White paper on Leveraging Neuroscientific and Neurotechnological (NeuroS&T) Developments with Focus on Influence and Deterrence in a Networked World

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Scope:

The interactive natures of deterrence and influence have been assessed for decades by students of political science, criminal justice, social and behavioral science, marketing and psychology. Contemporary deterrence thinking dates back to the post WW II era which lasted for over a half-century and contributed to maintaining peace between great powers. Over the last few decades, the security problems facing the global system have changed as articulated recently by LTG Flynn[1]

"…The nature of global conflict is ever-changing, and a clear understanding of the threat environment is critical to the mission success of our policymakers, diplomats, and warfighters. A few clear trends are emerging to transform the operational environment. Formally declared warfare among nation-states is becoming less likely while the potential for conflict ignited by violent transnational and sub-state actors grows. A rapidly growing and free-moving global population, the growth of urban areas in underdeveloped countries, and expanding access to transformative technology pose new and unforeseen challenges for both our allies and our adversaries…"

These evolving challenges have necessitated the need for new insights regarding the influences on human decision making for the purpose of maintaining peace and stability. Decision- and policy-makers need a set of revised influence and deterrence tools and approaches that are applicable to the emerging 21st century security environment. As the USG draws down its nuclear forces, deterrence becomes a key concern. In addition, the USG wants to achieve deterrence through volition, not hostility. In parallel to deterring hostile and aggressive acts, assurance of our allies is an added dimension.

In the last few decades, this interest and engagement has extended to the behavioral and cognitive sciences, and more recently, to neuroscience and neurotechnology (neuro S/T). This whitepaper introduces this added layer of novel scientific insights from these fields to complement and fortify earlier assessments. It is a sequel to a previously published white paper on the topic of aggression[2]. That paper provided a series of selected topics on the neurobiological bases of aggression, in the interest of introducing neuroscience to the community of experts in deterrence. The topics addressed were of most relevance to inform the deterrence community about those ways that neurobiological approaches – and information - could be incorporated as potentially useful tools in deterrence practice(s). The current paper advances those arguments further and focusses upon the application and consideration of evolutionary neurobiological mechanisms of cognition and social behaviors that are important to deterrence theory in contexts of conflict. It advances a systems'-based

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[1] Understanding Megacities with the Reconnaissance, Surveillance, and Intelligence Paradigm. Topical Strategic Multi-Layer Assessment (SMA) and U.S. Army Engineer Research Development Center (ERDC) Multi-Agency/Multi-Disciplinary White Papers in Support of National Security Challenges. Editor: Dr. Charles Ehlschlaeger (ERDC), April 2014

[2] Topics in the Neurodeterrence of Aggression: Implications to Deterrence; Editors Drs. Diane DiEuliis and Hriar Cabayan; February 2013

understanding of how individuals and/or groups make decisions and act, and seeks to provide frameworks for employing these neuro S/T approaches in the development and implementation of deterrence strategies.

As in the previously published white paper on aggression, the current paper also uses the term "Neurodeterrence" which refers to inclusion of insights from neurobehavioral sciences about mechanisms of violence and/or aggression as formative and additional components of the evidence base used in formulating deterrence approaches.

This revised edition includes a new article entitled "Applying behavioral economics to deterrence…Key Challenges" By Dr. Scott Huettel

Preface: Brig Gen Tim Fay (US Air Force)

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Effectively deterring our Nation's adversaries

For operators that know the fog, friction and unpredictability of the battlefield, effective deterrence is a desired outcome we must offer our Nation's policy makers, in addition to the capability to decisively defeat any potential adversary. Because we now operate in a globalized and hyper-interconnected security environment, a thorough understanding of our potential adversaries, and how to effectively deter them, is not optional and not something we can do on the fly. Science presents opportunities to help us with this challenge, and is something the operator can and should leverage.

A quick review of our current strategic guidance does nothing but reinforce this concept. The latest Quadrennial Defense Review uses the word deterrence, or a version of it, approximately 59 times. As frame of reference, the word defeat is used in that same QDR approximately 30 times. This emphasis is evidence of intent for operators to provide our policy makers with actionable courses of action that successfully deter adversaries. For the operator, this specified intent to provide deterrent optionality begs a range of challenges and questions when it comes to practical implementation and application.

While there is certainly no shortage of academic analysis available on how the product of credible capability and will produce effective deterrence, there is also a corresponding dearth of practical understanding on the application of a critical aspect of effective deterrence – how to, with reasonable certainty of outcome, clearly communicate with potential adversaries such that the deterrence message is received, processed and acted on as desired and intended. Without clear and effective communication, there is no possibility of creating a causal deterrent effect.

There is a range of reasons for this lack of practical and actionable deterrence communications capability, and one of them is the current state of applicable science and a corresponding gap in operational analytical tools. This white paper is a positive step to begin to address this gap. It shows that as our science continues to advance, it may help the operator provide a wider and more effective range of deterrence options. The articles also include a number of truly innovative considerations from an operators' perspective.

Among topics of interest to operators are items related to more precise understanding of the cultural and environmental communication considerations—in effect an operational preparation of the environment-like task. Additionally, there is discussion that could be seen as demonstrating the potential of how to, in effect, find, fix and finish deterrence communication “targets,” as well as potential considerations of potential post-delivery analysis. When considered through the lens of practical application to deterrence communications and operations, the potential becomes clear, even as we acknowledge the need for further development and evolution of the science.

In conclusion, while we as operators always prepare to decisively defeat our adversaries, we also are required to provide policy makers the means to achieve strategic outcomes by effectively deterring. The articles contained in this collection offer some interesting insights into the art of the possible when it comes to the future science of building and applying tools that enhance our ability to effectively deter.

Executive Summary: Hriar Cabayan, Ph.D. and James Giordano, Ph.D.

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This white volume focuses on possible ways that insights from the neurosciences may be incorporated into, and used within the United States Government's (USG) approaches and ability to conduct optimized influence and deterrence operations for the purpose of maintaining global stability. In this context, neuroscientific techniques, technologies and information are viewed as viable means to build upon and enhance tactical approaches from other disciplines such as the social sciences. Understanding the neurobiology of human behavior can provide an added dimension to formulating deterrence and influence strategies in the context of a security environment that has become more complex and far more fluid over last few decades. In this white paper, the term "neurodeterrence" refers to the consideration and application of evolutionary neurobiological information about, and understanding of cognition and social behaviors that are important to deterrence theory in contexts of conflict.

Key insights provided by contributing authors that are of particular relevance to the operational community include:

- Modern deterrence must draw on multiple disciplines ranging from physics and engineering to the psychological sciences. Neuroscience and neurotechnology (neuro S/T) might well offer new insights and methods to aid military practitioners and to enhance their decision-making.

- Neurodeterrence is the application and consideration of evolutionary neurobiological bases of cognition, emotion and behaviors that are influential to individual and group aggression and violence. Such information is important to deterrence theory in contexts of understanding, predicting and mitigating/preventing conflict.
    - The use of neuro S/T and the information these approaches afford can be important to the interpretation of human behaviors that do not appear to follow rational or mathematical models.
    - Equally important is that while neuroscience affords great potential, it is also limited in particular aspects of technical capacity and applicability and, therefore, does not – and should not – provide a stand-alone or absolute toolkit for understanding aggression and violence. Neuroscience should be integrated into the development and evaluation of approaches to influence and deterrence.

- The field of neuroeconomics and related disciplines can provide unique insights to underlying mechanisms of human decision-making and behavior, and therefore are of importance and value to informing new developments in influence and deterrence.

- Improved understanding of the mechanisms of decision making could make important contributions toward effective deterrence. New approaches to deterrence will require consideration of the biases and motivations of decision makers as they approach complex choices. Thinking about deterrence in terms of social partners – rather than opponents – may improve the process of decision making.

- The psychology of revenge is important to explain the evolution of deterrence, which attempts to prevent aggression and overt violence prior to initiation. While characteristically considered in contexts of nuclear armament strategies, deterrence – as a concept and operational construct – predates nuclear weapons, and evolutionary models are useful to explain how deterrence emerged as an approach to individual and group actions aimed at protecting and defending people, objects, and lifestyles of value.

- There is empirical evidence that experiencing a narrative can be transformational, and can induce long-term effects upon audiences' beliefs, attitudes, and behavioral intentions and actions. Therefore, the prudent use of narratives may be a crucial approach through which to influence the beliefs of those who (are predisposed to) disagree with the position espoused in the persuasive message.

- It is important to consider not only the perspective of the person being influenced but also the potential for each actor to influence others. Preliminary evidence suggests that brain systems implicated in perspective taking and social cognition (e.g., considering 'how might this idea be of value to others?' or 'what will they think of me if I share?') may be key to understanding individual differences in being a successful idea salesperson

- Techniques and recent research findings of social neuroscience and neuroeconomics can be useful to predict changes in individual behavior. Studies have shown, for example that neurobiological information in response to persuasive messages can provide more accurate predictions of behavior change than assessment of participants' own attitudes toward the behavior in question and their intentions to perform the behaviors in question.

- Individual differences in sensitivity to both rewards and punishments are culturally determined to some extent, but also reflect underlying genetic-environmental interactions on a variety of levels.

- Biological events, affecting the brain, and induced by neural functions (i.e. so-called "bottom-up" and "top-down" effects), have been shown to be involved in the formation of trust. Of particular interest in this research has been the putative role of the neuropeptide oxytocin in neurobiological mechanisms of trust formation and execution. Research to date indicates that oxytocin appears to exert influence upon subliminal (i.e. preconscious) perception of social information by increasing attention given to socially-relevant interpersonal and environmental cues (thinking about the "other-in-contexts") and by lowering sensations of (social) threat. Neuroimaging studies suggest that humans experience trust as rewarding, through activation of key mid- and forebrain networks, which may be important to functional fortification of these networks activity in various social/environmental conditions to reinforce future trust/cooperation.

- The neural phenomenon of "prediction error" can help U.S. policymakers to cause intended effects, and avoid unintended effects, on an adversary in a diplomatic or military confrontation. Prediction error provides a tool to *increase* or *decrease* the impact of our actions. A prediction error framework forecasts important effects such as inadvertent escalation; and it simplifies across existing strategic concepts so it can be operationalized without additional analytical burden. It explains historical cases and makes clear policy recommendations for doctrine and practice in China-U.S. escalation scenarios (Table 1).

- The human capacity for individual and group empathy, and the behaviors fostered by these cognitive-emotional states (e.g. the extent to which altruism supersedes egoism, and empathic emotions repress self-interest) can affect attempts at deterrence in those situations when "stronger threatens weaker". Simply put: Humans care about groups, and experience strongly emotional reaction to perceived threats to an "in-group". Such emotionality can affect, influence (and interfere with) more rationalized decision-making relative to engaging behaviors that affect self, and "in-group" or "out-group" others.

- The intersection of new and iterative cyber-based communication technologies (CBCT) and psychological and neurobiological dimensions of behavior should be regarded as a potentially important – and viable - convergence of S/T. Possible applications and implications of such (cyber-neuro) convergence include:

    - Synthesizing traditional methods of social influence with recent advances in neuroscience, cyberpsychology, and captology (the study of persuasive technology) toward development of an advanced set of personalized persuasion tactics.
    - Establishment and use of chat rooms and other forms of social media to serve as digital echo chambers to effect greater social polarization.
    - Novel approaches to crafting effective messages that capitalize on current neurocognitive and anthropological research about individual and group beliefs. Such research has shown that one cannot start by simply crafting a message; rather it is essential to incrementally prepare a person or an environment to make communicated messages credible.
    - Combining actor-specific approaches to tailored deterrence methods within the broader neuroscience and technology (neuro S/T) framework can provide a model for operationalizable Neurodeterrence approaches.

