

Maladaptive Behavior in Survivors: Dysexecutive Survivor Syndrome

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This paper attempts to answer the question: why does normal, goal-directed, purposeful, and coordinated behavior fragment in a survival situation? Events accompanying the initial impact phase of a survival incident are characterized by speed, danger, violence, and uncontrollability. The following recoil phase is known to produce behavioral and cognitive impairment that leads to a reduced ability to produce a response that is meaningful and may result in tonic immobility. The author argues that the commonly witnessed responses among survivors comprise a subset of known behaviors, including loss of initiative, stereotypy, perseveration of thought and action, hyperkinesia, hypokinesia, and, in extreme cases, akinesia or cognitive paralysis. These behaviors are characteristic of executive dysfunction and a model is given suggesting how this condition may arise under survival conditions. The case is presented that during the initial phase of a survival incident, victims show a transient, nonclinical dysexecutive syndrome. This model should aid survival training and provide a context for conducting behavioral autopsies by accident investigators.

Keywords: survival, dysexecutive survivor syndrome, supervisory system, contention scheduler.

THIS PAPER PROPOSES a theoretical model to explain the occurrence of maladaptive behaviors commonly witnessed among people under threat and during the initial stages of a survival situation. Examples of symptomatic behaviors commonly witnessed in survival incidents are presented initially. These behaviors are then considered within the context of executive function. Finally, empirical and clinical evidence are presented to provide the basis for a functional, cognitive theory of survivor behavior.

Survival situations (e.g., shipwreck, aircraft crash, fire, earthquake, hostage taking) entail risks to life or limb. The author defines 'survival' as continuing to exist in the face of adversity. Survivorship refers to behaviors that support survival. Psychologically, a survival situation involves switching from more or less routine actions to ones of danger, uncertainty, and high information load. During hostile circumstances one would intuitively expect a behavioral response enabling victims to survive long enough to transition to a more benign environment. Paradoxically, often behavioral and cognitive impairment (43,64,85) results in meaningful responses being inhibited (54) and may result in cognitive paralysis (47). 'Cognitive disarray' (70) describes the psychological disruption that can threaten order or logic. However, closer examination of responses witnessed during survival incidents suggest that, rather than being haphazard, responses represent a symptomatic behavior subset.

Survival incidents have a natural history, of which two key phases are impact and recoil (45). The impact phase, characterized by speed, danger, and violence, is usually uncontrollable and involves an overwhelming of the senses. It is brief, usually lasting seconds or minutes. The recoil phase begins once the initial dangers have dissipated, although secondary threats may persist (e.g., a risk of hypothermia following sudden and unexpected immersion in cold water). Survivors show a gradual return of awareness that may take up to 3 d and even extend into the post-rescue phase. This recoil phase is when maladaptive behaviors are often witnessed among victims (44,48,85).

Maladaptive behavior describes those thoughts and actions counter-indicated for survival and which increase the risk of death or injury. These include responding as though the threat did not exist, continuing with an ineffectual action despite a diminishing opportunity for escape, 'freezing' in the face of danger, and so on. Cognitive behaviors comprise: loss of initiative, stereotypy, perseveration of thought and action, hyperkinesia, hypokinesia, and, in extreme cases, akinesia or cognitive paralysis (44,47).

Some survivors do show adaptive behavior. For example, 12–25% of survivors of various disasters in Canada showed adaptive behavior with apparently negligible cognitive disturbance (82). Others put this figure at 10–20% (44), while 59% of victims of a factory explosion and fire showed optimal performance, although this figure is attributed to a high level of disaster experience and training among the victims (85). Nonetheless, it is clear that most victims do show maladaptive behaviors under threat.

Symptoms of Survivor Behavior

Loss of Initiative

A common initial response to threat is an inability to think or plan. One survivor of the ferry MV *Estonia* that

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sank off Finland in 1994 with the loss of 852 lives reported: 'I didn't think. Shock is so disorienting it doesn't allow us to think clearly' (46). The explosion and collapse of the *Piper Alpha* oil platform in 1988 resulted in the deaths of 167 men. The official inquiry found that the death toll was considerably greater than it would have been if initiative had been taken with respect to escaping (23). Furthermore, 'Individual actions are not encouraged on oil platforms but in this case it was those who took matters into their own hands who survived. The rest did not' (19).

A British hostage taken by terrorists aboard a Boeing-747 airliner described his initial psychological response as; 'In the hand that was on the end of the arm that was around the flight attendant's neck, [the terrorist] had a pistol... I didn't duck, or go to help, or shout, or run away, or anything. For what seemed like an age, and was probably about 2 seconds, I gawped. If anything went through my mind at all, it was the thought, How extraordinary – that man has a gun [...] At first it was numbing. I couldn't respond, I was so stunned' (78).

