the HRO environment (Volatility, Uncertainty, Complexity, Ambiguity-Threat, and Time Compression, Table 3) (16). Such situations do not often readily translate into straightforward problems with definitive constituents, rules, and outcomes (13, 50, 51). Inquiry is active and operational, supporting authority migration and information flow, enlarging small cues and evaluating context (10, 35, 51).

Table 3. VUCA-2T (16)

Volatility	The rapid, abrupt change in events
Uncertainty	Lack of precise knowledge, need for more information, unavailability of the necessary information
Complexity	A large number of interconnected, changing parts
Ambiguity	Multiple interpretations, causes, or outcomes
Threat	Impaired cognition and decision-making
Time Compression	Limitations acquiring information, deciding or acting before consequential changes

Liminality. It is a bit discomfiting when we find ourselves in a space we do not belong or are meant for passage. The discomfort arises from the loss of context but also when the discomfort triggers the sympathetic nervous system. The liminal zone described in anthropology is that space between a world we know and a world we do not, where our old rules do not apply and we have not learned the new rules (52). In this area of experience, we must engage the situation to leave, yet we do not know what works; we cannot rely on learned concepts, policies, or rules (8).

Liminal zones are not continuous with routine operations or with each other. Abrupt changes disrupt operations. Our treatments may abruptly disrupt the disease process and the neonate's physiology. Such a sequence of experiences creates the more common "punctuated experience" of resuscitation that necessitates constant evaluation and re-evaluation. "HRO is a trajectory of engagement that fuses the *now* with the experience of *then* into simultaneous inquiry and redescription," Karl Weick (personal communication), rather than sensemaking guiding us from the immediate past to the immediate future. Karl Weick describes the repeated presentation of abrupt changes as "punctuated sensemaking" (personal communication). Every action is a failure, and every action creates an unrelated or disconnected experience.

"Common experiences do not describe how VUCA-2T or the liminal zone places demands on the brain's survival system. Nor how those demands affect our thinking and behavior. The liminal experience shapes the HRO by shaping the individual. Experience describes the changes within an individual due to the environment (8)."

Common experiences do not describe how VUCA-2T or the liminal zone places demands on the brain's survival system. Nor how those demands affect our thinking and behavior. The liminal experience shapes the HRO by shaping the individual. Experience describes the changes within an individual due to the environment (8). The more severe environment of the liminal zone has a profound effect on the individual, sometimes as a larger number of small liminal experiences or fewer but more severe incidents. What makes High-Reliability Organizing is not the number or se-

verity of liminal experiences but learning how to perform in the liminal zone.

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WWII American bomber crews arriving in the theater of operations were insecure and defensive. In action, they were overly self-assured though some were particularly diffident (53). About the time of their tenth raid, the airmen had entered and remained in liminality:

> "The man had experienced fear and by now knew that he could deal with it; he found that care and skill and coolness in the pilot and crew had a real bearing upon the question of his return; he saw that his crew and his airplane could withstand catastrophe; he developed an "esprit de corps" in regard to his squadron, and was now really part of it. He developed for the first time a sense of his responsibility to his mates and to formation. At this stage…the men were effective, careful, fighting men, quiet and cool on the ground and in the air. They attained a sort of tranquility in spite of their anxiety. *They had very little need for defensive mechanisms of any sort to deceive themselves or anyone else.* [Author's emphasis.] They talked easily and quietly" (53).

Gaps from Belief

"How do you identify when you are wrong?" "Would you please describe an actual error in leadership, administration, or management?" One of the authors (DvS) has asked these two questions privately and in discussion groups for over 20 years. No one has answered; most people ignore the question.

The most difficult gaps to engage are the gaps between identity or belief and the environment – made less than visible when the conversation hinges on a person's depth of knowledge, extensive experience, and good judgment, the triad that must not be questioned. It is of little use to describe the somewhat shared character of those who suffered a severe failure or have had extensive experience in dangerous contexts – described above in the vignette of WWII bomber crews. It does seem true that the stronger the belief, the weaker the experience. Knowledge by description can be mastered, while knowledge by acquaintance seems to increase doubt. Crossing the gap described by Benner (32) between competence and expertise does not protect one from equating mastery with knowledge and identity.

