A Primer on the Neurocognitive Science of Aggression, Decision Making, and Deterrence

Diane DiEuliis, PhD
Center for the Study of Weapons of Mass Destruction,
National Defense University,
Ft McNair, Washington, DC

James Giordano, PhD
Departments of Neurology and Biochemistry,
Georgetown University Medical Center
Washington, DC

Strategic Multilayer Assessment (SMA) Periodic Publication

Introduction:

There are numerous national security challenges relative and relevant to the aggressive and/or violent intent and behavior of individuals, groups, and societies. In an ever more networked world, the ways that people think, emote, and behave are being increasingly affected by social, and informational factors; many made possible or fortified by the iterative use of various forms of technology. Despite demonstrably positive outcomes of such trends, there are also clear and present burdens, risks, threats and harms in the geo-political sphere that current and near-future social and technical developments can, and likely will incur.

A recent global risks study by an international forum of experts elucidated such geo-political and societal threats to national security, and emphasized interactive elements including social instability, individual and groups' vulnerability to social volatility, radicalization, terrorism, and interstate conflict, as being strongly contributory[1]. Each and all of these factors can be conceptually and practically reduced to the decisions and actions made by individuals, and/or groups, whether acting alone or as state actors. Attempts to investigate contributory variables and possible causes of such threats to social stability and peace have entailed a variety of disciplines (e.g. - social and political sciences, anthropology, psychology, economics, etc.). Thus, resulting theories of correlation and causality reflect the diversity of these disciplines' approach(es) and focus, to include resource scarcity, perceived unfairness, pride/nationalism, vengeance, anticipation of reprisal, preservation of cultural norms, and risk/threat and fear of harm, and/or death. Such studies have paved the way for various agencies within the United States government (USG) to consider the use of a variety of tools to address these issues in national security, intelligence and defense (NSID) operations to prevent violence, deter unwanted actors, and foster cooperation.

Neural Mechanisms of Human Cognition and Behavior

However, somewhat absent from these studies has been appreciation for, and specific address of (neuro) biological factors that may be influenced by – and may influence – psychological, behavioral, social and group effects and outcomes. This may be considered as a practical limitation, in that organisms (including the human organism) are biological entities that exist in, and physically and psychologically interact with other organisms within social environments. Thus, developing a better understanding of underlying neurobiological factors that are involved in, and instrumental to human decisions and behaviors may be important – and operationally valuable – to developing effective means for achieving fundamental USG goals in the national security space.

[1] http://reports.weforum.org/global-risks-2016/

In recent decades, the neurosciences have made ardent strides in studying and demonstrating neurobiological mechanisms that are involved in cognition, emotions, behavior, including decision-making (in and under a range of contexts and circumstances, respectively). Advances in, and combined use of various neurotechnological assessment tools, such as brain imaging and molecular genetics, have enabled more precise depiction of brain structures and functions engaged in various forms of human thought and action. So while human behavior cannot, nor should not be reduced to the mere activity of brain cells and chemicals, the structures and functions of the brain are involved to varying extent(s) in sensitivity and response to a host of (internal and external) environmental stimuli. As a consequence of this expanding capacity of neuroscientific investigation (and intervention), there is a broadened and deepened understanding of the role of neurobiology in human psychology and anthropology, and this has afforded a somewhat new picture of human behavior - as a complex interplay of bio-psychosocial factors that develop and occur over varying time periods in particular environments.

Such advances in neuroscience and neurotechnology (neuroS/T) have prompted both ongoing assessment, and governmental/Department of Defense (DoD) endorsement of combined use of neuroS/T and socio-behavioral approaches to address complex problems that are of interest and value to national security. Yet, it is important to note and acknowledge that the United States is not the only nation that is dedicating efforts (and subsidy) to explore and capitalize upon research and development of neuroS/.T that may be operationalizable in NSID efforts[2].