Stereotypical Behavior

In 2001 a sea kayaker capsized in heavy seas off southern England. He realized that he was in serious danger, but did not establish an appropriate response. After clinging to his upturned kayak for some 20 min he recalled that he had a mobile telephone in the kayak. His response: to call his father who was working 3500 mi away in Dubai and who then called the coastguard, which had a lifeboat station located less than 1 mi from the kayaker's position. This is stereotypical behavior occurring under threat. During the capsizing of the *Estonia* ferry, people were reported to be still pestering the Purser's office to exchange money at 01:00 when the ship had a 30° list and was obviously sinking in a gale (14). Again, this is stereotypical behavior; in other words, behavior initiated without reflection.

Aircraft evacuation testimonies report passengers, instead of exiting the aircraft immediately, stop to retrieve their carry-on baggage from the overhead bins despite instructions not to do so (81), e.g., during a Boeing-737 engine fire the aircraft was stopped on the runway and an evacuation ordered. Crew stated, 'Despite being advised to leave everything behind, many passengers insisted on retrieving their carry-on baggage. When confronted at the exits by cabin attendants, some passengers tried to return to their seats to stow their baggage in the overhead bins' (2).

During the 2001 attack on the Twin Towers in New York, a woman is reported breaking away from her group saying that she was returning to fetch her bag (she perished); one man returned to fetch his mobile telephone, while another wanted to return to collect his minidisk player (26). Why did they do this? Because this is what they always did before leaving the building at the end of the day.

Stereotypical behavior is acquired both through training and through inherent response production. This can benefit survival behavior; e.g., helicopter underwater escape training instills behavior that can be initiated

reflexively (vs. stereotypically) to aid a person in surviving a ditched and submerged helicopter. An important part of this training is learning to inhibit more prepotent behaviors, such as not inflating the life-jacket while inside the fuselage or exiting the aircraft while the rotor blades are still turning above the victim. Both inherent and acquired stereotypy can be evinced during a survival incident.

Perseveration of Behavior

During an intensive military survival exercise an air force serviceman repeatedly gave his radio call-sign when prompted for his name. This he continued to do despite being told that his responses were incorrect. He gave his name on the fifth prompt. Later the airman commented that, while he knew his responses were incorrect, he was unable to break out of the response rut (personal debrief). This particular error has been reported by more than one person undergoing military survival training. Giving his call-sign instead of his name in the first instance is also an example of stereotypy as this is standard operating procedure for aircrew.

Action Disorders

Three frequently reported abnormal action and motor behaviors observed in survivors are hypoactivity, hyperactivity, and cognitive paralysis:

Hypoactivity: This term refers to a decrease in both cognitive and motor (hypokinesia) functions that are commonly seen in victims as a passive and depressed reaction coupled with affective demotivation and a cognitive withdrawal from the situation. Survivors of the sinking of a cruise liner who were observed during the incident by two psychiatrists acted initially as if they had been sedated, observing that the "... survivors presented themselves for the most part as an amorphous mass of people tending to act passively and compliantly. They displayed psychomotor retardation, flattening of affect, somnolence, and, in some instances, amnesia for data of personal identification. They were nonchalant and easily suggestible" (30). An officer in charge of a lifeboat launched after the capsizing and loss of a cargo ship logged that after a while, "...a sort of coma appears to have settled on to many of the crew, and whatever was done was done more or less automatically and without thought" (29).

Hyperactivity: This is characterized by an intense but undirected liveliness or restlessness (hyperkinesia). Victims are prone to distraction, often flitting from task to task, i.e., one survivor of a military aircraft that crashed in the Arctic became agitated, kept crawling over his companions, and periodically removed his gloves. He continued to suggest that he and his fellow victims should leave the crash site (their source of shelter and location) and walk across the snowcap to seek help. He was dissuaded from this action by his colleagues and died before rescue (44). In the rapid sinking of a tug in the Gulf of St Lawrence in mid-winter, two very experienced Master Mariners paced backward and forward from one wing of the bridge to the other and did nothing as the water rose above their knees. They drowned, yet a much younger

and less experienced deck hand standing next to them quickly donned his survival suit and survived (14).

Following an attack on shipping in the North Atlantic during World War II, approximately 300 men were rescued from open boats after 52 h afloat. The naval surgeon described the survivors' behavior thus: "Everyone was in excellent spirits, but this amounted in several cases to mild hysteria, as shown by a temporary excitement and garrulousness" (hyperactivity) (22). This garrulousness was also reported among survivors of the sinking of the above cruise liner who had a compulsive need to tell their story: "And they did tell their story, over and over again, to anyone who would lend a willing ear" (30).