Identity

"Sustained conversations about failure are difficult because they are mined with threats to identity," Eric M. Eisenberg (54) writes about Karl Weick's concept of sensemaking and the individual's struggles over meaning. Meaning, like classification, favors some images and actions at the expense of others. People identify with the meanings they give. Weick lists identity first in his properties of sensemaking.

Our experiences are processes of doing or making. At the moment, our experiences contain story arcs that connect us to our past to others and form extensions into our future. For John Dewey (55), our experience becomes our identity and is the source of our pride. Experiences are the assets people bring to a program, their identity, and pride in their accomplishments rather than the team or organization. Experience and identity carry a quality of self-sufficiency, as experience gives meaning to one's life (55).

A difficulty working with common sense knowledge is associating "common sense" with one's identity and self-image. When questioned about a source, the person answers, "I just know it" (56), ending further inquiry. Others become offended when suggestions are not acted upon and can become less than cooperative when the team is engaged with a situation.

Identity is sensemaking emerging from social feedback – the individual deduces their identity from the behaviors and attitudes directed toward them as they also attempt to influence those behaviors and attitudes (57).

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This is also dynamic for the development of moral agency described by Benner as the individual moves toward proficiency and expertise. The awareness of shifting values from conformity to obedience, initiative, and creativity becomes visible. The five HRO values described above become internalized. It is the shared duty of workers in dangerous contexts to precept the novice for safety and performance (16). How we treat subordinates can create the expert we will later defer to for expertise.

This is the locus where identity can be damaged, and transition to expertise stalled or irreparably damaged. Negative behaviors and attitudes toward colleagues and subordinates or the ecology of fear (58) impede the actions necessary to gain experience and a sense of agency with long-acting consequences. An organization may better be identified as HRO through the more subtle and nuanced interactions that reflect moral agency and reveal the five HRO values.

Thinking and acting are contextual. Who the person is, in that context, is their identity. Identity and context influence engagement, interpretation of the situation, and enactment (59). HRO leaders contribute to the creation of a positive identity.

As a fire rescue medic, one of the authors (DvS) was detailed in 1976 to a firehouse where some of the first paramedics in California were assigned. They had been trained in 1971. Physicians at the time did not know how to train paramedics, resulting in less than professional medical knowledge and terminology. In the intervening few years, physicians had developed better training, and paramedics became more adept with the language and principles of medicine. Nearly all the firefighters assigned to that firehouse had about 30 years of experience, and with longevity and veteran credits (many were WWII veterans), they could easily promote to a higher rank for a higher salary, then retire at higher pay. The Author asked his captain why these paramedics did not improve their performance or retire.

Bill Corr, the fire captain, described earlier, responded, "Davey, those men went through the Depression. They fought in the war. They are able to provide shelter for their family. Food for their family. They have a car. They *are* successful. They are the most successful person in their family."

When the Author works with a medical assistant, nursing attendant, or any line staff or student, the Author, and his co-authors, see the most successful person in their family. Moreover, they receive respect.

Logics about Belief

Beliefs about logic, particularly the sole reliance on classical logic, make the belief-environment gap one of the hardest to bridge (60).

Doxastic logic (Greek *doxa*, "belief"), a form of epistemic logic, concerns the logic of the belief of participants. Doxastic logic provides reasons about belief rather than knowledge; the difference is that a belief is probably, though not necessarily, true. When we are not careful, we may collapse knowledge and belief into the same system as conviction in epistemic logic. Our beliefs become refractory to disconfirming evidence, contributing to the development of *motivated reasoning.* Doxastic operators capture belief change as "belief revisions" or "belief updates" when they receive conflicting information or encounter a discrepancy or disruption.

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Belief Revision. People have inconsistent beliefs. We revise when we accept old information as less reliable; we then favor new information we consider reliable. The most significant sources of inconsistencies are motivated reasoning and cognitive dissonance. Paraconsistent logic drives inquiry to correlate and revise belief to context, as opposed to motivated reasoning and cognitive dissonance. We cannot eliminate all inconsistencies (61).

A *belief update* refers to accounting for a change in the situation and acquiring new, more reliable information; this requires us to change our inaccurate old beliefs to a more accurate, new belief. One of the authors (DvS) encourages staff to offer "updated information" when presenting information that disagrees with the physician's understanding of the situation.

Paraconsistent and *paracomplete logics* permit contradictions and overlapping values (the law of the excluded middle does not apply) (62, 63). These logics also allow changing a deduction after it is reached, an operation that is not permitted in classical logic.