Neuro-ecology and "Neuro-deterrence"

But while neuroS/T provide tools and techniques that can be employed in certain NSID agenda and operations, it is critical to reiterate that neuroS/T – and neurobiology - alone should not be relied upon to explain or affect human thought, emotion and behavior. However, it is equally important to recognize the role that neurobiology plays in human psychology and actions, and the reciprocal interactions of bio-psychological factors and environmental factors. As shown in Figure 1, such interactions occur on a variety of levels, and to varying extents. This dynamic interplay of neural and psycho-sociocultural engagement has been termed "neuro-ecology" (i.e. - the study of interactions between neurological and environmental variables. Individual and group neuro-ecology influences awareness, orientation, decisions, and responses toward other individuals and scenarios, that operative in the range of human cognitions and actions, inclusive of those contributory to amiability, affiliation, fear, disgust, aggression, and violence. Thus, understanding the neurobiology of human behavior, within a particular neuro-ecological frame, can provide added dimensions to formulating approaches to preventing, or mitigating (i.e.- deterring) fear, volatility, aggression and violence, and to promoting affability, and cooperation.

Prior work by our group has focused on the neuroscience of both aggression and deterrence, and we have used the term "*neurodeterrence*" to refer to the consideration and application of evolutionary neurobiological information and approaches within deterrence theoretical construct to affect neuro-cognitive substrates of vulnerability volatility, and hostility. As the security environment becomes

[2] The Human Brain Project, https://www.humanbrainproject.eu/

increasingly complex and fluid, and given limited time and funds, choosing an ineffective approach can be costly (in terms of time, effort and outcomes). In this context, we posit that chances for success could be increased by incorporating existing and newly developed neuroS/T tools, and neurodeterrence-type approaches that are valid and viable for operational employment.

A fundamental first step in any attempt to gain insight to, and assess the viability of current and newly available neuroS/T methods and tools is a basic knowledge of how neurobiological systems function in cognition, emotions and behaviors relevant to settings and effects of NSID concern. To that end, this primer condenses and highlights the major findings of current literature, several deep dive white papers, and additional recent observations to provide an overview of neurobiological processes of fear and aggression, decision-making and violent behavior, and how these processes might be accessed and affected to promote deterrence.

In this way, this primer will serve to make these fundamental neuroscience findings accessible so they can be evaluated, and/or incorporated for use in operational NSID strategies and tactics. It is intended to be used as pre-reading, and/or a simplified educational companion to accompany the following Strategic Multilayer Assessment (SMA) group white papers:

> *Assessing and Anticipating Threats to US Security Interests: A Bio-Psycho-Social Science Approach for Understanding the Emergence of and Mitigating Violence and Terrorism* (March, 2016)
>
> *Countering Violent Extremism: Scientific Methods and Strategies* (July 2015)
>
> *The Science of Decision Making across the Span of Human Activity* (May 2015).
>
> *Leveraging Neuroscience and Neurotechnological (NeuroS/T) Development with Focus on Influence and Deterrence in a Networked World.* (May 2014).
>
> *Topics in the Neurobiology of Aggression: Implications to Deterrence* (February 2013)

This primer describes a three-part model (as shown in Figure 1, below), which is based upon and affords insight to the interplay of aggression, decisional processes and deterrence to which neurobiological, and other human terrain team-based information may be incorporated and employed to engage NSID operations.

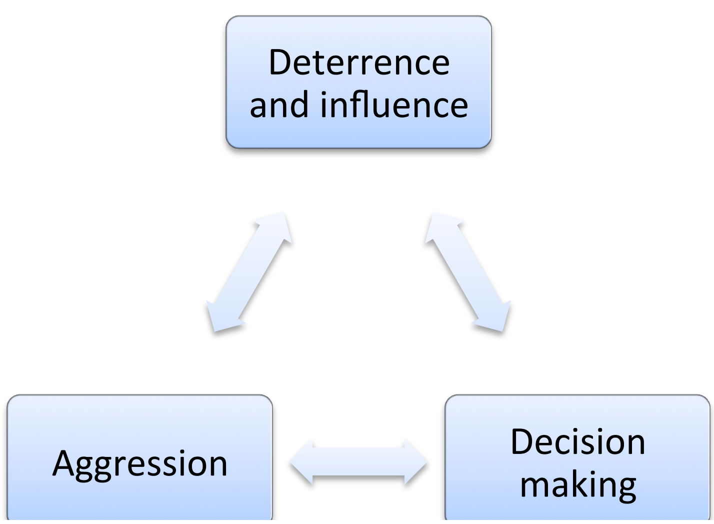


Figure 1

Reciprocal interactions of decision-making and aggression, and capacity to affect and be affected by defined approaches to deterrence and/or influence, as explained in the text.