Cognitive paralysis: This can lead to 'freezing' behavior or akinesia in the face of danger (47), i.e., the *Estonia* survivor commenting on his fellow passengers reported, "People just sitting in complete shock and me not understanding why they're not doing something to help themselves. They just sat there and being swamped by the water when it came in." In an airline evacuation a passenger sitting next to an emergency exit made no attempt to open the door; even when directed by the cabin attendant to open the exit, she "...did not respond" (80). During an engine fire aboard the Boeing-737 airliner at Manchester airport that resulted in 55 fatalities, passengers were reported as sitting immobile in their seats until overtaken by smoke and toxic fumes (1). Interestingly, an empirical study prompted by this incident observed some volunteers in an airliner simulator as being "behaviorally inactive" (55).

While the above examples are illustrated from different survival incidents, they have been recorded as occurring collectively in a single disaster; namely, an explosion and fire that destroyed a Norwegian industrial paint factory in 1976, killing 6 and injuring 23 workers (85). The report covers the first 15 min of the disaster from the point of the blast (impact phase) until the victims had reached safety (recoil phase). "Motor hyperactivity" was reported among the 125 victims and "[m]otoric paralysis as part of a psychic shock reaction was the most frequent behavioral disturbance. These individuals became stupefied, torpid or completely motionless as in a freezing response, or their movements were rigid, slow, and mechanical, lasting from a few seconds to hours, thus in some continuing into the shock reaction of the immediate aftermath. The other main types of disturbances were various degrees of uncontrolled flight behavior and stereotypical or habitual actions." Furthermore, "Losses of cognitive functions were frequent and of considerable intensity: substantial proportions of the groups appeared to have totally or nearly totally lost their capacity to perceive and think. In the middle range of the disturbed cognitive functions, [...] like narrowing field of attention, selective reinforcements of what has been perceived, fixation to one idea, response perseverance, and stereotypical thinking."

Executive Function

The behaviors commonly witnessed in victims during a survival incident are: loss of initiative, stereotypy, perseveration of thought and action, hyperkinesia, hypokinesia,

and cognitive paralysis. This constellation of behaviors suggests the source of cognitive impairment as being dysexecutive in nature, particularly as the same types of behavior are observed in patients suffering from disorders affecting executive function, e.g., Parkinson's disease, Alzheimer's type dementia, schizophrenia, and Korsakoff syndrome (9,39). Indeed, so close is this mapping that survivor behavior might be considered as a transient form of nonclinical dysexecutive syndrome.

This model of survivor behavior fits well within dual-process theories of executive function that incorporate two separate systems for controlling thought and action (58). At the level of routine actions behavior is controlled by a relatively automatic system (contention scheduler) which modulates stimuli from the environment that may trigger certain actions. In tasks that require attention or planning a separate system is invoked, known originally as the supervisory attentional system and more recently as the supervisory system. The supervisory system is called upon in situations that involve planning, novelty, trouble shooting, error correction, the inhibition of a habitual response, and in situations where attentional control is required.

Normal routine operations, actions, and thoughts are represented by a series of schemata that are run off consecutively. These routines are capable of realizing relevant goals effectively and are selected through the automatic triggering of well-learned perceptual or cognitive cues (73). In routine situations (e.g., skills, habits, or well-learned behaviors), environmental stimuli are sufficient to trigger the activation of relevant schemata that are under the control of the contention scheduler (20,21). It was long considered that the formulation of plans was the role of the supervisory system while the carrying out of plans was the role of the contention scheduler. However, a more subtle distinction has now been made between novel actions involving the supervisory system, routine actions involving the contention scheduler, and everyday actions involving the contention scheduler with some supervisory system input (20,67,68).

A threatening situation often unfolds at a faster rate than the supervisory system can process, placing a high information load on the cognitive system with consequent temporal constraints on the survival response (46). The supervisory system is relatively slow acting and can take between 8-10 s to create a new, temporary schema of behavior (56). Consequently, any threat that unfurls at a rate faster than 10 s cannot be adequately processed by the supervisory system. This leaves behavioral responses vulnerable to dictation by environmental triggers. If an appropriate response has been previously established, then this should be activated by matching environmental and perceptual triggers, e.g., in the event of a helicopter ditching in open water, a person who has successfully undergone helicopter underwater escape training will initiate this escape response rapidly, in the correct sequence, and independently of the supervisory system. However, if no suitable training has been undertaken, then the closest match to the environmental

triggers will be found (e.g., in the event of a stricken airliner, passengers are likely to collect luggage from the overhead bins rather than conduct an emergency evacuation) or no match will be triggered and the victim will remain passive. However, supervisory system impairment does not necessarily impede naturalistic action production through contention scheduler modulation (67). A basic premise of this paper is that a survival situation produces a temporary dysfunction in supervisory system function, resulting in actions and behavior that are fragmented and maladaptive. This supervisory system dysfunction causes difficulty in formulating goals and maintaining appropriate goal-directed behavior in working memory.