Topic Overview

In her introductory chapter, Dr. Diane DiEuliis frames the issues addressed by the white paper by raising the question of how deterrence and influence strategies should best be enhanced to deter violent extremist acts and thereby promote National Security. She goes on to state that globalization is changing how people think, learn, form attitudes, and interact, and the neurobiological and behavioral components of these changes are beginning to be investigated. The past several decades have seen a convergence of findings in basic neurobiology with cognition, psychology and behavior largely due to technological advances such as non-invasive imaging and neurogenomics. She goes on by listing a set of questions that the paper will address in the context of deterrence. She closes by stating that while neuroscience offers tremendous insights applicable to deterrence and influence operations, it is neither a panacea nor silver bullet to success; rather, research findings should be cautiously repeated, verified, and combined as an additional layer to our existing understanding.

Chapter 1 sets the contextual stage on deterrence for the discussions of neuroeconomics and neurodeterrence that form the substance of this paper. Hunter Hustus and Ed Robbins provide military perspective by describing the current conceptual foundation that nests denial of benefits, imposition of costs, and encouragement of adversary restraint under the single umbrella of deterrence. Nevertheless, these goals are best examined discretely because fusion of the three would de-emphasize important behavioral and cognitive distinctions. Modern deterrence must draw on multiple disciplines ranging from physics and engineering to the psychological sciences. Neuroscience and neurotechnology (neuro S/T) might well offer new insights and methods to aid military practitioners and to enhance their decision-making. Alternative technologies must be applied over differing timespans. Operationalizing neuro S/T methods in the deterrence arena also entails deliberate socialization and confidence-building among practitioners. Situated in the midst of a revolution in military affairs concerning deterrence, neuro S/T might play a significant role in improving American military planners' understanding and in affecting adversaries' behavior.

In his section entitled “Applying behavioral economics to deterrence…Key Challenges”, Dr. Scott Huettel states that an improved understanding of the mechanisms of decision making could make important contributions toward effective deterrence. Traditional game theory dating back to Schelling had posited that effective deterrence requires more than simple rewards and punishments; it relies on recognition of others’ goals, and thus the most effective sorts of deterrence can involve signals about one’s own goals and capabilities. The current more fluid geopolitical environment requires moving beyond the tenets of traditional game theory by incorporating new insights from behavioral economics. Two such insights will be most relevant. First, strategic interactions involve a more complex incentive structure than present in traditional economic models. And, second, the introduction of social contexts changes the very process of decision making, which in turn alters the sorts of interventions most likely to be effective deterrents. In summary he states that new approaches to deterrence will require consideration of the biases and motivations of decision makers as they approach complex choices. Current research in behavioral economics has led to a reconceptualization of those biases and motivations. Importantly, that research does not show merely that people are irrational, as commonly reported, but instead that the processes of decision making change in systematic ways across contexts. In modern deterrence contexts, the incentives that shape decisions may include reputational and pro-social factors that might otherwise be absent. Thinking about deterrence in terms of social partners – rather than opponents – may improve the process of decision making.

Dr. Nicole Cooper follows-up with a discussion of neuroeconomics and states that the field of neuroeconomics combines theories and tools from economics, psychology, and neuroscience. This interdisciplinary field and its relatives (e.g., cognitive neuroscience, social neuroscience, and communication neuroscience) can provide unique insights into the underlying mechanisms and realities of human decision-making behavior, informing new developments in influence and deterrence. By working to understand how the brain determines behavior, the field of neuroeconomics has made significant progress in developing simpler models of decision-making, with more predictive power, than can be generated by rational choice theory or each approach alone. She discusses some key findings:

- People demonstrate strong avoidance of decision scenarios involving ambiguity, and prefer to deal with situations in which outcome probabilities are defined. Finding ways to make the outcomes of a given political move less ambiguous could prevent some surprising and maladaptive choices.
- People are loss averse – they avoid payoffs that appear as losses more than they seek out the same amount of gain. Relatively subtle changes to negotiation and influence tactics, to avoid framing outcomes as losses and instead reframe in terms of gains, could greatly improve the efficiency of these exchanges.
- People have a strong tendency to discount, or devalue, rewards that involve a delay. Understanding how people might change their decision patterns based on new information and norms will be crucial for designing successful interventions

She concludes by stating that a clearer understanding of factors that influence decision-making (e.g. biases, new information, and norms) will help to develop successful behavior change interventions.

Dr. Diane DiEuliis defines neurodeterrence as the application and consideration of evolutionary neurobiological mechanisms and substrates of cognitions and psychosocial behaviors that are important to deterrence theory in contexts of conflict. She highlights the neurobiology of a variety of related and overlapping areas of study that are relevant such decision making analyses, game theory, and aggression. DiEuliis concludes by stating that in the very least, a primary understanding of the neurobiology in these and the above categories can provide insightful context to the interpretation of seemingly irrational human behaviors, or behaviors that do not follow rational or mathematical models. At the most, tools for adjusting deterrence and influence could be utilized which steer deterrence and influence activities into directions which could allow for successful outcomes. This is the end goal.

In their introductory section to Chapter 2, Drs. James Giordano, William Casebeer, and Diane DiEuliis argue that neuroscientific information gained from methodologically rigorous research in noninvasive imaging and computational neuroanatomy, neurophysiology, neurogenetics, etc…can provide understanding of how individuals' neural functions contribute to various cognitive (and emotional) states that are important to both individual and group decision-making and behavior. They posit that the prudent use of neuro S/T can enhance the USG ability to conduct influence and deterrence operations. They note however that while neuroscience affords great potential, it is also limited in particular aspects of technical capability and applicability and, therefore, should not provide a stand-alone or absolute toolkit for understanding deterrence and influence. However, if/when used in combination with other disciplines such as political science, anthropology, and psychology, neuroscientific information may enable depth of insight(s) to (neuro)bio-psychosocial factors that are effectively operationalizable and, therefore, most useful and meaningful in/to programs of influence and deterrence. They advance the thesis that employing neuro S/T approaches within a larger framework of bio-psychosocial analyses and interventions will be important to fortifying extant methods and developing new and innovative means to planning and implementing effective influence and deterrence operations. Drs. Giordano, Casebeer and DiEuliis assert that the pragmatically sound, and prudent use of neuro S/T methods (to assess brain states that are correlated to particular cognitive, emotional, and behavioral patterns) offer potentially important means to define structural and functional correlates of aggression and violence that could be viable–and of value–in assessing, if not predicting, such dispositions and actions.

In section 2.2, Dr. Rose McDermott offers evolutionary considerations. She states that the psychology that underlies revenge helps explain the evolution of deterrence, which serves the purpose of trying to prevent those attacks before they begin. In short, the psychology of revenge motivates the drive toward deterrence. Deterrence existed long before nuclear weapons, and evolutionary models can help explain how deterrence emerged as a way people sought to protect and defend the people and things they valued. In this context, deterrence is understood to reduce the probability of aggression before it can begin in the next round. It can serve both a preventative as well as a pre-emptive function. She makes three points for deterrence to work:

- The enemy believes the opponent poses a credible threat
- The enemy is aware that the defender is committed to responding to particular acts in particular ways
- The enemy wants to survive, and either does not have kin they value, or holds a reasonable belief that such kin cannot be located and thus targeted for retaliation subsequent to attack.

In section 2.3, Dr. Victoria Romero discusses the role of narratives and narrative transportation in creating persuasive messages. She defines narrative transportation as the experience of becoming lost within the world of a story. At its core it is the intersection between stories, transportation, and persuasion. She states there is empirical evidence that experiencing a narrative can be a transformational experience with long-term effects on audiences' attitudes, beliefs, and behavioral intentions. She relates a key observation that "Use of narratives, in fact, may be one of the only strategies available for influencing the beliefs of those who are predisposed to disagree with the position espoused in the persuasive message". This is in contrast to persuasive narratives which often are not effective. She goes on to discuss an impressive list of effects of narrative transportation on persuasion. She then discusses neurological mechanisms underlying narrative transportation and relates that while viewing a transportive narrative a viewer's brain is less sensitive to stimuli that are not part of the story world. She goes on to say that these lines of research may also lead to better means to measure transportation than the self-report scales currently used. She states that on-going research does offer insight into what makes a narrative transportive. Some of these include:

- The identifiability of the main character; i.e. culturally familiar and demographically similar to audiences;
- Highly suspenseful story
- An imaginable plot (citation)

In the following section, Dr. Emily Falk tackles the topic of Neuro S/T and the spread of ideas and behaviors. She raises the question of how can we increase the effectiveness of influence and deterrence through traditional channels (mass media, interpersonal) and in the new media environment. She goes on to ask what are the pathways through which influence translates into behavior? How do people move from sympathy to violence? In what ways might attention and behavior be shifted away from violence to more prosocial ends? She states that neuroscience methods complement existing tools from psychology, sociology, communication science, political science and other social science disciplines by offering a window into psychological processes as they unfold (for example, in the moments that influence takes hold). She specifically relates some key findings

- Research in social neuroscience and neuroeconomics has identified brain systems that calculate implicit self-relevance and positive valuation. Neural activity within these same brain regions also predicts changes in study participants' behavior better than the participants' own attitudes toward the behavior in question and their intentions to change that behavior. Activity in these brain regions within small groups can also forecast the success of large-scale media campaigns.

- The new media environment is optimized for tailoring messages; given that tailoring is known to directly increase the effectiveness of messaging, and seems to operate in part through the brain regions identified as predicting behavior change above, this may be one strategy that would leverage new technological capabilities and increase the power of influence and deterrence

- The brain's reward system responds both to primary rewards as well as to more abstract social rewards. A growing body of literature suggests that social signals powerfully shape responses to otherwise neutral stimuli within the reward system.

- Avoiding punishment and social exclusion can powerfully drive behavior. Brain systems that encode the distress of physical pain also respond to exclusion and social loss.

- There are individual differences in sensitivity to both rewards and punishments, which are in part culturally determined, but which are also likely driven by gene x culture interactions.

- Neuroscience research on the spread of ideas suggests that those who are best at recreating their preferences and beliefs in the minds of others tend to use brain systems implicated in perspective taking more when they initially encode ideas.

In the following section entitled "Neuroscientific Considerations of Trust and Influence", Dr. Jorge Barraza states that the neuroscience of trust provides a framework for examining how emotions, pre-existing beliefs, and individual differences can impact influence at individual and group levels. He posits that influence can have ancient roots in our evolutionary development as a social species. He states that trust is generally viewed as a *behavior* that makes one party (influence target) *vulnerable* to another party (influence source). In this context, biological events, primarily occurring in the brain, have been shown to be involved in the formation of trust and key in this body of research is the relationship between the hormone oxytocin and trust. Research to date indicates that oxytocin influences the perception of social information below conscious awareness (lower order processes), particularly by increasing attention given to social information (thinking about the "other") and by lowering social threat. He summarizes following key findings:

- Oxytocin will not increase trust when past history leads to an initial evaluation of the partner as untrustworthy. The reverse also appears to be accurate: when trust initially exists, it takes much longer to "spot" an untrustworthy partner. As such, ensuring that first encounters create positive evaluations will be beneficial to future influence attempts.