The Basic Neurobiology of Fear and Aggression

Neurobiologic processes of fear and aggression are strongly contributory to violent behavior, as (1) apprehension (i.e.-fear") of harm (to self, kin and kith) can induce fight or flight responses; and (2) aggressiveness and violent actions often result from these primal emotions. There are two primary types of aggression: impulsive and premeditated, the former occurring more commonly in response to environmental cues, while the latter is purposefully committed with intent toward specific harm. While much is known about the neurobiology of impulsive aggression, less is known about the pathways involved with premeditated aggression. It appears, however, that many of the same brain nodes and networks are involved in both types of aggression. Three brain regions are of primary importance to mediating aggression and the precipitating emotion of fear: these are networks of the *amygdala,* and *hippocampus,* which are components of the *limbic system,* and the *frontal cortex,* which while not a limbic structure per se, receives input from, and provides input to limbic networks, as well as other cortical and sub-cortical regions of the brain. (see Figure 2).

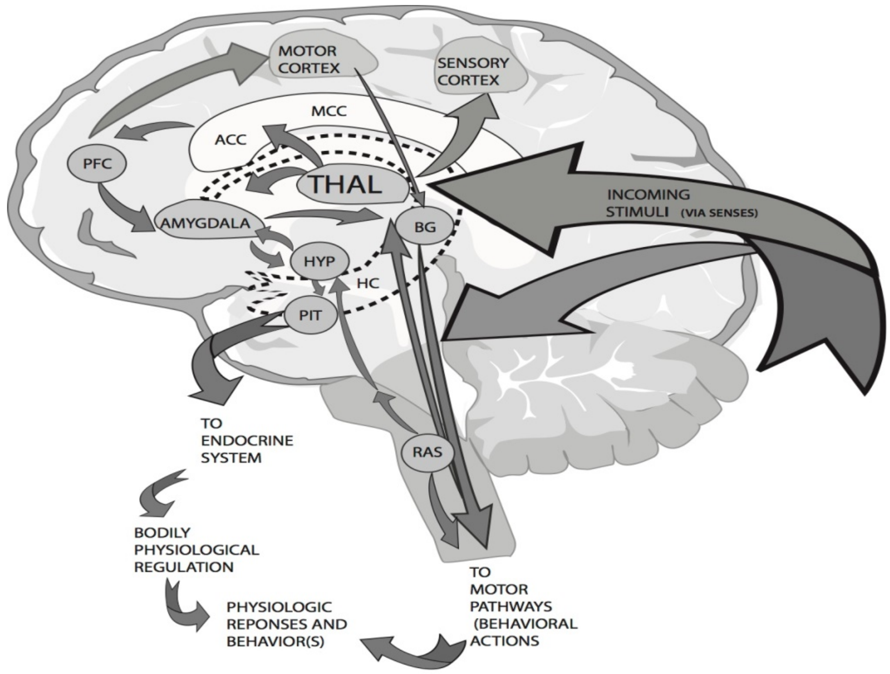


Figure 2

Schematic representation of brain regions and networks involved in fear, aggression and aspects of decision-making, inclusive of body-to-brain processes (i.e.- "bottom-up" mechanisms) that relay input to the brain, and the brain-to-bodily processes (i.e.- "top-down" mechanisms) that regulate hormonal (endocrine) and other physiologic responses that are operative in exerting various behaviors. Note that the hippocampus (HC) is not completely shown, but is represented as dotted lines in order to allow view of other brain structures and networks. Arrows demonstrate interactions between various brain regions and key nodes within networks, as described in the text. Structures are not drawn to scale; refer to text for further detail.
Abbreviations: ACC= anterior cingulate cortex; BG = basal ganglia; HC= hippocampus; HYP= hypothalamus; MCC= medial cingulate cortex; PFC= prefrontal cortex; PIT = pituitary gland; RAS= reticular activating system; THAL = thalamus

Networks of the amygdala play an important role in "emotional" tone, as the amygdala receives sensory (i.e- visual, auditory, tactile, olfactory) inputs from pathways from the brainstem, thalamus, and sensory, associate and cingulate cortex. Summation of these inputs can result in the "fight or flight" response: once key areas of the amygdala are activated, it directly or indirectly stimulates other brain regions (e.g.- specific nuclei of the hypothalamus, and the reticular formation of the brainstem) to activate the sympathetic nervous system, prompting release of stress hormones and engaging "fight" or "flight" responses that mobilize various bodily functions (e.g. - elevated heart rate, blood pressure and respiratory rate, increased muscle tone, increased glucose metabolism), etc. This system has provided humans (and other animals) with an important survival mechanism by facilitating either resistance against, or escape from threatening events. The dual role of amygdalar networks in mediating both fear and aggression is critical; in modern society, these networks are "primed" to function to evoke fleeing (i.e.- avoidance) or fighting (i.e.- aggressive) responses, and are operative in, and contributory to such human behaviors in scenarios that are perceived as psychologically – if not physically – threatening.