Empirical Evidence

Executive and working memory functions were tested during three studies of cognitive function under duress: during a naturalistic threat situation (sport parachuting) and during two military (SERE) survival exercises. In the first experiment the working memory capacity of parachutists was measured under three conditions: control, immediately prior to a jump, and immediately after landing (49). Restriction in working memory capacity was found during the jump phase in both storage and processing capacities. The data also suggested that executive function was affected as indicated by an inability to switch attention to long-term memory. This supports Engle's contention that working memory involves executive control of attention in maintaining information in an active, quickly retrievable state (27).

The second experiment (48) specifically addressed the question of attentional impairment arising under field duress. Significant impairments were found in both selective and sustained attention among aircrew during the field phase of a survival exercise compared to both a classroom phase and a control group. The combination of selective and sustained attention can be considered as executive attention that enables the modulation of working memory capacity (28). This study provided further evidence for possible executive dysfunction occurring under environmental duress.

Executive function is not a unitary process, but rather an integrated yet separable system comprising at least five executive subprocesses (3,18,57). These processes include the capacity to coordinate simultaneous activities; set switching; the suppression of prepotent responses; the capacity to encode (learn), access, retrieve, and manipulate information in long-term memory; and planning ability. In the third study individual measures were taken of each of these processes from aircrew undergoing a survival exercise (61).

The results showed that, while undergoing the survival field phase, participants had significant impairment in inhibition (Stroop test); set switching (random letter generation); and planning ability (Tower of London task). No impairments were found in dual-task performance or in the recall of items from long term memory. The specific pattern of results suggested selective

impairment occurring in the left, but not right, dorso-lateral prefrontal cortex (DLPFC). This suggests the involvement of the contention scheduler either directly as the left DLPFC may be the location of the contention scheduler (57), or indirectly following the suggestion that the role of the DLPFC is the modulation of the contention scheduler by the supervisory system (31). If so, such impairment may lie at the supervisory system-contention scheduler interface.

Cognitive Model of Survivor Behavior

The above studies provide empirical support to the theory that behavior commonly witnessed in survival situations is dysexecutive in origin. Survival requires willful, goal-directed behavior and such goal formulation and regulation is a key function of the supervisory system (20,71). Goal achievement is subsumed by task planning and moment-by-moment task control of actions, especially for goals that are not immediately attainable (59,71). The supervisory system is required for task control that enables a victim to produce different and appropriate cognitive and motor responses to suddenly changed environmental demands (65). Given its proposed structure the supervisory system would be expected to construct a temporary schema of survival behavior through interaction with the contention scheduler in response to a hostile situation. However, survivor testimonies suggest that the supervisory system is often unable either to create such a schema or to create such a schema in the time available. This is significant given that schema formation and activation are necessary for achieving goals (21) and in this instance the goal is survival. This inability to create a temporary and appropriate schema of action is seen in the victim as a loss of initiative. Given this loss of initiative from a temporarily impaired supervisory system it is possible to model the other commonly witnessed survivor behaviors in relation to differential functioning of the contention scheduler.

Supervisory System Impaired and a Normally Functioning Contention Scheduler

In this situation the contention scheduler, although functioning normally, is unmodulated by the supervisory system. Consequently, a person's behavior will be dominated by the prevailing task or environmental triggers (8), which will result in stereotypy, poor set switching, and 'stuck-in-set' responses similar to those found in patients with frontal lobe damage and which can be understood as resulting from absent or faulty contention scheduler modulation secondary to an impaired supervisory system (67,71).

Without supervisory system modulation, a stored schema of action behavior will be triggered by environmental stimuli based on its closest match for firing, although this does not necessarily impede naturalistic action (67). This results in routine stereotypical actions occurring which may not be adaptive to the new situation, e.g., aircraft passengers removing their luggage

from the overhead bins before leaving the aircraft is a routine action and appropriate behavior; however, this behavior, while still 'routine', becomes maladaptive when the aircraft catches fire and life is under threat.

A more extreme clinical form of this response is termed 'utilization behavior', where patients are unable to inhibit actions triggered by their environment, e.g., a patient may be unable to pass a door without trying to open it (74) or, in a survival context, to fire off flares even though no one is around to see them. So, what do people do under threat? They do what they always do. Consider again the capsized sea kayaker whose telephoning his father in the Middle East demonstrates both a loss of initiative in not calling directly for the rescue services and stereotypical behavior such as calling his father, which apparently was a regular occurrence. Thus, once he had a mobile telephone in his hand, the perceptual and environmental triggers activated the schema that resulted in his telephoning his father to obtain help rather than the emergency services, even though he was at risk of drowning.