Cognitive Dissonance

The dissonance between opposing cognitions is nearly impenetrable, but, fortunately, the outward appearance is reliable and has become well known. However, the dissonance will interfere when information changes and events are in flux.

One of the authors (DvS) had an extended discussion with Karl Weick regarding cognitive dissonance as a risk for uncorrected errors and failures. Weick concluded with this reply [his comments in italics]:

> "Knowledge in the threatening, unstructured state acts as a degree of belief that must be updated from information generated during the event. Mistaken beliefs must be identified and corrected, no matter how dearly held. A mistaken belief, compared to an updated belief, is stronger depending on its presence at the beginning of the incident or the length of time the individual has held the belief. Events in flux create the need for dynamic reasoning processes and more easily acceptance of new, disconfirming evidence. Long-held entrusted beliefs must be freely questioned, not an easy thing to do for most people, regardless of level of skill or logic used" (64).
>
> *The clash between a mistaken old belief and an updated belief would seem to be a form of dissonance. An interesting possibility is that the more you engage in dynamic reasoning, the less chance there is for dissonance between old belief and updated belief to develop, and the fewer errors you make.*
>
> Karl Weick, personal communication

Motivated reasoning

Motivated beliefs are unconsciously directed toward a goal (65). Protecting a self-serving conclusion comes from their prior beliefs making their conclusions seem more plausible. Motivation appears to affect cognitive processes rather than emotion (66). The individual will attempt to be rational, constructing an "objective" justification persuasive to a dispassionate observer. This can involve creatively combining knowledge to construct new, logical beliefs supporting their desired conclusion. People are unaware of their use of motivated reasoning, which comes from motives to achieve an accurate conclusion or maintain a specific conclusion (66).

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A person firmly holds their desired conclusion, supported by overscrutinizing or rejecting disconfirming evidence (66-68). The individual reasons for a preferred conclusion affect forming impressions, determining beliefs and attitudes, evaluating evidence, and making decisions (66, 69). Analytical sophistication and education do not reduce the presence of motivated reasoning (65).

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A direct challenge can evoke strong emotions, even physical anger, and outrage (65, 66). This clearly shows you have encroached on a protected, cherished belief.

Motivated reasoning enhances self-efficacy against a problem of self-control or gives utility to beliefs to counter a perceived weakness in a desired trait. Motivated reasoning also protects personal and social identity. Selective updating by information avoidance

and asymmetric processing of good and bad information protects these beliefs (65).

Accuracy requires greater cognitive effort for reasoning, attending to relevant information, deeper processing, and the use of more complex rules (66). This is similar to the approach described by Simon for the ill-structured problem (70). The concern to avoid a wrong judgment and drawing the wrong conclusion while more careful cognitive processing parallels HRO reasoning. A consequence is a reduction of cognitive biases (66).

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The Gap of No Complaints

A dominant account of systems or events reflects the beliefs of those in authority, the most distant from events. This is common in Lessons Learned and After Action Reports. An organization's culture can be described by its beliefs, behaviors, tools, or artifacts. The dominant account influences culture through beliefs, just as the organization's tools will. (The 'tools' of an organization include its rules, protocols, and algorithms, hence Weick's dictum "drop your tools" in a crisis (71) would encompass the necessity to drop rules and protocols.)

The dominant account comes from those in authority, excluding contextual elements from the environment and within the human-environment interface. For this reason, certain voices are or are not heard within and outside the organization. In an organization, there are three main types of authority: line authority, staff authority, and functional authority.

- *Line authority* directly follows the chain of command from the most senior executive to the line worker.
- *Staff authority* is the authority to advise and support line executives and managers; members with staff authority include legal counsel, finance, and human relations.
- *Functional authority* is based on expertise and authority over a particular function for staff personnel or a particular situation for line personnel.

Anyone with authority in an organization can enact an environment where non-HRO behaviors make sense. The person in authority can also enact an ecology of fear, such as fear of malpractice, litigation, short-term financial insecurity, or intractable social and leadership interactions. The failure of Enron can be traced to one CEO enacting beliefs that made sense of illegal and unethical practices; alternative definitions were discouraged if not tolerated (54, 59). On a smaller scale, we encounter the effect of the dominant voice with routine criticism of other services, specialties, and regulatory agencies. Once a dominant account develops, voices become hidden, and knowledge is lost.