Obviously, for *any* perception to occur, memory (and learning) must be involved. Simply put, in order to perceive what something "is" and whether it is "good", "bad" or "neutral", it is vital to (first) recognize it, and (then) situate it within contexts and results of prior experience. To do this, the brain works to (1) integrate sensations and perceptions in the present, with (2) prior experiences (and what has been learned from them), so as to (3) prompt thoughts and feelings that influence current actions, which will evoke some consequences that evoke (near-, intermediate- and long-term) future effects (upon both the actor, and others). Learning and memory play important roles in these processes, and much of learning and memory function involves networks of the second limbic component: the hippocampus (and its interactions with nearby – i.e.- para-hippocampal -regions of the cortex).

The third component, the frontal cortex, is part of the “cognitive” network of the brain. It receives, processes, and sends signals to coordinate activity of a number of other (cortical and sub-cortical) brain areas, including various structures of the limbic system. In this integrative and “executive modulating” function, the frontal cortex is involved in and mediates aspects of decision-making, long-term planning, emotional regulation and impulse control. Importantly, the networks of the amygdala-frontal cortex are not uni-directional, but are reciprocally interactive. Excitatory and inhibitory feedback loops between the amygdala and frontal cortex are important to processes mediating whether emotional impulses are reasoned (i.e.- modulated/suppressed) or expressed, and are contributory to decisions about the restraint or execution of (impulsive or deliberative) behaviors.

The frontal cortex is more anatomically complex in humans than in most other species, and is the last brain region to mature during human development (with complete maturation and inter-connections to other brain areas not occurring until 20-25 years after birth, with maturation somewhat later in males than females). Thus, individual differences can exist in frontal cortex function that are predicated on sexual phenotype, and interactions of biological substrates with ecological cues that foster learned patterns of perception to various environmental and inter-personal stimuli as a consequence of experiences both in early life, and throughout the lifespan.

As well, situational variables, such as group/social circumstances can differentially engage these networks to evoke individual feelings and responses of concordance/reinforcement/reward or discordance/suppression. These (often subtle, but frequently influential) differences are important to appreciate and acknowledge when assessing both individual and group patterns of cognition, emotion and behavior. Thus, the context in which affiliation and/or aggression occur is vital to any consideration of how neurobiological factors can be/are activated and engaged. Such engagement of these networks can be elicited by a host of factors that directly affect physiology (e.g. - drugs, neurotechnological devices, and even environmental variables such as temperature, resources, etc.) to engage the brain in a so-called body-to-brain, or “bottom-up” process, or more indirectly by situational and/or informational stimuli (e.g. - narratives, psychological conditions, etc.) that evoke both bodily responses (i.e.- “bottom-up”), and which engage limbic and cortical networks to activate brain-to-body (i.e.- so-called “top-down”) physiological effects (e.g.- endocrine system-mediated hormonal changes, and behavioral responses; see Figure 2 for diagrammatic representation of these substrates) .

While these three networked regions of the brain play principal roles in fear and aggression, a number of other brain structures and affiliated networks have also been shown to be involved in aspects of aversive and aggressive cognition and behaviors. These include:

The thalamus: which serves relay of several networks and pathways, and acts to modify and integrate activity of sensory and motor tracts to/from the cortex and limbic system.

The sensory, associative and motor cortex: which function to integrate sensory and motor activity, and relay such information to other areas of the cortex and sub-cortical brain regions.

The medial and anterior cingulate cortex: which are involved in integrating bodily perceptions, expectation, and perceptions of the relative “noxiousness” of various stimuli.

The insular cortex: which is involved in subjective emotional experiences generated by bodily sensations, inclusive of feelings of disgust and aversion, with the anterior insular regions being strongly implicated in regulating fear, anger, sadness, happiness, arousal, unfairness, uncertainty, social exclusion, trust, and empathy

The basal ganglia: which are a group of structures (i.e. - the caudate nucleus, putamen, and globus pallidus) that are involved in preservation of ideas, escalation of impulses and impulse control and execution/modulation of movement and behavior.