During the fire in the Twin Towers complex, many people delayed their escape to answer telephones that had started to ring (26). This is a clear instance in which environmental triggers dominated behavior in a survival situation, and again describes behavior that can result from an absent or faulty modulation of the contention scheduler as a result of an impaired supervisory system. Poor set switching results in a reduced capacity for continual reconfiguration between those task sets needed in response to a changed goal (viz. active survival). This ability to switch task sets flexibly, especially in the presence of habitual responses, distracters, interference, and ambiguous stimuli is supported by working memory capacity (41).

Supervisory System Impaired and Hypoexcitatory Contention Scheduler

Impairment in the contention scheduler can disrupt its modulatory function. A hypoexcitatory contention scheduler will have too little inhibitory ability and will result in instability between task sets and action schemata (65) leading to indecision, which is often reported by people in emergencies; e.g., during the King's Cross fire, a young woman reported, 'I could see a big orange glow underneath the escalator. I started to push the people in front of me. I thought about pushing the emergency button to stop the escalator but I didn't know whether that was the right thing' (19). A hypoexcitatory contention scheduler will result in a victim showing hyperkinesthetic behavior, one characteristic of which is a proneness to distraction and impulsiveness. Clinically, such distractibility can result from damage to the supervisory system coupled with an impaired control function of the contention scheduler (25,51,86).

An emergency situation often produces environmental triggers that do not match any survival-related schema of behavior, but might find some correspondence to behavioral schemata which, while not appropriate, possess sufficient subconditions that can raise it above

the threshold for initiation. These partially matched schemata are now in competition, but neither the contention scheduler nor the inhibitory process of the supervisory system is capable of suppressing them. Consequently, shortly after activating one schema, another dominates and becomes activated; then either another is triggered or the first schema is reactivated. The result is that the more irrelevant aspects of the situation are likely to capture control of action or thought, resulting in distractibility and impulsiveness (70,72). The problem for the survivor is that this behavior is captured by routines that are adapted to their former context but not to the current situation. This tendency to perform actions that are associated contextually but are inherently maladaptive is commonly observed in the mundane action slips and the capture errors of everyday life (62,66,69). Such errors in survival situations do not appear to be of a substantially different type from those of routine action slips, but rather of a more pronounced form. In survivors as in clinical patients, action errors, especially when distracted, present as exaggerated forms of errors of normal subjects (20).

In its clinical form hyperkinesia is characterized by an overreaction to environmental stimuli (17) and a difficulty in focusing and maintaining attention when faced with a surge of environmental information. This inability to maintain attention has been found to occur under environmental duress (48) and this evidence supports the view that hyperkinesia is not a primary behavior but occurs secondary to a cognitive and attentional deficit (50). Hyperkinesia can occur through a failure to maintain information or goals in working memory coupled with difficulty in focusing or allocating attention to relevant information (32,34). Again, this view is consistent with findings from empirical studies in survival environments (48,49,61).

Another consequence of a hypoexcitatory contention scheduler is perseveration. In normal circumstances the contention scheduler selects a schema that remains active until it has attained its goal or is actively inhibited by a competitor or higher level control. Without supervisory control a selected schema remains continuously active and, if the contention scheduler is also unable to inhibit this action, will result in perseverative behavior.

There exist two forms of perseverative behavior: continuous and recurrent. In continuous perseveration the patient produces immediate repetitions of actions, whereas in recurrent perseveration the patient returns to a sequence of actions after an interval. Continuous perseveration may be the result of a failure of the inhibitory system, while recurrent perseveration occurs through faulty operation of the signal controlling the selection of schemata held in a competitive queuing system (38). Both types of perseveration have been observed in patients with frontal lobe damage (68) and a double dissociation has been found in perseverative behavior in frontal apraxic patients (38). However, both types of perseveration may arise from a single mechanism with different levels of impairment (20) and the double dissociation in perseverative behaviors is consistent

with the view that continuous perseveration occurs if inhibition following completion of a schema is insufficient, while recurrent perseveration occurs from decay of information concerning goal achievement (21). Accordingly, continuous perseverative behavior is considered to arise due to an insufficient inhibitory process (20,39). Where perseverative behavior does occur in survival situations, it appears to be of the continuous type; that is, once a victim has broken out of a perseverative action, he does not appear to return to it, suggesting insufficient inhibition as the cause rather than a decay of information.

Supervisory System Impaired and Hyperexcitatory Contention Scheduler

In this instance the modulatory function of the contention scheduler is impaired by being overly active and suppressing the various schemata that are competing to be triggered. This suppression may occur either by raising the schemata trigger threshold or by active inhibition of their firing and differs from normal inhibition, which is a deliberate, controlled suppression of a prepotent response. The result is a victim who is very slow to respond (hypokinetic), usually with concomitant impairment in volition (apathy), or who remains unmoving in the face of danger (akinetic).