The dominant account becomes a mistranslation of the environment – reduced and simplified to fit a normative view framed from the fixed point of a spectator. Context and meaning, critical for engagement, are lost. The dominant group sets the discourse, defines categories and classifications, sets limits of what can be spoken about and what cannot, and who can speak with legitimacy. The dominant account is the privilege of being listened to (26).

Why No One Complains

Belief that one's experience is shared by or subordinate to another person's experience risks negating that person's experience. Using technical terms more fluently or speaking more forcefully does not make the person's experience more important than other people's experience. This absolutist view happens in healthcare when a physician or surgeon negates the experience of others, removing their experience from consideration. It then becomes the dominant account, driving other views to become hidden voices with a loss of the expertise the leader could have deferred to (9).

It is not uncommon to hear from an authority figure, "Why didn't I hear about this?" "Why wasn't I told?" Some of this is the climate created by the dominant group that impedes information flow or generates the ecology of fear.

Only the executive can say "no." One of the authors (TAM) kept this as a rule of command for a US Navy ship – only the captain can say "no." The subordinate would learn how to solve a problem or provide assistance through direct action or with support from a superior. This increased the person's capabilities and contributed to a sense of agency. Benner described how providing such assistance engenders *moral agency* and *identity* within the profession (32). Before saying "no" to the captain, midlevel managers would consult each other, resulting in a body of *distributed knowledge*. In *epistemic logic*, distributed knowledge is a modal operator for pooled knowledge in a specific frame of reference (13, 72). The most difficult decisions would more quickly reach and alert the captain. Whatever decisions were made at the appropriate level, positive or negative, they were passed up the chain of command to inform the executive.

"It is difficult to go against the dominant account. Individuals who identify substantive issues make sense from their identity, an identity shared with the organization. If the issue involves integrity, the individual's evolving identity of integrity and autonomy is made more unstable when superiors and colleagues treat the person as dishonest or marginally qualified."

It is difficult to go against the dominant account. Individuals who identify substantive issues make sense from their identity, an identity shared with the organization. If the issue involves integrity, the individual's evolving identity of integrity and autonomy is made more unstable when superiors and colleagues treat the person as dishonest or marginally qualified. Social interactions become restricted and redundant. The individual misjudges cues interpreted to confirm the person's developing bias, ongoing events impair efforts to cope, and everything or nothing seems plausible. Enactment begins to violate important norms that diminish the person's influence (73). The emerging cognitive dissonance creates isolation and stops information flow that could have moved important information to leaders and those in authority.

Hidden voices containing valuable information and insights remain hidden. The dominant account guides the culture and operations. The gap never closes.

Conclusion

Myriad approaches and models describe the difference between the situation and an outcome or consequence. Perhaps the fundamental difference or influence is the certainty of the past, a form of stability, and the uncertainty of the outcome, a form of instability. The difference lies in our environmental responsiveness.

The human brain, rather than being analytical, evolved to respond to consequences within the environment. Several inheritable traits support mental and behavioral responsiveness, such as alertness, vigilance, and environmental responsiveness (boldness and aggression). These traits also influence the engagement of situations of consequence.

Gaps in interpretation and between models develop because of two disparate types of environments – stable and unstable. The elements we discussed do not operate over a spectrum; rarely do they lie on a continuum. They more likely form discrete systems separated by a gap. The orthogonal relations of various systems and their gaps do not preclude us from engagement. What strengthens engagement along one axis can influence favorable developments along other axes.

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Engagement is not a mental exercise nor a purely cognitive activity. Again, the brain evolved to act. The executive functions coordinate cognition with action, stress responses and fear circuits limit distractions, and motor cognition changes behaviors in the flux of events.

We typically engage in these situations to gain a favorable outcome. Unrecognized gaps impede our ability to respond effectively to consequences. Engagement can also bridge the gaps in our various systems to understand, prepare for, and respond to consequential situations.

It is the recognition of these gaps that helps identify when to change models. In effect, we drop our tools when the tool is wrong. Rules, protocols, ideas, and frames of reference are tools we may need to drop. Identity and firmly held beliefs are the tools we hold most dear, the tools we believe will save us. They are the tools we are least likely to drop, yet the most likely to bring us harm.

Knowing how and when to drop our mental and behavioral tools is our entry on the path to High-Reliability Organizing.

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