The hypothalamus and hypothalamic pituitary axis: the hypothalamus is a group of cells (i.e. - nuclei) that receives both input from a number of brain networks, as well as direct input of hormones and other biochemical substances from its rich vascular network, and which modulates the activity of the pituitary gland to exert control of the endocrine (hormonal) system via a feedback system to mediate a number of physiologic processes, including responses to stress.

The reticular activating system: is a collection of cells and networks in the brainstem that both receives input from sensory pathways, and which is engaged by “top-down” processes involving limbic and hypothalamic inputs to exert control of the sympathetic nervous system to modulate responses to stress.

These brain regions and networks operate in concert to exert patterns of cognition, emotion and behavior in response to various stimuli, as based upon prior dispositions incurred through genetics, environmentally-influenced expression of phenotypes (i.e.- gene-ecological interactions), and (socio-cultural) situationally-conditioning/learning.

Key Points:

- *Overall limbic system functions:* learning/memory; emotional regulation
- *Amygdala network functions*: emotional ‘tone’; passivity and arousal
- *Hippocampal network functions*: memory, and integration of prior and current experience
- *Frontal cortical network functions*: cognitive processing; emotional regulation, executive decisions
- *Brain networks*: function in organized ways to influence limbic and cortical systems to mediate patterns of thought, feeling and actions based upon learning and memory of various situations, and their relative meanings.

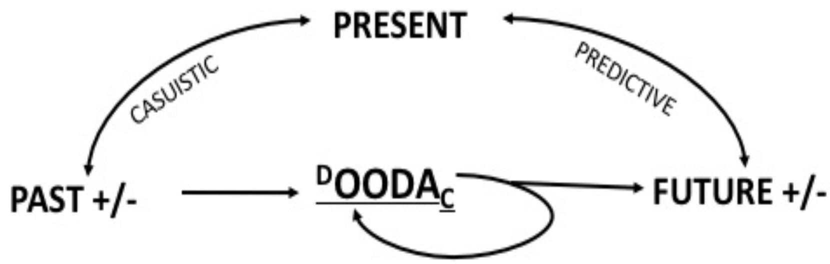
Fundamental Take-aways: Understanding Neurobiological Factors in Fear and Aggression.

1) Fear and aggression are linked to conflict and violent behavior;
2) Aggression can be impulsive or premeditated – the latter is frequently defined as the "intent to do harm".
3) Neurobiological processes mediating fear and aggression evolved as important for survival. These networks remain somewhat 'primed' to influence behavior in a variety of everyday scenarios that may be perceived to entail affiliation, hostility, and/or threat.
4) Neurobiological processes that control fear and aggression have several common features in and across individuals, but also can vary between individuals, as a consequence of differing genetic, physiological, environmental/situational factors that interact both during development and through the lifespan.
5) Biological factors tend to not cause aggression, per se, but rather modulate responses to contextual stimuli.
6) Neuroscientific studies of human behavior suggest aggression can be a useful, but costly strategy in terms of evolutionary survival, and consequently, humans have evolved a tendency to cooperate in many social situations. This tendency for cooperation may be compromised in situations of great threat or high stress.
7) The contexts in which aggression and violence occur can be modified somewhat more easily than attempting to identify individuals likely to commit aggressive acts.
8) *What can be assessed may be affected*: currently available neuroS/T methods could be utilized to directly and/or indirectly assess and affect these brain systems to influence/deter certain patterns of individual and group cognition, emotion and behavior.
9) In these ways, neuroS/T may provide a viable toolkit to augment and synergize other methods that are currently available for influence and deterrence within the operational space.

Neurocognitive Processes of Decision-Making

In order to influence, deter, or encourage cooperation among groups and societies, it is crucial to understand their motivations and what factors influence their ways and types of decisions. There are a number of theories as to how human beings make decisions, which draw upon and contribute to an extensive literature on associative learning, the psychology of game theory, prospect theory, and rational choice theory. Many of these are now being tested by employing advanced approaches in neuroS/T. In light of this, and apropos to an understanding of the neurobiological aspects of aggression and violence, an examination of the neuro-cognitive processes of decision-making is equally important to both understanding and influencing how human beings behave in the environments and contexts in which they live.