Actions generated in a survival situation are frequently slow in initiation. However, once initiated they seem to proceed at normal speed; that is, behavior is characterized by hypokinesia but not bradykinesia. The terms hypokinesia and bradykinesia are often confounded, but the author adopts the following definitions: hypokinesia is a defect in an action-intentional system that results in an action being initiated after an abnormally long delay and bradykinesia refers to a slowness of movement itself and is independent of the time to initiate movement (37). Slowness in initiating a response arises because at the beginning of the task there are several competing schemata with similar activation values and time is needed for these competing schemata to be sorted (21). Once this competition has been resolved and the first action undertaken then any slowing after task onset is slight and this effect disappears when task constraints are strong. Hypokinesia is reduced significantly when action is highly constrained with little competition between alternate actions. In a hostile situation appropriate survival actions can be constrained through task prioritizing and this method is taught as action drills on many survival courses.

Survivor testimonies clearly report that victims do take an abnormally long time to initiate an action during the impact phase; however, once initiated actions appear to proceed normally. Similar responses have been found in Parkinson's disease patients on the Tower of London test (60). During the recoil phase, however, victims frequently report a delay both in initiating action and a slowing in the carrying out of their action; that is, both hypokinesia and bradykinesia are present, with bradykinesia arising from inadequate operation of the

contention scheduler (21). This observation is consistent with a study that found participants took longer both to plan and to execute moves on a Tower of London task compared to a control group during a 5-d field survival exercise, although both groups made comparable numbers of moves (61).

This delay in initiating appropriate survival behavior may account for some parachuting deaths. A study of 241 sport parachuting fatalities between 1993 and 1999 found that 26 (11%) were due to a failure to pull the reserve parachute deployment handle in time (35). This failure may be due to a slowing down in information processing at the executive level, resulting in more time being needed to switch attention to activating the emergency deployment action schema stored in long-term memory (49).

Impairment through hyperexcitation of the contention scheduler can last for long periods, with clinical patients showing symptoms of apathy and a loss of initiative for usual daily activities (50), including eating and drinking. Apathy describes an intense quantitative reduction in goal-directed behavior and is known to co-occur with dysexecutive syndrome (52). Apathy has been reported frequently among people in survival situations, including those in concentration and prisoner-of-war camps; the Japanese referred to this condition as 'do-nothing-sickness'.

Apathy is counter-productive in a situation that requires goal-directed behavior for survival and it appears not to be related to depressive disorders (50). This view is supported by a study that investigated depressed behavior among a group of military personnel undergoing a harsh winter survival exercise. No evidence of clinical depression was identified over a 3-d period from such measures as speech rate, word frequency, and Beck's depression inventory despite clear observation of apathy, withdrawal, and depressive type reactions in some individuals. While apathy is usually associated with impairment in volition it can also be expressed in executive form as bradyphrenia and presents as a difficulty in generating new rules or strategies, or a difficulty in shifting from one mental and behavioral set to another. Apathetic behavior may be overcome by strong intervention, as reported in clinical settings (11,42), and hence the effectiveness of strong leadership in disasters.

Akinesia is often expressed clinically as akinetic mutism; that is, the patient presents a silent immobility despite the motor pathways and speech centers being preserved (83). Akinesia results in the victim failing to respond to even simple commands; e.g., many people on the *Estonia* were, '...passive and stiff, despite reasonable possibilities for escaping' (40). This behavior arises clinically when the motor, cognitive, and limbic systems are disconnected from the frontal circuits (53), which again supports the idea of survivor behavior resulting from impairment in supervisory system function.

It is certainly possible that a hyperexcitatory contention scheduler can produce 'freezing' behavior or akinesia. Despite the common view that when faced with danger the body prepares for one of two responses,

'fight or flight' (16), even a cursory reading of survivor testimonies clearly reveals a commonly presented third type of behavior: namely, a temporary confusion coupled with physical immobility; in other words, a 'fight, flight, or freeze' response (46). The initial 'freeze' response corresponds to physical immobility coupled with a state of hypervigilance or guarded alertness that seeks to detect movement in the environment (12). Consequently, the correct sequence should be 'freeze, flight, fight'. Tonic immobility can be considered as a 'fright' response which usually occurs during actual physical contact with the threat and may be an adaptive survival behavior in both animals and humans; e.g., a tonic immobility and feeling of paralysis despite remaining conscious that has been reported by many rape victims (33).

Supervisory System and Contention Scheduler Unimpaired But With Impaired Interface Communication Channel

During the recoil phase of a survival incident the victim begins to recover cognitive and executive function. However, despite recovered function in the prefrontal cortex and other cortical and subcortical structures, the communication link between these may remain dysfunctional. This is where the interface between the supervisory system and the contention scheduler is impaired.