- Brain imaging studies suggest that humans experience trusting others as rewarding, which may act to reinforce future trust/cooperation.

- Oxytocin can promote outgroup cooperation in tasks that allow for the mutual benefit of groups. It appears that our biology will lean us toward in-group bias, but only when the framing of the conflict is zero-sum.

- The amount of emotional engagement with a message can indicate message effectiveness. Both subjective engagement with the message and the costly action (viewed as message influence) are associated with greater oxytocin in the brain.

In a section entitled "Neural prediction error is central to diplomatic and military signaling", Dr. Nick Wright states that prediction errors are key to forecast the impact of our actions on others. Here prediction errors are defined as the "difference between what happens and what was expected". It is central to how humans understand, learn and decide about the world.

- He states that one reason prediction errors matter is because they can cause inadvertent escalation. He illustrates this by considering the impact of the Soviet action of placing intermediate range nuclear missiles on Cuba in 1962. To Soviet decision-makers the action was not markedly more provocative than previous actions. But the action had a strikingly asymmetric psychological impact on the U.S. that was on the receiving end.

- Inadvertent escalation from insider knowledge is just one example of prediction errors' widespread impacts - and a simple framework captures these far-reaching impacts. (surprise, shock and awe etc.). This simple framework also simplifies across existing strategic concepts so it can be operationalized without additional analytical burden.

- In Table 1, he makes clear policy recommendations for how to increase or decrease the impact of our actions. He gives examples from a near-term a China-U.S. escalation scenario.

- He argues his paper can help U.S. policymakers to cause intended effects, and avoid unintended effects, on an adversary in a diplomatic or military confrontation.

In the final section in Chapter 2, Dr. Clark McCauley in an article entitled "When Deterrence Fails: The Social Psychology of Asymmetric Conflict" argues that the human capacity to care about groups, the emotions that follow from this caring, and the extent to which emotions triumph over self-interest—these together undermine deterrence when stronger threatens weaker.

- At the group level, deterrence requires a home address.

- At the individual level, deterrence requires that those threatened will put self-interest above group interest.

- In asymmetric conflict, both requirements are likely to fail.

He states that the foundation of deterrence is that the potential attacker must have a home address. In asymmetric conflict, however, the attacker often does not have a home address. Guerillas and terrorist groups are difficult to deter because it is not obvious what place or persons to threaten with a return strike. He raises the possibility that if states cannot easily deter non-state groups, perhaps they can deter individuals. He goes on to ask the question: Why doesn't this grim prospect deter individuals from joining a militant group at war with a powerful state? He argues that in broad terms the answer has three parts. Humans care about groups. We feel strong emotions depending on what is happening to a group we care about. And emotions get in the way of making rational choices to further our self-interest.

The intersection of emerging CBCT and human biology including both psychological and neurobiological dimensions of behavior has the potential to be a disruptive technology. Chapter 3 discusses some of the operational, ethical, and neuropsychological consequences associated with the adoption of disruptive neuroS/T. The topic is introduced in section 3.1 by Maj Jason Spitaletta who discusses the cognitive implications for influence and deterrence through Cyber-Based Communication Technology (CBCT). In section 3.2, Dr. James Giordano and Roland Benedikter give an overview of specific neurotechnologies that form the basis of many of the behavior frameworks discussed throughout. They first address extant limitations of neuro S/T, and the need for and reliance upon advanced integrative scientific convergence (AISC) approaches that employ cyberscience and technology to de-limit the techniques and technologies of brain science, so as to enable more capable comparative, descriptive and predictive use in operational settings. They posit the importance of the "neurocyber fusion" and the need for large scale computational infrastructures and methods to facilitate and fortify massive data acquisition, storage, analyses and use. The need for, and use of such "big data" methods, and perhaps more paradigmatic approaches, is addressed and discussed by Drs. Rochelle Tractenberg, Kevin FitzGerald, Jeffrey Collmann, and James Giordano in section 3.3. In explicating the concept and possible deterrence context(s) of big data use, they posit key strengths and important issues (of practical limitations, misappropriation and misuse of information, and potential ethico-legal concerns) that will be important to address when considering if and how big data initiatives can and will impact the utility and potential use (and/or misuse) of neuro S/T in influence and deterrence initiatives and operations.

The final Chapter "Operational Implications & Applications of Neuro S/T Based Influence and Deterrence" discusses what deterrence means for understanding the decision making of individual leaders and small leadership groups as well as implications for deterrence in the context of neural factors in Cyber-Based Communication Technology (CBCT). In his introductory section, Maj Jason Spitaletta states at the outset that intersection of emerging cyber-based communication technologies and human biology including both psychological and neurobiological dimensions of behavior has the potential to be a disruptive technology. He posits that synthesizing traditional methods of social influence with recent advances in neuroscience, cyberpsychology, and captology (the study of persuasive technology) can result in an advanced set of personalized persuasion tactics. He highlights some key trends that need to be closely considered:

- CBCT provide individuals (including lone wolves) an option to either actively or passively access information that is consistently biased toward already expressed preferences and, thus, reinforces and strengthens their existing worldviews and limits the probability of their encountering information that is potentially contradictory or disconfirming.
- Neither personality nor ideology predisposes one to radicalization, but anger at a perceived grievance, shame for not doing anything about it, and status seeking can contribute to the process. That is why jihad videos are so radicalizing; they instigate an emotional response.
- Chat rooms and other forms of social media serve as digital echo chambers and result in greater polarization.
- Primary research identifying the underlying neural correlates of specific psychological reactions to violent extremist stimuli delivered online may help provide a more empirically valid means of countering the radicalization process

He concludes by stating in order to craft effective messages, one has to identify what a person is willing to believe. Therefore, one cannot start by crafting a message; one must incrementally prepare a person or an environment to make the communicated message credible.

In the final section in Chapter 4, Maj Jason Spitaletta discusses the use of Cyber in neuro S/T based deterrence and influence. He states at the outset that given the advances in cyber-based communication technology (CBCT), and the increasingly prominent threat of small groups and super-empowered individuals, the logical operational environment through which to conduct influence operations is cyberspace. He posits that contemporary research in cyberpsychology and neuroscience, in conjunction with advances in persuasive technology, human computer interaction and leadership analysis can be used to develop tailored influence tactics that can be administered in cyberspace. He advances the insight that combining actor-specific approaches to tailored deterrence with the broader neuro S/T framework provides a model for an approach to neurodeterrence operations. He goes on to propose such an approach. He tackles the issue of access to individuals and states that the same CBCT that has increased the connectivity amongst individual can facilitate access to a particular target. CBCT also provides greater anonymity, lower emphasis on physical attractiveness, and greater control of the time of interaction all without geographical restrictions. He asserts that access must extend beyond the technological to the biological, psychological, behavioral and social. As far as target audience assessment, he asserts that ongoing assessment is necessary in neurodeterrence as baseline metrics and post-intervention changes must be monitored and compared with empirical data. Among the methods that have potential applicability are those that comprise human factors analysis, group and population analysis, social network analysis, and individual and leadership analysis. In addition, neuro S/T based deterrent and/or influence operations require themes, messages, and dissemination mechanisms specifically tailored to an individual's psychological vulnerabilities and/or susceptibilities and delivered to the device at the time when the effect will be greatest. He concludes by stating while existing neuro S/T has great potential to influence and/or deter targets in cyberspace, further research will allow planners to rely upon firmly established linkages between perception and actions when developing both their intelligence requirements and the desired psychological actions.

Introduction: Diane DiEuliis, Ph.D.

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For decades, the US government, its allies, academic institutions, think tanks, and others have attempted to understand the nature of conflict, both internationally and domestically. Presumptively, a greater understanding of the underlying causes of violent conflict will reveal ways in which violent acts stemming from such behavior can be deterred or influenced to promote greater national security. The effort is thus two-fold – understanding the evolving nature of the threat, and subsequently creating successful means of countering it. Globalization is changing how people think, learn, form attitudes, and interact, and the neurobiological and behavioral components of these changes are beginning to be investigated. Today's threat environment is considered highly asymmetric, amorphous, complex, rapidly changing, and uncertain[3]; hallmarked by a fragile global economy, stressed ecosystems, and ever increasing global sharing of information through interconnected cyber infrastructures. The threat may be in the form of emerging nuclear powers, failing states, virtual and non-state actors, as well as individual "lone wolf" type actors. It has become clear that the nature of these threats is not necessarily aligned to a post-Cold War deterrence infrastructure, originally conceived to contain communism. In light of this, how should deterrence and influence strategies best be enhanced to deter violent extremist acts and thereby promote National Security?

The social sciences have produced an extant body of literature on violent or other behaviors that have helped enhance options for influencing or altering such states[4]. Yet improvements both in assessing the threats and developing deterrence and influnece strategies remain a major goal. It is not surprising therefor that the defense and national security communities have turned to advances in neuroscience and neurotechnologies for novel ways of addressing both challenges outlined above. The past several decades have seen a convergence of findings in basic neurobiology with cognition, psychology and behavior – largely due to technological advances such as non-invasive imaging and neurogenomics. Several studies of the neurobiological and neurotechnological research landscapes have advised and directed the defense community to explore further the role of neuroscience in strategic decision making for particular desired outcomes[5] The areas actively being pursued could be divided into three broad categories: brain-machine interfaces, neuropharmacology, and areas related to cognitive enhancement. The latter category offers the most interest for deterrence and influence strategies, both in understanding the human nature of the threat environment as well as developing an influence tool set.

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[3] Operational Relevance of Behavioral and Social Science to DOD Missions, preface, March 2013.
[4] LaFree and Ackerman, The Empirical Study of Terrorism: Social and Legal Research, Annual Review of Law and Social Science, Vol. 5: 347-374.
[5] Emerging Cognitive Neuroscience and Related Technologies. National Research Council, National Academies Press, 2008.

Advances in understanding the neural mechanisms underlying social cognitive processes such as social perception, attitude formation, emotion recognition, and decision making, have provided a novel layer to understanding the psychosocial milieu of violent behavior and conflict. This research convergence is also moving forward to encompass the influence of the environmental and social backdrop upon which it occurs, which Giordano has referred to as "neuroecology" [6,7]. While direct linear convergence is not a reality, evidence of the underlying neurobiological mechanisms and substrates which show a correlation with human behavior on numerous levels continues to accrue. A neuroecological approach is not novel to the topic at hand. For example, the nascent field of neuroeconomics[8], marrying the traditional linear study of economics with underlying neuroscientific observations that relate to economic trends and individual decision making, is revolutionizing an understanding of the often irrational behavior of financial markets. Neuroeconomics allows for the consideration of the inescapable automatic and emotional aspects of human decision making – without which, the linear, and admittedly, rational, models remain inadequate. The neuroecological approach engages neuroeconomics as a mid-level consideration, taking into account the ways that mid-to upper-level neural network effects are operative in economics[9]. Similarly, neuromarketing, the study of neural mechanisms that underlie human decisions regarding interest in, or purchasing of particular products, has also become a thriving industry, frequently providing unique insight into which approaches in the marketplace will be most successful.