To date, studies of the neurocognitive processes of decision-making have centered upon the role of neural mechanisms of risk and reward/benefits. Recent findings suggest that neurocognitive processes involved in the evaluation of relative benefit and risk/harm also involve concomitant recollection, estimation, and valuations of broader contexts of current and prior experience, in order to establish a basis for actions that can evoke particular consequences (as related to benefits and risk/harms to self and specified others). As shown in Figure 3, the overall schema of this process can be based upon Boyd's "Observe-Orient-Decide-Act (OODA) loop", but embellished to incorporate relevant neurocognitive elements of (pre-)disposition (based upon prior experiences and the emotive aspects of their memory), consequences (of action), and the incorporation of the emotional aspects of these experiences into current and future dispositions toward certain biases in observation, orientation and decisions.



.

Figure 3

The D-OODA-C loop. Past experiences serve as basis for (positive and negative) memory and learning formation, which (1) establish dispositions to observation, orientation and decision-making, to (2) facilitate prediction of likely future consequences of the various currently possible actions, which (3) feed back to affect (i.e.- fortify or mitigate) dispositions via effect(s) upon memory and learned conditionalities. Retrospective (i.e. - present-to-past) cognition engages casuistic (i.e. - case- and experience based) analyses. Prospective (i.e. - present-to-future) cognition engages predictive analyses and expectation of gains and losses (see below, for further detail).

This D-OODA-C ("doo-dak") loop simplifies and summarizes the overall functions of the neural systems involved in cognitive processes of decisions, inclusive of those that are instrumental to aggression and violent behaviors. Not surprisingly, the brain networks that are primarily participatory in human decision-making involve the aforementioned (limbic, sensory and arousal) systems. Components of this "decision-circuitry" have been parsed into two major sub-systems: The first is the "valuation network", which is operative in assessing the relative "effect and worth" (i.e. - value) of various environmental stimuli. This affords a component of motivating behavior that enables both (1) comparison of different rewards among actions, and (2) discrimination between given choices.

The basic operation of this valuation process can be approximated by, and depicted in the equation:

$$V = E_G - E_L$$

in which the overall value (V) of a decision (and/or action) reflects those expected gains (E_G) from which any expected loss (E_L) will detract, and where the nature and effect of such gains and loss are focal to the “impact” upon self and others in a given circumstance. A second network, the “cognitive control network”, axiomatically functions to modulate cognitive patterns (inclusive of emotional tone) in the regulated inhibition or implementation of actions once rewards (and potential harms) have been assessed.

Sensory inputs provide informational content and context for neurocognitive decision processing, with distinct regions of the cortex being involved in abstract cognition versus concrete cognition (an example of the former being the decision to operate a vehicle; while the selection of physical skills used to execute the task is exemplary of the latter). Studies have shown that individuals: 1) tend to avoid decision-making under ambiguous conditions; 2) are loss-aversive, and 3) generally devalue delayed rewards. These findings support that both reward and risk are often perceived in ways that aren’t necessarily analytical, but instead, are more emotional (although emotional biasing may not always be consciously apparent).

The brain’s reward system responds both to primary rewards (for example, food) as well as to more abstract social rewards (such as receiving positive social feedback or increased social status). These systems function in what is regarded to be a “fast cognitive” pattern (e.g. - in response to stimuli that pose an immediate benefit or threat), and “slow cognitive” pattern (e.g. - to engage a more prospectively analytic mode to “plan ahead” in less proximate ways). A growing body of evidence suggests that social signals can shape responses to stimuli within the reward system that would otherwise be received as neutral. For example, learning that peers believe that one type of face is more attractive than others increases an individual’s reward response to that face; and believing that a particular wine is more expensive increases the reward response and ultimately the subjective perception of how good it tastes.

Human decisions in the face of the threat of punishment tend to heavily engage limbic networks (and conjoined input from the associative, temporal and anterior cingulate cortex), to involve strong activation of (specific areas and pathways of) the amygdala. In general, stimuli and situations that present higher risk and threat of punishment incur a greater likelihood that decision-makers will avoid taking action; and often punishments that are completely unavoidable or inescapable can foster a reduction of a broad range of behaviors, rather than mitigating a specific behavior or set of behaviors (this effect is referred to as “learned helplessness”). However, there are also threats to humans that go beyond fear and inhibition, to the point of provoking defensive actions, and these can be seen as analogous (if not homologous) to processes observed in a “cornered animal”.