Controlled processing as provided by the supervisory system is defined by a subjective experience of awareness; that is, an ability to reflect upon processing attempts and behavior. This includes the idea of agency or the experience of oneself as an agent of one's own behavior; the feeling that cognitive processing is effortful and the awareness that automatic processes are occurring, but that they can be counteracted with motivation (5–7). Survivor testimonies often describe a situation in which there is awareness of one's behavior and even awareness that the behavior is wrong, but that the victim is unable to intervene to correct it. Despite this conscious awareness the supervisory system is unable to communicate inhibitory information to the contention scheduler, as in the example above where an airman was instructed to give his name but responded repeatedly with his call-sign despite being aware that this was the wrong response.

An impaired interface might also account for the sensation of 'splitting' when under threat. In such instances the victim senses that he is watching his own actions as an indifferent observer; e.g., a medical officer who came under a bombing attack reported, 'It was strange that [my] mind functioned on two levels, one of which seemed to be watching [me] from a distance. It watched [me] hugging earth close to a tree trunk [which] was spattered with shell fragments' (63). One Jewish physician described similar sensations in a Nazi concentration camp: '...these horrible and degrading experiences somehow did not happen to 'him' as a subject, but only to 'him' as an object' (10).

Such sensations are accompanied by a lack of emotion, suggesting a dissociative reaction in which the cognitive

and affective functions are split (15). This 'splitting' often takes people by surprise because it runs counter to the idea of being an agent of one's own behavior and the victims wonder how they can be so emotionally indifferent while among devastation and loss of life (44). Such cognitive-affective splitting can be explained as a consequence of impairment in the communication link between the supervisory system and the contention scheduler while assuming otherwise normal, or near normal, functioning of both.

That the supervisory system is involved with emotional feelings is supported by the intimate linkage between the frontal lobes and the limbic system which plays a significant role in affect and self-awareness (77). As one example, humor can be considered as a noncognitive aspect of executive function and patients with lesions to the superior right frontal polar-medial region show impairment in appreciating verbal and nonverbal humor (76). Consequently, the right frontal lobe is required for the convergence of cognition and affect essential for humor. This suggests that a further consequence of dysexecutive syndrome is an impaired ability to appreciate humor, which is interesting given that the loss of a sense of humor is a signatory characteristic of a victim of a survival incident while recovery of a sense of humor is characteristic of a survivor (44). It is surely no coincidence that a person's sense of humor is the first quality to go in a survival incident and the last to return.

At the extreme end of behavior lies psychogenic death, in which victims can perish through psychological disintegration. Once this stage is reached then dying is simple. The observed behavior is consistent across witness testimonies and one typical description comes from a survivor of a sinking who reported his fellow passengers in the liferaft dying: 'I had no thought people could die so easily. Their heads just fell back, the light seemed to go from their eyes, and it was all over'. A doctor in a Korean PoW camp saw in certain victims '... symptoms you could assess without being able to describe them: a listlessness, a look, a turning from reality. When their symptoms appeared in various degrees and varying combinations, you could estimate very closely how long a particular man you come to know well would cling to life' (44).

Communication works both ways and one role for the supervisory system is the retrieval of information from long-term memory (3,4,75). That survivors have trouble remembering information that can be critical in aiding their survival is well documented. Consider the following example: A Royal Air Force bomber pilot shot down over the North Sea in 1941 managed to climb aboard a dinghy with other surviving crewmen. In the small hours of the morning they heard an aircraft approach. He reported, 'We shouted and waved, but never saw it: only heard it disappearing into the night. Afterwards we remembered the distress flare and almost wept at our stupidity' (84).

As well as retrieving information from long-term memory, the supervisory system is responsible for transferring

new information from working memory to long-term memory, and there is evidence that this communication may also be disrupted under threat. Poor learning of words in skydivers while jumping compared to learning on the ground is argued to be due to poor encoding under extremely emotionally arousing circumstances (79); also, some parachutists were unable to recall events that happened during their first jumps (13). Furthermore, difficulties with the recall of events following traumatic incidents are well documented (24).

Conclusions

The author has attempted to answer the question: why does normal, goal-directed, purposeful and coordinated behavior break down in a survival situation? I also attempt to place survivor behavior in a formal cognitive context rather than viewing it simply as a haphazard set of responses. This model should support survival training [e.g., military SERE training, combat (see 36), aviation, marine survival, etc.] and provide a context for conducting behavioral autopsies by accident investigators.