With these ideas in mind, the following volume focuses on insights in the neurosciences intended to improve the United States Government's (USG) ability to conduct influence and deterrence operations. Chapters provide discussions of neuro S/T related to critical dimensions of influence and deterrence. These include basic overviews of the neural bases of human interaction(s) that are relevant and influential to both individual as well as group influence and deterrence behavior, in-group and out-group behaviors, the neurobiological basis of aggression, and the natural evolution of deterrence behaviors. The application of neuroscience to deterrence and influence suggests, as noted herein, that traditional thoughts about deterrence in terms of one state deterring another must be refined and expanded; States are inanimate objects that do not think or act, so an approach aimed at identifying the key decision-maker(s) is thus essential for planning effective deterrence and influence operations, so that individual components that contribute to their actions can be understood. Further, how should incentives then be used to motivate or demotivate actors? A strategy matrix is presented for consideration. Overall, it is the goal of this paper to provide insights into key questions posed by those working in influence and deterrence fields:

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[6] Giordano J**.** Neuroethics: Traditions, tasks and values. *Human Prospect*, 1(1): 2-8 (2011);
[7] Giordano J**.** Neuroethics- two interacting traditions as a viable meta-ethics? *AJOB-Neuroscience* 3(1); 23-25 (2011).
[8] Glimcher and Rustichini Neuroeconomics: The Consilience of Brain and Decision. Science 15 October 2004: Vol. 306 no. 5695 pp. 447-452.
[9] Caňadas A, Giordano J. A philosophically-based bio-psychosocial model of economics: Evolutionary perspectives of human resource utilization and the need for an integrative, multi-disciplinary approach to economics. *Int J Interdisciplinary Soc Sci* 5(8): 53-68 (2010).

- How and when do people decide to forego behaviors they would otherwise engage in? How does this vary by culture and decision setting environment?
- Under what conditions are threats effective, or counter-productive? How does this vary with different types of people or groups?
- Are there indicators that can be observed, without direct contact with an individual or group, that it has chosen to be deterred?
- How can social norms be formed or fostered quickly?
- Do people process (understand and respond to) threats or incentives under conditions specific to the possibility of conflict (e.g., fear, fluid v. rigid decision settings, time pressure, high stakes, perceived threats to personal versus collective interests, etc.)?
- How do we design messages for one actor without threatening or mis-signaling to others?
- How do we know when a message has "gotten through" the way it was intended?
- How can we craft deterrent messages that are credible and likely to endure?

Finally it should be acknowledged that while neuroscience offers tremendous insights applicable to deterrence and influence operations, it is neither a panacea nor silver bullet to success; rather, research findings should be cautiously repeated, verified, and combined as an additional layer to our existing understanding.

Chapter 1: Setting the Contextual Stage

1.1: Deterrence from a Military Perspective: Hunter Hustus and Edward Henry Robbins, PhD.

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"Deterrence is still fundamentally about influencing an actor's decisions. It is about a solid policy foundation. It is about credible capabilities. It is about what the U.S. and our allies as a whole can bring to bear in both a military and a nonmilitary sense."

USAF General (ret.) Claude Robert Kehler, Former Commander U.S. Strategic Command

Abstract. The world has much changed since the foundations of Strategic Deterrence were first set forth during the early atomic age. Since the collapse of the Soviet Union, the Western Alliance has faced a complex picture of threats from nation-states and hostile groups that might seek to employ Weapons of Mass Destruction against our nation or its allies and partners. The military needs new conceptual foundations both of how to deter adversaries from such actions and of how, in the long term, to posture our capabilities for preparedness against such potential enemies. Neuroscience and neurotechnology might well offer new insights and methods that will aid military practitioners to achieve the necessary goals involved with modern deterrence.

Introduction

The Cold War ended. Some people anticipated a commensurate end to history.[10] Hopes and beliefs about a conclusion to international conflicts certainly have not borne fruit. Instead, the nature of adversarial relationships among nations has changed. Lessened emphasis on a potential existential Russian-American war has been replaced with suspicions about economic, political, and military aggressions coming from East Asia;[11] religious-based fanaticism from South, Central, and Southwest Asia and from Africa; [12] terrorist threats running rampant across the world; and motives even among our allies and partners to proliferate or to employ Weapons of Mass Destruction.[13] Complex military challenges confront American military

[10] Fukuyama, F. (1992). *The end of history and the last man*. Avon. New York
[11] Naím, M. (2013). The most dangerous continent. *The Atlantic Monthly*. Retrieved at: http://www.theatlantic.com/international/archive/2013/10/the-most-dangerous-continent/280528/
[12] U.S. State Department. (2012). Country reports on terrorism 2012. Retrieved at: http://www.state.gov/j/ct/rls/crt/2012/index.htm
[13] Kim, D. (2011). Tactical nuclear weapons and Korea. The center for arms control and nonproliferation. Retrieved at: http://armscontrolcenter.org/issues/northkorea/articles/tactical_nuclear_weapons_and_korea/index.html

practitioners, who seek new conceptualizations to improve deterrence analysis, planning, and operations.

Conceptual framework

The official framework for the U.S. military deterrence practitioner is the Deterrence Operations Joint Operating Concept (DO JOC).[14] Published in 2006, it describes deterrence operations 8-20 years into the future. It calls for a "wider range of military deterrence options…tailored to the perceptions, values, and interests of specific adversaries" and directs that "…deterrence strategies and actions must span daily operations and must be developed for all phases of conflict planning."

The DO JOC incorporates (1) denying benefits, (2) imposing costs, and (3) encouraging adversary restraint (i.e., threat, denial, and enticement) under the same deterrence umbrella. Yet, the same document acknowledges benefit of considering each component discretely - separate from the others. Contributors to this White Paper are likely to agree that fusion of the three de-emphasizes important behavioral and cognitive distinctions. Whether one perceives "influence" or "deterrence" as better terminology to encompass all three mechanisms, the fields of neuroscience and neurotechnology hold promise to improve military effects and political actions.

A trail that seems to have gone "Cold"

Utility-based game theory methods were central to development of deterrence theory from the 1940's onward.[15] But, decades of behavioral economics research provides ample institutional and empirical evidence that such *rational actor* analysis sometimes fails to model how humans actually make decisions.[16] New insights are re-kindling intellectual fires; rethinking the conceptual foundations of deterrence has become a critical endeavor. There is room for other approaches and integration of new technologies. That recognized, a litany of issues remain to be addressed.

In need of a tailor

First, military practitioners face the task of deterring multiple adversaries concurrently, where the form of deterrence must be tailored to fit specific circumstances.[17] Two-person game theory sometimes offers solutions that all too readily fail in multi-player games designed to reflect the multi-polar world in which we live. Lacking adequate models, current military

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[14] U.S. Department of Defense. (2006). *Deterrence operations, joint operating concept*. Washington, DC. Retrieved from: http://www.dtic.mil/futurejointwarfare/concepts/do_joc_v20.doc

[15] For a review, see Delpech, T. (2012). *Nuclear deterrence in the 21st century: lessons from the cold war for a new era of strategic piracy.* Rand Corporation. Santa Monica, CA. Retrieved from: http://www.rand.org/content/dam/rand/pubs/monographs/2012/RAND_MG1103.pdf

[16] Kahneman, D., Tversky, A. (1974).Judgment under uncertainty: heuristics and biases. Science 185(4157). 1124-1131.

[17] Schneider, B., Ellis, P. (2011). New Thinking on deterrence. In B. Schneider, P. Ellis, (eds.) *Tailored deterrence; influencing states and groups of concern*. Air University Press. Maxwell Air Force Base, AL

methods are necessarily unscientific, deriving more from an artistic flair, or *savoir faire*, than from a formal logical system. To advance the state of the art, effective techniques to tailor deterrence to a specific adversary must be identified and incorporated into military deterrence operations across the threaten-deny-entice spectrum.

Knowing the adversary is necessary, but insufficient. The military practitioner has the additional responsibility to design, build, and maintain credible military forces and concepts of operations. This complement to knowledge of the adversary requires its own form of analysis, management, and planning. Typically, such a broad problem set confounds the thinking of researchers and analysts because it stretches across many disciplines and varying timespans.

Disciplines

Regarding disciplines, those too narrowly focused on physics will believe that design and development of the "physics package" is the quintessential element of deterrence. But, that goal was largely achieved more than one-half century ago and is only subject to minor modification in contemporary research and practice. Major new work in this area would be contrary to current national policy prohibiting development of new nuclear warheads.[18] The engineering disciplines will find the center of things to be designing and building nuclear-capable heavy bombers and ballistic missiles. Those focused on maintenance or sustainment will find preservation and operability of the systems to be the heart. And, those in the broadly defined psychological sciences (including neuroscience) will concentrate on the perceptions engendered among adversaries and how we can alter those perceptions to our advantage. Each discipline constitutes a blind man trying to assess an elephant by touching a single part—and consequently only capable of understanding limited components of the broad process of deterrence.

Timespans

Related to the span across disciplines, but less obvious, is the concurrent existence of multiple relevant deterrence timespans. Technologies and techniques useful over the timespan associated with the design, acquisition, and utilization of weapons systems (invariably, decades) need not be at all useful in handling crises or conflicts.[19] With regard to this characteristic, many neuro S/T contributions are likely to apply to the short time horizons of crises or conflicts. If they can also aid the longer problems of capability creation, that will be a spectacular contribution.

[18] U.S. Department of Defense. (2010). Nuclear posture review report. Washington, DC. p.39

[19] Robbins, E., H. (2012) Strategic deterrence: working on the same page. Submitted to National Research Council. (2013) *U.S. Air Force strategic deterrence capabilities in the 21st century security environment: A workshop*. Washington, DC.

Integration

Finally, adoption or operationalization of new technologies requires that they be accessible, assessable, reliable, and reusable. A deliberate engagement plan to introduce new concepts to practitioners is the first step. Equal in importance, such engagements must give providers of new technologies opportunities for feedback to refine their concepts and make them relevant. They must come with methods to evaluate their effectiveness.

Following socialization, the technologies must prove to be reliable. Practitioners cannot afford the luxury of employing capabilities based on their complexity or elegant specificity. Planning and execution take place in bureaucratic structures bounded by doctrine and committed to courses of action with the highest probability of success. Capabilities must be useful "in the context of conflict."

Another luxury practitioners can ill afford is single-shot solutions. Confidence in reliability comes through repeated usage. Socialization and confidence-building phases for the integration of new technologies present a significant investment. They are more likely to be pursued for those capabilities that can be successfully employed many times against diverse adversaries.

Summary

Deterrence practitioners recognize ongoing change in security environments and focus on emergence of potential adversaries. As a result, the deterrence framework continues to evolve. We hope to exploit our growing understanding of human decision-making under risk and threat. "Legacy" utility-theoretic methods remain valuable in some contexts (particularly, those involved with long-term planning over binary adversarial relationships). The changing deterrence landscape requires integration of modern concepts and tools allowing us to tailor deterrence for multiple/asymmetric opponents across disciplines and timespans. To be viable, new contributions will require socialization to operationalize and build confidence. We are situated in the midst of a revolution in military affairs concerning deterrence. Neuro S/T might play a significant role in expanding the boundaries of our understanding and in altering our future behavior.