Additionally, the more proximate and likely the threat, and the fewer (and evidently decreasing number/viability of) options or actions for avoidance or escape, the greater the potential – and probability - that it will evoke defensively assertive if not aggressive action(s).Thus the notion of *deterrence* (i.e. - threats posed to *prevent* particular actions) is relevant, and differs from *compellence*, in which threats are posed which *require* particular action be taken. Simply put, as options to reduce or avoid threats increase, so does the likelihood of aggressive behavior. But, with absolute negation of escape or reprieve, a broad range of behaviors tend to be suppressed. Thus, the “danger zones” of volatility occur in situations that foster a perceived increase in expected “gain(s)” that could be achieved by exerting aggressive action, versus the expected “loss(es)” that such actions could incur (refer to the previously presented equation).

Perceptions of fairness also contribute to patterns of decision-making. Humans will often reject – and/or react against - unfairness when it is perceived in particular individual and social situations, despite such actions’ evoking outcomes that do not appear to sustain individual reward - or in some cases, may even incur harm - to the actor(s). Similarly, individuals will tend to reject and react to particular threats that conflict with their sense of (individual and/or group/communal) honor and so-called “sacred values” (i.e. - those ideas and ideals that are held to be immutable and meaningful to constructs of individual and/or group morality and mores).

Neuroscientific studies have shown that brain nodes and networks involved in processing cognitive information (and behaviors) that are related or reactive to sacred values differ from those networks involved in simple valuation or analytical processing. Cognition focusing upon information related to non-sacred values tends to activate brain networks associated with reward and logical cost/benefit analyses; whereas cognitions about sacred values tend to engage areas of the brain that are more strongly involved with both emotional tone, and self-referent effects - what are referred to as “first person” benefits or risks. Thus, a perceived threat to honor or sacred values can stimulate emotions of anger and disgust. These emotions tend to suppress other cognitive options, and can foster responses of outrage and aggression.

Perceptions of fairness, and the concept of sacred values are characteristically learned through various narratives and via behavioral reinforcement (on a variety of levels, from the individual to the social-populational). Narratives have the potential to play a powerful role in individuals’ (and groups’) sensitivity and response to events, in that narratives can factor prominently patterns of thinking, beliefs, acceptance or rejection of ideas, and can thus significantly influence decisions and behaviors. In most social (and non-high demand intellectual) situations, cognitive networks of the brain generally tend to function in a “default” (i.e. - passive acquisitional) mode, rather than an analytical one. Cognitive default mode operations are susceptible and responsive to narrative, and are relatively fast, intuitive, experiential, and associated with images and emotions. Thus, understanding the neurocognitive processes that are (1) operative in narratives, environments, situations and actions, and (2) influential to whether particular threats inhibit or compel a desired action can be instrumental to developing methods, tactics and strategies to affect and influence human behavior.

Fundamental Take-aways: Understanding Neurocognitive Processes of Human Decision-Making.

1. Human decision-making involves the assessment of risk and reward, in particular environmental constructs, to culminate in behaviors.

2. Individual differences in sensitivity to both rewards and punishments reflect biological-environmental interactions on a variety of levels.
3. Decisions have an inherently emotional component, which may be conscious or unconscious.
4. Social interactions influence a number of cognitive processes, and perception of social reward and risk/threat/burden is operative in decision-making.
5. Reward may function less effectively as a behavior-changing approach, but may function more effectively to sustain certain types and patterns of behavior.
6. Individuals tend to avoid decision-making scenarios that involve ambiguity, and prefer to deal with situations with more defined, probabilistic outcomes.
7. Individuals tend to be loss averse, and avoid decisions that result in outcomes that are perceived as losses.
8. Individuals tend to discount, devalue, or avoid potential rewards that are delayed.
9. Decisions are frequently affected by an individual's perception(s) of fairness, honor, sacred values, which are characteristically learned through narratives and socio-behaviorally reinforced.
10. Threats and/or violation of perceived honor or sacred values trigger neurocognitive processes of fear and disgust, which can prompt aggression and violence.
11. Narratives can affect neurocognitive processes involved in affiliation and consonance, dissonance and dissimilarity, and foster cognitive patterns operative in beliefs, ideals about identity of self and others, risks and threats, honor, and sacred values.
12. Narrative cognitions tend to involve the brain's "default" mode, which is associated with stories, images, and emotions.
13. These neuro-cognitive networks may be accessed and affected through tactical and strategic use of narratives, social engagement, environmental effects, and specific neuroS/T approaches; which may be important and instrumental to improving effectiveness of human terrain operations.