The model proposed here is based on a dual system of control involving a supervisory system and a contention scheduler that modulates well-learned or simple actions (58). Under normal circumstances goal-directed behavior is guided by internal representations rather than being triggered exclusively by external environmental stimuli and executive processes are required to modify behavior following significant changes in the environment. A survival situation is often unpredictable and requires survivors to have flexibility in adjusting their behavior as events develop. Many people who function normally on a daily basis show behavioral dysfunction during a survival incident, in particular a weakened ability to adapt and regulate their behavior. Instead they manifest a pattern of behaviors comprising loss of initiative, perseveration of thought and action, hyperkinesia,

hypokinesia, and even akinesia that characterize executive dysfunction. I propose that survivor behavior can be explained as a functional impairment in controlled supervisory processing either alone or coupled with a dysfunctional contention scheduler (See Fig. 1).

This is important because survival is about creating options and options need initiative. An impaired supervisory system, but with a normal functioning contention scheduler, will produce stereotypy. A hypoactive contention scheduler will result in hyperkinesia, distractibility, and perseveration, and a hyperactive contention scheduler results in hypokinesia or even akinesia.

Survival situations are not ‘natural’ in that they are not common occurrences at the individual level. Consequently, a victim’s behavior may be natural in that it is everyday behavior, but unnatural in that it is maladaptive to the changed circumstances. This observation has implications for training. Those in occupations considered to carry high risk do undergo survival and emergency training (e.g., merchant seamen, aircrew, armed forces) so that naturalistic behavior produced by the contention scheduler is a more appropriate and readily available match to the emergency situation as natural actions but not everyday actions.

A threatening environment results in both a depletion of executive resources and a restriction in attentional capacity which hinders people from interfacing flexibly with their environment in a goal-directed manner (48). This makes it difficult either to maintain task-relevant information in an active state or to suppress unwanted environmentally triggered stimuli from entering working memory. When these goal states are not actively maintained by working memory then behavior becomes disorganized, perseverative, or otherwise maladaptive. Without sufficient resources controlled processing breaks down, resulting in an environmentally induced decrease in attentional control.

The impact phase of a survival incident is sudden, violent, often uncontrollable, and carries a high information

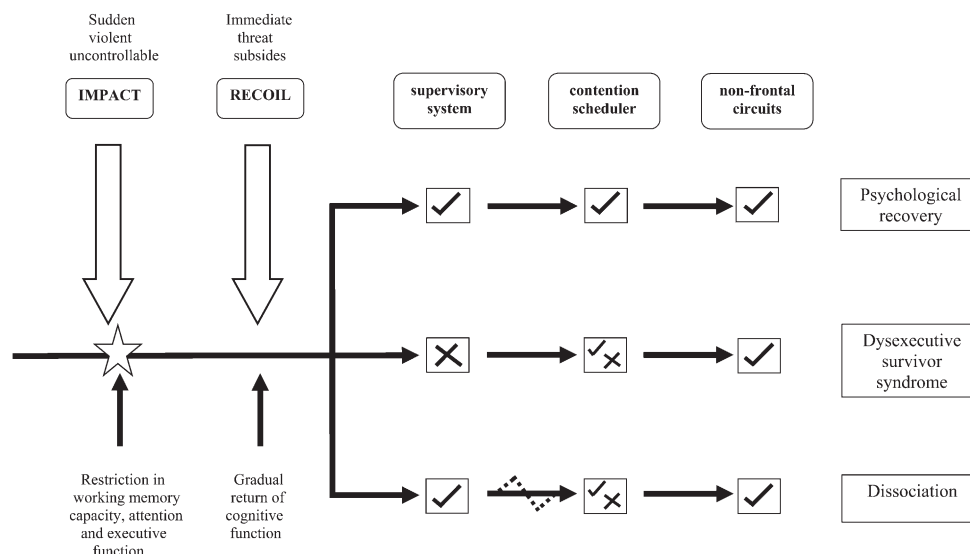


Fig. 1. Schematic of survivor behaviors.

load. During the following recoil phase symptoms of a transient, nonclinical dysexecutive syndrome become manifest and the difference between survivors and victims becomes apparent. Survivors show rapid recovery in both supervisory system and contention scheduler function and are soon able to look after themselves in setting survival goals, implementing action sequences to support those goals, and in inhibiting unwanted actions. Victims, however, continue to show dysexecutive syndrome for a significant time during the recoil phase and may perish before they can be actively recovered by others such as rescue services or other survivors. There also appears to exist a special case in which the victim shows functional recovery in both supervisory system and contention scheduler function yet the modulatory link between the two is not sufficiently re-established. In this case the victim shows awareness of the situation, but the concept of agency is faulty, giving rise to a sense of dissociation; in other words, the victim views his actions as though he were a third person able to observe himself but not to control himself.

To conclude: survival requires goal-directed activity, yet a survival environment depletes executive resources, and biases processing away from goal-directed tasks and toward behavior captured by environmental stimuli. This presents as a transient, nonclinical, dysexecutive survivor syndrome.

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