1.2 Applying Behavioral Economics to Deterrence…Key Challenges: Scott Heuttel, Ph.D.

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Introduction

No one approach – whether technological, political, or behavioral in nature – will suffice to ensure effective military deterrence. But, as introduced in the *NeuroS&T* white paper, generally, and in the section by Hustus and Henry, specifically, an improved understanding of the mechanisms of decision making could make important contributions toward effective deterrence.

The application of economics to deterrence is not new. Thomas Schelling's seminal monograph, *The Strategy of Conflict*, demonstrates how different actors' or countries' competing goals lead to often counterintuitive outcomes – through adaptation of the mathematics of game theory to both simulated and actual conflicts. The key insights from this (and related) work were that effective deterrence requires more than simple rewards and punishments; it relies on recognition of others' goals, and thus the most effective sorts of deterrence can involve signals about one's own goals and capabilities.

Yet, as emphasized in the white paper, the geopolitical milieu of today differs dramatically from that considered by Schelling and the policy makers of the 1960s. Interactions are more multilateral, information flows more freely, and the boundaries between states and citizens are more fluid. Accounting for these changes requires moving beyond the tenets of traditional game theory by incorporating new insights from behavioral economics. Two such insights will be most relevant. First, strategic intersections involve a more complex incentive structure than present in traditional economic models. And, second, the introduction of social contexts changes the very process of decision making, which in turn alters the sorts of interventions most likely to be effective deterrents.

Insight 1: Incentives are more complex than rewards and punishments

The central tenet of rational choice models in economics is that decisions are based on a consideration of their potential outcomes; that is, outcomes serve as incentives that shape decisions. Research in behavioral economics – and in psychology and neuroscience – now reveals that incentives are much more complex than previously recognized.

Most notably, some classes of actions serve as incentives, in that taking the action itself serves to motivate future behavior, independent of its outcomes. A clear example can be seen in actions that promote group cohesion. People are willing to sacrifice their own resources in order to punish someone who acts in an anti-social manner, even if they were not the target of the original anti-social actions. This effect – known as altruistic punishment – is difficult to explain in terms of external incentives, but it can be modeled by assuming that people are motivated by taking actions that send signals about one's own internal motivations. Similar examples can be seen for other actions relevant to deterrence, such as signaling support for allies, indicating trust in a strategic partner, and even bringing to mind recent memories.

Insight 2: Social interactions evoke specialized decision processes

Deterrence relies not only on managing costs and benefits but also on shaping social interactions. New work in behavioral economics and related fields now shows – quite conclusively – that how people approach decisions depends on whether they view the decision as involving social interactions. At one extreme, when people view a strategic opponent as not a true social partner (e.g., they are from a marginalized part of society or from an out-group), then the neural and psychological processes associated with social cognition are not engaged – and the decision is based on simple costs and benefits. At a societal level, such *dehumanization* could arise when dealing with cultures very unlike our own. But, if people recognize that the strategic opponent has goals and desires and they can take the opponent's perspective, then specialized processes associated with social cognition do come online and shape decisions.

Broadly considered, when people think of a decision as involving a social interaction, decisions change in two ways. First, people become more likely to consider others' outcomes as relevant for their decision; this can lead to more pro-social decisions (e.g., taking actions to help another) or to more anti-social decisions (e.g., seeing others as a threat). Second, people are more likely to consider the effects of decisions on their own reputation, looking forward to future social interactions. These changes have particular relevance for deterrence because they imply that social and cultural factors could shape the very process underlying deterrence decisions.

Summary

New approaches to deterrence will require consideration of the biases and motivations of decision makers as they approach complex choices. Current research in behavioral economics has led to a reconceptualization of those biases and motivations. Importantly, that research does not show merely that people are irrational, as commonly reported, but instead that the processes of decision making change in systematic ways across contexts. In modern deterrence contexts, the incentives that shape decisions may include reputational and pro-social factors that might otherwise be absent. Thinking about deterrence in terms of social partners – rather than opponents – may improve the process of decision making.

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1.3: A Primer in Neuroeconomics: Nicole Cooper, Ph.D.

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Abstract: The field of neuroeconomics combines theories and tools from economics, psychology, and neuroscience. This interdisciplinary field and its relatives (e.g., cognitive neuroscience, social neuroscience, communication neuroscience) can provide unique insights into the underlying mechanisms and realities of human decision-making behavior, informing new developments in influence and deterrence.

- The growing field of neuroeconomics combines ideas from economics, psychology, and neuroscience
- The combination of strengths from these different fields allows for a more robust understanding of complex decision behavior
- Interdisciplinary work has shed light on brain mechanisms of learning and decision-making, and on how brain system mechanics affect behavior
- A clearer understanding of factors that influence decision-making (e.g. biases, new information, norms) will help to develop successful behavior change interventions

Introduction

Neuroeconomics is a relatively new and rapidly expanding field of research, which draws on normative behavior models from economics, decision-making models in psychology, and neuroscience models of how and where the brain implements valuation and choice. The first discussions of such a convergence were merely a decade ago (for early views see: Camerer, Loewenstein, & Prelec, 2005; Glimcher, 2004), but in the time since, there has been a flood of neuroeconomics papers. By working to understand how the brain determines behavior, the field of neuroeconomics has made significant progress in developing simpler models of decision-making, with more predictive power, than can be generated by rational choice theory or each approach alone.

Many topic areas within neuroeconomics will be relevant to neurodeterrence. For example, studies have investigated the effects of incidental state changes, such as emotion, sleep deprivation, or cognitive overload, on how people make decisions and how the brain adapts under such circumstances (Sokol-Hessner, Camerer, & Phelps, 2013; Starcke & Brand, 2012; Venkatraman, Huettel, Chuah, Payne, & Chee, 2011). A complete overview of the field is beyond the scope of this chapter, but key examples of high relevance to neurodeterrence are reviewed below. Readers interested in a more comprehensive review are referred to the current neuroeconomics textbook (Glimcher & Fehr, 2013)

Choices about uncertainty

Many of the decisions that people make incorporate some element of uncertainty. One type of uncertainty, termed "risk", refers to the uncertainty about outcomes when the probability of each is known. For example, experiments frequently ask people to decide between gambles – say, a 90% chance of winning $15 vs. a 10% chance of winning $0, or a 50% chance of winning $27 vs. a 50% chance of winning $0. A second type of uncertainty is known as "ambiguity", and refers to situations wherein the likelihood of different outcomes is unknown. People demonstrate strong avoidance of decision scenarios involving ambiguity, and prefer to deal with situations in which outcome probabilities are defined (Ellsberg, 1961).

One question is whether these two decision types require different neural circuitry. It has been well-established that two brain regions in particular, the ventral striatum (VS) and the medial prefrontal cortex (MPFC), reflect the value of choice options on a subjective, person-specific scale (for meta-analysis, see: Bartra, McGuire, & Kable, 2013; Clithero & Rangel, 2013; Levy & Glimcher, 2012). Recent work finds that subjective value is ultimately represented in the same brain structures for both decision types (Levy, Snell, Nelson, Rustichini, & Glimcher, 2010). There is also evidence of additional activation during ambiguous choices in the lateral prefrontal cortex, which has been frequently cited as supporting processes such as behavioral flexibility and working memory (Bach, Seymour, & Dolan, 2009; Huettel, Stowe, Gordon, Warner, & Platt, 2006). This demonstrates that decisions involving ambiguity require additional cognitive processing to fully construct choice, but that ambiguous and risky choices share a final common valuation path – an example of the capacity of neuroscience to distinguish between possible decision models.

In the context of neurodeterrence, awareness of this bias away from ambiguity will aid in behavior prediction. For example, when deciding between a plan of action with known outcomes and one with unknown outcomes, an agent might choose the path with known outcomes, even if those outcomes are unlikely to result in the desired effect. The additional cognitive processing of ambiguous options is likely to be difficult or time-consuming. Finding ways to make the outcomes of a given political move less ambiguous could prevent some surprising and maladaptive choices.

Choices about gains and losses

The majority of research in decision-making has focused in decisions that result in gains, rather than those resulting in losses or punishments. Behavioral evidence shows that decisions involving losses are not simply the mirror opposite of those about gains, or rewards. For example, it has been widely shown that people are loss averse – they avoid payoffs that appear as losses more than they seek out the same amount of gain. This was noted by Samuelson (1963) and is considered in Prospect Theory (Kahneman & Tversky, 1979). For example, the amount of money a person demands to sell an object is more than the amount that they would pay to purchase that object (Horowitz & McConnell, 2002; Thaler, 1980).

One proposal for the underlying cause of this asymmetry between gains and losses has to do with the brain's differential responses to events that are aversive (such as losses or punishments) versus appetitive (such as gains or rewards). Rather than signaling along one continuum for whether events are appetitive or aversive, research indicates that there are opponent systems signaling these types of events. These systems also lead to different behaviors - if future outcomes are predicted to be appetitive, this leads to engagement and approach, whereas predictions of aversive outcomes lead to withdrawal and avoidance (Dayan & Seymour, 2008; Wright et al., 2012). It could be, then, that the observed behavioral avoidance of monetary losses (Tom, Fox, Trepel, & Poldrack, 2007; Wright, Morris, Guitart-Masip, & Dolan, 2013) is due at least in part to a reflexive avoidance of such an aversive outcome.

Loss aversion can impede situations such as negotiations, particularly when the terms are framed as losses rather than gains. A radical group, for example, may work hard to defend an acquired position, even harder than they would have worked to obtain that position in the first place. This strong aversion to loss, whether of money or perhaps territory, is biologically based and inherent. Relatively subtle changes to negotiation and influence tactics, to avoid framing outcomes as losses and instead reframe in terms of gains, could greatly improve the efficiency of these exchanges.

Choices over time

A category of decision people frequently encounter is one in which they have to choose between a reward they could have now, and one they have to wait into the future for. People have a strong tendency to discount, or devalue, rewards that involve a delay. There has been much debate in behavioral economics and psychology concerning the functional form of the discounting curve, particularly whether the steepness with which people discount should be described by a single term (hyperbolic) or two terms (quasi-hyperbolic). Neuroscience has added a new factor to this discussion. At a neural level, the hyperbolic model posits that during a discounting task, a unitary system evaluates immediate and delayed rewards (Kable & Glimcher, 2007). The quasi-hyperbolic model, however, posits that two separate systems interact competitively, with one evaluating immediate rewards and the other evaluating both immediate and delayed rewards (McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004). This idea of competing dual-processes has strong roots in psychology (such as the hot/cold dichotomy; Metcalfe & Mischel, 1999).

Despite some early human imaging evidence for a quasi-hyperbolic model (McClure et al., 2004; 2007), many follow-up studies using careful experimental design and modeling support the hyperbolic model. Evidence for a unitary representation of discounted subjective value has been consistently identified in MPFC and VS, and the response in these regions reflects the degree of discounting expressed behaviorally by the individual (Ballard & Knutson, 2009; Kable & Glimcher, 2007; 2010; Peters & Büchel, 2009; 2010; Pine et al., 2009; Wittmann, Leland, & Paulus, 2007). On the other hand, there has not been consistent neural evidence in humans for two competing systems that respond separately to immediate vs. delayed rewards, which is required in the quasi-hyperbolic, dual-systems framework. This lack of neural support for a dual-systems process of discounting questions long-held views in psychology, and informs alternative explanations.