Conclusion: The Value of Neurocognitive Approaches to Influence and Deterrence Operations

In prior publications we have described the potential utility and value of understanding and employing neurocognitive approaches to the study of deterrence. We have referred to these approaches as "neurodeterrence", which we have defined as:

> "...*the application and consideration of evolutionary neurobiological underpinnings of cognitive and psychosocial behaviors that are important to deterrence theory in the context of conflict. It refers to the inclusion of a systems understanding of how individuals or groups behave and make decisions, in the development of deterrence strategies. It refers to inclusion of these neurobiological systems, such as neurobehavioral violence or aggression, as a formative and additional component of the evidence base used in formulating deterrence approaches. It*

assumes the evolutionary progression of warfare between groups and that deterrence as a concept may be a long learned aspect of human psychology."

We posit that it should be logical – and thus important - to view deterrence in neurocognitive contexts, given that deterrence, as both a concept and set of practices, appears to be fundamental to human evolutionary and social psychology, and therefore of potential value to intelligence, human terrain, and both non-kinetic and kinetic security and defense operations. In this light, many of SMA's deep-dive products have focused on elucidating neurocognitive substrates and mechanisms of fear, aggression, and decision-making, and have explored ways that a variety of methods (e.g.- neuroS/T tools; environmental considerations, inter-individual and –group interactions, narratives) could be employed to evoke influence and/or deterrence. The relative capabilities, constraints, and steps necessary toward de-limiting these capabilities in national security and defense use are provided/summarized in the recent SMA whitepaper: *Leveraging Neuroscience and Neurotechnological (NeuroS/T) Development with Focus on Influence and Deterrence in a Networked World.* (May 2014); additional overviews are provided by Giordano (2015; 2016; 2017a,b), and Giordano and Wurzman (2016). Taken together, the over-arching goals of such studies and use of neuroS/T are to illustrate and provide an additional layer of capability to enable more effective, efficient and successful national security tactics and strategies in the varied, complex scenarios of the twenty-first century global operational environment.

Suggested Additional Reading

Damasio A. *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*. NY: Harcourt, 1999.

Giordano J. (ed.) *Neurotechnology in National Security and Defense: Practical Considerations, Neuroethical Concerns*, Boca Raton: CRC Press, 2015.

Giordano J. The neuroweapons threat. *Bulletin of the Atomic Scientists* 72(3): 1-4 (2016).

Giordano J. Weaponizing the brain: Neuroscience advancements spark debate. *National Defense,* 6: 17-19 (2017a).

Giordano J. Battlescape brain: Engaging neuroscience in defense operations. *HDIAC Journal* 3:4: 13-16 (2017b).

Giordano J, Wurzman R. Integrative computational and neurocognitive science and technology for intelligence operations: Horizons of potential viability, value and opportunity. *STEPS- Science, Technology, Engineering and Policy Studies,* 2(1): 34-38 (2016).

Glimcher PW, Camerer CF, Fehr E, Poldrack RA. (eds.) *Neuroeconomics: Decision Making and the Brain.* NY: Academic Press, 2008.

Johnston E, Olson L. *The Feeling Brain: The Biology and Psychology of Emotion*. NY: Norton, 2015.

Mattson MP. (ed.) *Neurobiology of Aggression: Understanding and Predicting Violence*. Dordrecht: Springer, 2003.

Miczek KA, Meyer-Lindenberg A. *The Neuroscience of Aggression*. NY: Springer, 2014.

Nelson RJ. (ed.) *The Biology of Aggression*. Oxford: Oxford University Press, 2005.

Sapolsky R. *Behave: The Biology of Humans at our Best and Worst*. NY: Penguin, 2017.

Simpson EH, Balsam PD. *Behavioral Neuroscience of Motivation*. NY: Springer, 2016.

Stoff DM, Susman EJ. (eds.) *Developmental Psychobiology of Aggression*. Cambridge: Cambridge University Press, 2005.

Volavka J. *The Neurobiology of Violence*. Washington, DC: American Psychological Association Press, 2002.