Given the ubiquity of choices people make that involve delays, there has been much interest in finding ways to make people more patient decision-makers. Recent experiments find presenting people with an argument for a more effective decision strategy can greatly reduce discounting of money (Senecal, Wang, Thompson, & Kable, 2012). Normative influence also reduces monetary discounting – when presented with advice from peers, either about a financial strategy or more prospection-oriented reasons to discount less, participants become significantly more patient (Senecal et al., 2012). In other domains, asking people to think about the longer-term health consequences of eating junk food increases choice for healthy foods, and also changes representations of value in medial prefrontal cortex (Hare, Camerer, & Rangel, 2009; Hare, Malmaud, & Rangel, 2011). In the context of influence and deterrence, understanding how people might change their decision patterns based on new information and norms will be crucial for designing successful interventions. It might be the case, for example, that convincing people to wait longer for a peaceful resolution to be established could avert some terrorist actions. One hallmark of a successful intervention is likely to be a change in neural representation of the value of decision options.

Conclusions

Adding neuroscience to the study of decision-making, traditionally dealt with by economics and psychology, has significant advantages. It allows measurement of the neural variables that directly produce behavior. Knowledge of the neural processes behind decision-making, particularly those decisions not well explained by rational choice theory, can discriminate between functional forms of existing models as well as inform the design of new, simpler, and yet more comprehensive models of human behavior. While the field has not yet reached the point of a full understanding of decision-making, a considerable amount has been learned over only the last decade about how value is computed and choice is executed in the human brain.

Such improvements to decision-making models will have a significant effect on the deterrence effort. A fuller understanding of what factors impact decisions and at what level will allow for better out-of-sample prediction, from one population to another. Since most research is not done directly on terrorist groups, predicting their behavior is necessarily out-of-sample – with better models, such fundamental environmental changes will pose less of a problem. With the remarkable progress that neuroeconomics has made in the last decade, the coming years promise even more powerful developments.

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1.4 Neurodeterrence: Diane DiEuliis, Ph.D.

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As can be noted from the preceding, the neuroscientific knowledge base continues to expand and be refined as our ability to understand the brain advances through technology. This expanding knowledgebase is more often and consistently being applied to current extant fields of endeavor, enriching those fields with novel insights. Neuroscience has been correlatively applied to the advancement of the traditional fields of economics, marketing, psychology, social sciences, and behavioral and cognitive sciences. In practice, what this means is that the ability to view the brain, and examine its genetic, molecular, cellular and network characteristics that control specific functions, can provide a novel layer of understanding of behaviors most frequently studied in these related fields.

As authors note above, economics provides a useful framework example of how the disparate fields of neuroscience and economics converge; mathematical or logic models that have been developed to predict or explain behaviors within economics can be substantiated, negated, or extended, when correlated to the neurobiological mechanisms happening in the brain during those behaviors. A key aspect of the successful correlation of economics and neuroscience is to determine, from within the wide body of neuroscience research, which aspects of brain function writ large are most important when attempting resolve challenges and questions within economics.

Similarly, this volume is dedicated to introducing a comparable construct, that is, the application of neurobiological underpinnings of behavior to the traditional study of deterrence, referred to as "neurodeterrence". We have previously formally defined neurodeterrence 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." [20]

It is hoped that themes discussed herein can provide added tools for deterrence and influence operators. As noted, of vital consideration is the determination of which aspects of neuroscience study are most advantageously applied to deterrence studies and initiatives? For

[20] Topics in the Neurodeterrence of Aggression: Implications to Deterrence. http://nsiteam.com/scientist/wp-content/uploads/2014/02/Neurobiology-of-Aggression-Implications-to-Deterrence.pdf

those who are actively pursuing deterrence and influence strategies, what are the unresolved challenges? And how can neuroscience help as a force multiplier to getting more accurate understanding and deterrence approaches that have a greater likelihood of gaining desired results?

In answering these questions, one could frame this as a cost-benefit analysis that drills down to neurobiological underpinnings. This would include the neurobiology of a variety of related and overlapping areas of study:

- Decision making analyses: how does the brain make decisions, at what levels, and what is the emotional component of this? How is decision making affected by varied levels of stress?
- Game theory: How do individuals process reward and punishment in the brain? Neuroimaging studies have shown that simple material gain is less compelling when the brain perceives unfairness or inequity; and “reward” areas of the brain can become activated during cooperation or collaboration behaviors.
- Aggression: What neurobiological components contribute to aggression and aggressive behaviors and how are those controlled? For example, studies have shown that the biology of the brain controlling aggression is highly affected by environment, early experience, and other stimuli (potentially more so than genetic proclivity or hormonal stimuli, although these play a role). Changing these outside influences allow more leverage into whether and how individuals aggress.

These are just some representative examples; others that will be covered herein also include the neurobiology of cultural narratives, trust, in-group and out-group behaviors, etc. In the very least, a primary understanding of the neurobiology in these and the above categories can provide insightful context to the interpretation of seemingly irrational human behaviors, or behaviors that do not follow rational or mathematical models. At the most, tools for adjusting deterrence and influence could be utilized which steer deterrence and influence activities into directions which could allow for successful outcomes. This is the end goal.

Chapter 2: Application of Neuroscience and Neurotechnology Insights to Key Aspects of Influence and Deterrence

2.1: Introduction: James Giordano, Ph.D., William Casebeer, Ph.D., and Diane DiEuliis, Ph.D.

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The growth and development of neuroscience and neurotechnology (neuro S/T)

Many of the observations and insights provided thus far, and in subsequent chapters, have been borne out by a neuroscientific evidence base; while findings may have been corollary or suggestive in the past, a direct connection to a basic brain functionality is validating – or invalidating - much work to date within human behavioural studies. This is primarily due to the growth of neuroscience, which has undergone a greater than 70% growth during the 10 year period from 2000-2010, as evidenced by the increased number of studies reporting basic and translational research and various clinical applications (Giordano, 2012a). Neuroscientific information gained from methodologically rigorous research in noninvasive imaging and computational neuroanatomy, neurophysiology, neurogenetics, etc., can provide strong, evidence-based understanding of how individuals' neural functions contribute to various cognitive (and emotional) states that are important to decision-making and behavior. An overview of currently used categories and types of neurotechnologies is provided in Table 1.

Table 1: Categories of Neurotechnologies

Assessment Neurotechnologies
Imaging Approaches Computed Tomography (CT) Positron Emission Tomography (PET) Single Photon Emission Computed Tomography (SPECT) Magnetic Resonance Imaging (MRI) Functional Magnetic Resonance Imaging (fMRI) Functional Near Infrared Spectroscopy (fNIRS) Diffusion Tensor Imaging (DTI)
Physiological Recording Approaches Electroencephalography (EEG) Quantitative Electroencephalography (qEEG) Magneto-encephalography (MEG)
Genomic, Genetic and Proteomic Analyses
Neurochemical Biomarker Analyses
Interventional Neurotechnologies
Neuro-psychopharmaceuticals
Transcranial Magnetic and Electrical Stimulation
In-dwelling (Deep) Brain Stimulation
Peripheral/Cranial Nerve Stimulation
Genetic Modification
Tissue and Gene Transplants
Brain-Machine Interface Devices (Neuroprosthetics)

For overview and address of neuroethico-legal issues fostered by the use or misuse of specific neurotechnologies, see: *Neurotechnology: Premises, Potential, and Problems*, Giordano J. (Ed.), Boca Raton: CRC Press, 2012. For overview of these neurotechnologies' employment in national security and defense initiatives – and the attendant neuroethico-legal and social issues generated, see: *Neurotechnology in National Security and Defense: Practical Considerations, Neuroethical Concerns*, Giordano J. (Ed.), Boca Raton: CRC Press, 2014.

Extant limitations of assessment neurotechnology

At present, the interval needed to translate concept to construct, and theory to tools is estimated at 60 to 90 months. However, despite this translational pace, these approaches also incur a number of potentially controversial issues and questions, based, at least in part, upon the capabilities and limitations of the techniques themselves. Neuroimaging technologies and techniques (e.g.-positron emission tomography (PET), functional magnetic resonance imaging (fMRI), diffusion tensor imaging (DTI)) tend to have rather good spatial resolution, but less than optimal temporal resolution. Physiological measures (e.g. - quantitative encephalography (qEEG) and magnetoencephalography (MEG)) have good temporal accuracy, but only marginal spatial resolution, and cannot assess subcortical activity (with any reliable precision, at least to date). Genomic and genetic (and proteomic) assessments may be viable to assess certain predispositions to patterns of neural structure and function; but direct prediction of brain structure and functions (i.e.- phenotypes) can be difficult (if not impossible) given (a) multiple gene effects upon brain structure, function and cognitive and behavioral patterns; (b) single gene effects upon possible expressions of neural structure and physiological, cognitive and behavioral functions, and (c) the diversity of interacting biological and environmental factors affecting physical expression (Wurzman and Giordano, 2012). (*NB*: For further clarification, refer to definition of terms and techniques/technologies as provided in the Lexicon).

If used together in what is being developed as a paradigmatic approach, called Advanced Integrative Scientific Convergence (AISC), many of these constraints can be de-limited (see Section 3.2, this report, and also Giordano, 2012b; Vaseashta, 2012). Multiple studies by think tanks and academic boards have reviewed this landscape of neuro S/T, and have outlined specific opportunities for the public safety and national security community writ large (see, for example: Air Force Studies Board: Emerging Cognitive Neuroscience and Related Technologies (2008); Board on Army S&T: Opportunities in Neuroscience for Future Army Applications (2009); National Defense University: Bio-Inspired Innovation and National Security (2010); Force Fitness for the 21st Century (Military Medicine, 2010). Neuro S/T progress has thus raised hopes that new insights will improve the United States Government's (USG) capability to address national security challenges, including the ability to conduct influence and deterrence operations.

But neuro S/T does not provide a stand-alone or absolute toolkit for understanding deterrence and influence. Only when used in combination with other disciplines such as political science, anthropology, and psychology could neuro S/T provide the type and depth of insight(s) to bio-psychosocial factors that are effectively operationalizable and, therefore, most useful and meaningful in/to programs of influence and deterrence. Indeed, utility - and applicability - of these approaches are credible if and only if the relative constraints and underlying assumptions (and misassumptions) are acknowledged and accounted for in any and all attempts to apply said techniques - especially in situations beyond the research or restricted clinical realm (such as social norming and/or law).

This fosters a paradox: Given (a) trends in, and relative speed of neuro S/T advancement, and (b) recent events of social violence, there is a pervasive- if not increasingly strong - call from the public (as well as certain government sectors) to employ neuro S/T to define, describe and predict who will be most likely to commit acts of aggression or violence, and fortify the realities - and initiatives - of neurodeterrence. At the same time, apprehensions that such neurotechnologies will be used to probe consciousness and usurp privacy and autonomy are equally strong. Can – and could - equivocal calls for protection and privacy be prudently balanced under a rubric of neurodeterrence? It is crucial not to lose insight to the capabilities and limitations of these technologies and techniques, and imprudently employ them in inapt ways (e.g. - for legal inference or determinations of culpability or even disposition to certain patterns of thought and action, beyond what actual current technological capabilities allow). Moreover, given the growing availability of, and reliance upon the brain sciences, the use of neuro S/T for cognitive, emotional and/or behavioral control (i.e.—interventional neurodeterrence and neuroinfluence; viz. "neuroweapons") must also be considered (Giordano and Wurzman 2011; Wurzman and Giordano, 2014).

For example, recent work in development of selective pharmacological agents (such as certain types of benzodiazepine derivatives, such as midazolam), transcranial magnetic or electrical stimulation, and deep brain stimulation are all currently possible and may be regarded as steps toward affecting cognitive functions to alter emotional reactivity and behaviour (Giordano and Wurzman, 2011; Wurzman and Giordano, 2014; Moreno, 2012). These studies are important, but altering brain activity to change cognitive and emotional states relative and relevant to situational responses is not a new approach, even in the brain sciences. What *is* new is the specificity and precision that state-of-the-art techniques and technologies enable. What generates unease is using science and technology to probe and change thoughts and emotions – whether overtly or covertly. Without doubt, there are situations that might sustain the use of neuro S/T to alter cognitions, emotions and behaviors of aggression and/or violence (e.g. - florid psychopathy; Jotter and Giordano, 2013). However, this same capability could also be used in ways that might be viewed as more controversial and provocative, such as in interrogations, intelligence operations, and even certain contexts of what is construed to be "public safety". A key consideration will be the justification(s), conditions, and parameters that define and/or establish the use or non-use of neuro S/T in deterrence and influence initiatives.

Leveraging neuro S/T

To be sure, such considerations must address the actual capabilities, limitations and constraints of the S/T itself, as well as the contingencies and exigencies that might infer and prompt utilization. But, it is also important to recall that recent reports reveal neuro S/T generated over $150 billion in revenues, and showed an excess of 5% total market growth in 2011-12. Current predictions posit a greater than 60% increase neuro S/T research, development and translational application(s) within the next 10 years (NeuroInsights, 2010). What is crucial to recognize is that Asian, Russian and South American efforts are becoming equal to, if not surpassing US and western European enterprise in neuro S/T research, development and translation into operational use (Sobocki et al, 2006; NeuroInsights, 2010). This establishes brain science as a major economic factor and force affecting power distributions upon the world stage of the forthcoming decade. Such leveraging will not be limited to the economic sphere, as the aforementioned potential for neuro S/T use will likely gain momentum in various nations' programs of, and postures toward security and defense (for overview, see Giordano, 2014a).

We have previously argued, and unapologetically reiterate here, that given these contingencies and exigencies, the adoption of a simple precautionary principle (i.e.- cessation of endeavor if/when potential burdens or risks are greater than observed or anticipated benefits) is imprudent, and untenable. Other nations can and *will* engage neuro S/T research, development and translation into approaches that are usable in a host of scenarios relevant to national security and public safety. Therefore, we have called for – and renew the urgency of – a stance of preparedness that anticipates such shifting trends in global S/T (Giordano, Forsythe and Olds, 2010). Important to this agenda are the needs to (a) be well and currently informed of the trajectories and valence(s) that such trends may assume; (b) be cognizant of the effects that such developments may have upon the security and defense of the United States and its allies, and (c) engage active, but well guided, governed and directed programs of neuro S/T research, development, testing and evaluation (RDTE) to remain ready – and responsive – to these contingencies. As with all potentially dual-use technologies, the research will serve both the USG's preparedness stance in national defense, while also providing relevant tools for neurodeterrence and influence.

For these reasons, decision- and policy-makers need to re-address, if not revise current views and consideration(s) of influence and deterrence tools and approaches that are applicable to the 21st century security environment. As the USG draws down its nuclear forces, deterrence has become a key concern; the USG seeks deterrence through volition, not hostility. Mutual assurance of our allies is also important (Benedikter and Giordano, 2012). Contextualizing neuroscientific findings and the use of neurotechnology within the deterrence milieu is therefore more important now than ever. The goal is to weave a layer of neuroscientific tools and insights into individual, group, and state levels of deterrence opportunities. Empirical tests of key deterrence theoretical expectations, including the size of the state, military superiority, previous willingness to fight, and threats of destruction, have been inconclusive. Thus, the USG requires clearer understanding of what deterrence constitutes, and how deterrence works - at multiple levels.

In this light, key questions include:

- How and when do individuals and groups decide to forego those behaviors that they would otherwise engage? Does/how does this vary by culture, circumstance, and decision-making environment?
- Under what conditions or for which types of individuals or groups are threats effective/counter-productive?

- Are there indicators/metrics that can be remotely observed (i.e.-without direct contact with the individual or group to be deterred)?
- Can/how can social norms be quickly formed?
- Do individuals (either singularly or in groups) process (understand and respond to) threats or incentives under conditions specific to the possibility of conflict (e.g., fear, fluid v. rigid decision settings, time pressure, high stakes, perceived threats to personal versus collective interests, etc.)?
- How can messages be designed for one actor without threatening or mis-signaling others?
- How can messages' "meaning-- as- intended" be assessed/determined?
- How can deterrent messages be crafted in ways that are credible and likely to afford sustainable influence at individual and/or group levels?

Neuroecology: Contextualizing consideration and use of neuro S/T

In describing the role of neurobiology in social and psychological interactions, we emphasize the term "neuroecology" to define the neural structure(s) and functions that are embodied in organisms embedded in, and responsive to, various conditions, effects, and cohorts within particular environment(s) (Giordano, 2011). These mechanisms influence individual awareness, responses, decisions, and actions toward others, environmental conditions, and situations that may be regarded as positive, neutral, or negative (Avram et al, 2014; Berns et al, 2012; Borg et al., 2006; Finger et al. 2006; Wunderlich, Rangel and O'Doherty, 2009; and Young et al, 2010; for overviews, see: Casebeer, 2003; Verplaetse et al, 2009; Giordano, 2014b). In this way, neuroecology affords insights to predispositions to a host of environmental variables, which may then establish bases for the cognitions, and emotions that affect behavior(s) related to myriad environmental and inter-personal circumstances that arise within individual, group, community, and even population-wide dynamics. From this standpoint, neuro S/T can be seen as providing techniques and tools that could be employed in a convergent multidisciplinary approach to (a) study, define, and possibly predict human ecologies, and (b) afford methods that may be viable, and therefore of potential value, in affecting cognitive and behavioral functions within certain ecological conditions relevant to deterrence. Understanding the neurobiological response to these environmental variables, at the individual level, for example, should help form the basis of any deterrence or influence approach to that individual. Similar considerations should be made of groups.

Neuro S/T may be developed and operationalized on "synaptic-to-social, and social-to-synaptic" scales. This "individual-to-group, and group-to-individual" approach may alter traditional views of deterrence (i.e., in terms of the posture and activities of one state deterring another). National/political states are inanimate objects that do not think or act. Yet, the polis of any nation state is composed of individuals who interact, exert, and effect influence(s), and instrumentalize decisions and activities of groups. Thus, employing (the correct type and extent of) neuro S/T approaches within a larger framework of bio-psychosocial analyses and interventions will be important to fortifying extant methods and developing new and innovative means to planning and implementing effective assessment, influence and deterrence operations (Wurzman and Giordano, 2014; Giordano, Kulkarni and Farwell, 2014).

Operationalizable neuro S/T?

Current findings suggest that the brain receives – and processes - information through one of two modes: story mode or analytic mode. When in story mode, which might prove to be the default setting, brain activity may dispose an individual to be more likely to accept new ideas. This receptive state is ideal for “narrative transportation,” which can be measured via behavioral assessments, peripheral physiological correlations, neurophysiological metrics (e.g.-qEEG/MEG techniques) and neuroimaging (e.g.-fMRI/DTI studies). Combined with the existing literature on narrative transportation, these measures improve the ability to forecast which narratives (and which parts of narratives) are more likely to be persuasive. Understanding the characteristics of narrative transport could not only help with influence and deterrence in terms of the types of messages that may be most effective, but also temporal actionable approaches, when individuals or groups might be more receptive to additional messaging or ideas while in narrative transport (see Romero Chapter).

Other research, focusing on influence, suggests that social cues are used to attribute trustworthiness/veracity of a message. In short, influence is a social process. However, an important caveat is that not all individuals respond to stimuli in the same ways. Neuro S/T approaches are being shown to be of value in discriminating how various narratives are neurologically processed in different individuals, and how various circumstances, effects, and perspectives (of the individual, environment and narrative) affect engagement/activity of certain neurological mechanisms to affect decision-making (for overview, see Verplaetse et al, 2009; Giordano, 2014b).

One social cue relevant to influence is trust. Much current research has focused upon the putative role of the neuropeptide oxytocin in regulating neural activity that affects cognitions and emotions that have been shown to be influential in pair-bonding, trust, empathy and altruism. For example, based upon a body of animal studies, recent experiments have examined the effects of (intranasally infused) oxytocin on human neurocognitive state and resulting thought, emotions and behaviors. Preliminary findings reveal that subjects receiving intranasal oxytocin were more likely to trust a stranger during experimental situations of interpersonal interactions. Oxytocin may act to heighten neurocognitive sensitivity and responsiveness to social cues that are important to trust. As well, oxytocin may influence positive in-group and negative out-group perceptions. These studies will be highly relevant to situations in which one wants to deter an individual, despite a particular group dynamic, or to engage with, or persuade/influence groups by using particular social cues.

While these- and related findings - are promising, if not provocative, in their suggestion that exogenous oxytocin may have use as a potential pharmacological approach to fostering trust and empathic cognitions and behaviors, caution is warranted in superficial interpretation or application(s) of such results. While oxytocin clearly is important, instrumental, and perhaps even strongly operative in attraction, attachment, and the more expansive constructs of trust and altruism, these cognitions and emotions are the result of a dynamic interactions of numerous nerve chemicals at several brain sites, which, may actually differ, at least to some extent, in each individual (Giordano, 2010).

Neuro S/T approaches to understanding terrorism

Until the turn of the 20th century and the introduction of rational actor theory, a unified concept upon which to base deterrence was absent. However, the last several decades have shown certain limitations of rational actor theory in predicting or accounting for emotions, beliefs, desires, and attitudes. In the 1980s, heuristics and biases were layered onto a revised version of rationality in explaining deterrence. Yet the focus remained on the nation-state. As well, the last 15 years have seen a pivot towards other levels of analysis, primarily non-state actors, individuals, and social movements. There are many reasons why an individual might join an extremist group—revenge, status, love, fear, and belonging; ideology is not one of them. Attitudes are not a good predictor of behavior. In fact, radicalization is not a single dimension—one should not conflate ideation with behavior. At present, the neuroscientific community does not have a viable theory to posit why individuals transition from passive sympathy to aggression/violence.

One potentially influential factor in this transition is feeling(s) of disgust toward, and dehumanization of “the other”. Individuals and groups are perceived to have essences. When a group’s essence is perceived to be negative, if not detrimental to the in-group (e.g. - when people start talking about the other as vermin, lice, etc.), sentiments and behaviors are directed toward mitigating or eliminating the source of repulsion and threat of harm. Narratives can be used to convey the idea of disgust and dehumanization, as has been historically evidenced in social and political propaganda. In contexts of conflict, the “bad essence” of the other becomes integral to the narrative. Mitigating and/or changing sentiments of disgust (to more empathetic or sympathetic views) can be useful in generating narratives that can be disseminated through neurocyber approaches to diffuse escalating individual and group aggression and violence. However, it should be noted that this effect may not always be achievable within the short-term; research suggests that although exceptions exist, social constructs of “others’ (bad) essence” often become deeply entrenched within cultural norms, and effecting change to such ingrained beliefs and attitudes can take considerable time and enterprise.

The cognitive revolution, which started in the 1960s, has a flourishing literature on how aspects of the environment interact with the brain to effect behavioral change. Neuroscience affords approaches through which to deepened and fortify understanding of, and insights to communication and transmission of information, and the ways that social content can influence behavior. It can also provide the setting and context for what is best received by individuals or groups, which may require distinct approaches. Such assessment can be employed to develop interventional approaches, which are not simply applications of neurotechnology to effect outcomes through invasive means, but rather, the use of neuroscientifically-generated information about the brain and its functions to develop more effective tactics and strategies of evaluating, influencing individual, group and social cognition and behavior.

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2.2: Evolutionary Considerations: Rose McDermott, Ph.D.

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Humans want to protect what they believe to be their own territory, resources, friends and loved ones. When such values are threatened or harmed, the instinct to "get back" at the perpetrator can be strong and immediate, even among those who believe that violence is not the best way to solve problems. This instinct represents the desire for revenge, which appears to be a universal tendency, present across time and a wide variety of cultures. The psychology that underlies revenge helps explain the evolution of deterrence, which serves the purpose of trying to prevent those attacks before they begin. In short, the psychology of revenge motivates the drive toward deterrence.

Deterrence existed long before nuclear weapons, and evolutionary models can help explain how deterrence emerged as a way people sought to protect and defend the people and things they valued. If everyone knows that an attack will be followed by an immediate attempt to retaliate swiftly and decisively out of an automatic desire for vengeance, it makes such an attack less likely to begin with because it reduces the likelihood that such an attack will prove worth the subsequent cost of retaliation. In many cases, retaliation for past attacks may have destroyed the entire group which launched it. By literally eliminating the enemy, such destroy and conquer strategies served to vanquish any possibility of future attacks from the group that is annihilated. Thus, deterrence is understood to reduce the probability of aggression before it can begin in the next round. In this way, it can serve both a preventative as well as a pre-emptive function.

Before the development of agriculture, avoidance often proved the best route to safety in a conflict. It also meant that it was hard to protect herds that were often easily stolen since they could move themselves. Under such conditions, it is important to develop a reputation for swift and decisive retaliation if such theft occurs in order to prevent others from controlling resources, invading your territory or stealing your mate. In this way, deterrence becomes both a matter of honor as well as survival. However, as humans came to live in larger groups, and became more sedentary, escape was not as easy. In addition, the development of militarized weapons proved to a great equalizer, allowing weaker individuals to still wreck huge destructive power. Although the conditions may have changed, the psychology underlying revenge and the motivation it provides to establish deterrence have not shifted as quickly.

The threat of retaliation which underlies deterrent strategies rests on the assumption that the attacker would rather retreat, withdraw, and live to fight another day, on average. Psychological problems and limitations with this model can arise in various ways. First, deterrence will only work is the enemy believes the opponent poses a credible threat; if the opponent believes he can escape retaliation by hiding his identity, or by being able to credibly assign blame to another, he will not be as likely prevented from his actions. This is why deterrence needs to be swift and strong. Second, deterrence only works is the enemy is aware that the defender is committed to responding to particular acts in particular ways; if this is not clear in advance, then subsequent messages may deter future attacks but not the initial one.

Finally, and perhaps most importantly in the current climate of suicide bombers, deterrent strategies only work if the enemy wants to survive, and either does not have kin they value, or holds a reasonable belief that such kin cannot be located and thus targeted for retaliation subsequent to attack.

2.3: Deterrence via narrative - The role of narrative transportation in creating persuasive messages: Victoria Romero, Ph.D.

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"The world is shaped by two things - stories told and the memories they leave behind." - Vera Nazarian

Abstract

Stories engage a different type of cognitive processing than do logical arguments; stories can bypass the psychological defenses that hinder persuasion by argument. Narrative transportation heightens this story-specific processing and may hold the key to creating highly persuasive stories. Key findings from research on narrative transportation include:

- Audiences are more open to ideas and position that conflict with their own when they are presented within stories.
- Audiences' intended behaviors can be impacted by stories.
- Audiences remember information learned in stories as though it is true – even when they know the story is fictional.
- Stories disengage parts of the brain associated with self-referential, internally focused thought.
- All of these effects are magnified when a story is highly transportive.
- Research offers guidelines on creating transportive stories.

Narrative transportation is the experience of becoming lost within the world of a story. Gerrig (1993) first used the travel metaphor to express how readers become psychologically detached from the real world as they become more engrossed in world of the story. In the 20 years since, we have learned a great deal about the intersection between stories, transportation, and persuasion. We have empirical evidence that experiencing a narrative can be a transformational experience with long-term effects on audiences' attitudes, beliefs, and behavioral intentions (see Van Laer, et al., 2014 for a review). The impact of transportation on persuasion is strong enough to lead Slater (2002) to suggest that, "Use of narratives, in fact, may be one of the only strategies available for influencing the beliefs of those who are predisposed to disagree with the position espoused in the persuasive message" (p. 175).

The experience of narrative transportation

Transportation is composed of an affective component and a cognitive component. Affectively, narrative transportation occurs when a story's audience is emotionally invested in a story. Much of the research on this topic has focused on empathy (e.g. Slater & Rouner, 2002). Empathy is the audience's ability to experience the narrative from the protagonist's perspective; not just to feel for the character (that is sympathy), but feel *with* the character. Highly transported audiences will feel the fear, anger, sadness, and elation that a character depicts, as though they are in the character's place. Cognitively, narrative transportation is associated with tightly focused attention on plot-relevant elements, but decreased analytical processing (Green et al., 2008). Both the affective and cognitive components are integral to transportation's impact on persuasion.

Persuasive effects of narrative transportation

Historically, persuasion research has focused on how people analyze (or fail to analyze) arguments. Narrative persuasion is different; persuasive narratives are not effective because they present persuasive arguments. In fact, they do not present arguments at all. Instead, narratives present information and positions that are true and valid within the context of the story. Since Green and Brock (2000) invented the first quantitative measure of transportation, we have learned that narrative transportation is key to narrative persuasion. The list of effects of narrative transportation on persuasion is impressive:

- Highly transported audiences disengage from their real-world beliefs and perceive story-consistent beliefs as valid, even when they know the story is fictional (Marsh & Fazio, 2006).
- Transported audiences encode "facts" learned through stories the same way they encode facts learned in the real world, and are later unable to distinguish between them (Marsh & Fazio, 2006).
- When transported, audiences are less likely to generate critical thoughts about information and positions presented within a narrative, even when they are inconsistent with their own beliefs (Slater & Rouner, 2002).
- Transportation is associated with impacts on audiences' intended behaviors. Dunlop et al. (2010) found that greater transportation increased audiences' willingness to use sunscreen. Williams et al. (2011) found impacts on smoking cessation and Kaufman and Libby (2012) found effect on voting.

Neurological mechanisms underlying narrative transportation

Although the effects of narrative transportation are well documented, the mechanisms underlying these effects remain an area of active research. Recent work undertaken Bezdek et al. (2014) provides confirmation that while viewing a transportive narrative (in this case, suspenseful film clips) a viewer's brain is less sensitive to stimuli that are not part of the story world. These results also suggest that transportation is associated with a decrease in Default Mode Network (DMN) activity. The DMN is associated with self-reflection and self-referential thought; the reduction in DMN activity supports the notion that transportation is a detachment from one's own reality. Work underway in another lab (Dmochowski et. al., 2014) is exploring findings of identifiable EEG signatures at moments of peak engagement (the affective component of transportation) and which are synchronized between people. These new lines of research hold promise for shedding light on the neurological mechanisms of narrative transportation and persuasion. These lines of research may also lead to better means to measure transportation than the self-report scales currently used (e.g. Escalas, 2004; Green and Brock, 2000).

Creating a transportive narrative

As interesting as the impacts of narrative transportation are, these findings are only useful if we are able to apply this research to reliably create highly transportive stories. Fortunately, the research does offer insight into what makes a narrative transportive. Although these guidelines provide no guarantee of results, they do increase the likelihood that a narrative will be transportive, which in turn increases the likelihood that it will be persuasive. The variables that affect transportation can be classified into two categories: narrative characteristics and audience characteristics.

Narrative characteristics

One key characteristic of transportive narratives is the identifiability of the main character. To empathize with the perspective of story's characters, the audience must be able to identify with those characters (Escalas & Stern 2003). Characters are more identifiable when they are culturally familiar and demographically similar to audiences. Creating a maximally transportive narrative requires familiarity with the audience and tailoring characters to fit that audience. Narrative techniques such as first-person voice and character-centered story telling also help invest the audience in a specific character's point of view (Kaufman & Libby, 2012).

Another key characteristic of transportive narratives is an imaginable plot (Green, 2006). This is not to say that plots must be realistic; fantastical stories can by highly transportive. Rather, stories must be familiar enough to audiences that they can be imagined. For example in Western cultures, stories set in worlds similar to Medieval Europe (e.g. Game of Thrones or The Hobbit) may be clearly fictional, but they are also highly imaginable due to our extensive exposure to this genre. We are able to imagine details not explicitly included in the narrative which allows us to flesh out a rich narrative world. Transportation is also increased when the narrative supports the audience's suspension of disbelief. This requires that the story must be internally consistent. Inexplicable inconsistences or highly unfamiliar story structures draw audiences out of transportive states and cause them to process stories analytically (Bal et al., 2011).

Audience characteristics

Transportability varies across individuals and appears to be associated with the capacity for empathy (Mazzocco et al. 2010). It should be noted that all of the research on transportation (and narrative persuasion more generally) has been conducted in affluent, industrialized, Western nations. Stories are a universal phenomenon - all cultures have stories. This gives us good reason to expect that narrative transportation also exists in all cultures, but there may be nuances that will not be apparent until we replicate our research across a spectrum of other cultures.

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2.4: Neuro S/T and the spread of ideas and behaviors: Emily Falk Ph.D.

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Abstract

How can we increase the effectiveness of influence and deterrence through traditional channels (mass media, interpersonal) and in the new media environment?

- Neuroimaging offers the ability to interrogate multiple psychological processes simultaneously and can provide insights about how and why ideas and behaviors spread.
- In addition, the brain reveals information that may be difficult to uncover using other methods-- neural signals predict behavior change in response to such influence beyond what is predicted by people's own intentions to change.
- Of particular importance to influence and deterrence are brain systems implicated in implicit self-related processes and valuation (i.e., does the message register positive value to the recipient) and emotional drives to approach rewards and avoid punishments.
- Finally, it is important to consider not only the perspective of the person being influenced but also the potential for each actor to influence others. Preliminary evidence suggests that brain systems implicated in perspective taking and social cognition (e.g., how might this idea be of value to others and what will they think of me if I share?) may be key to understanding individual differences in being a successful idea salesperson.
- Neuro S/T can leverage the predictive capacity of neuroimaging data to improve our ability to design, select and predict the effectiveness of messages, and to identify network structures and individuals within networks who are likely to be most effective in transmitting or deterring ideas and behaviors.

Mass media and social media each constitute powerful forces that contribute to social context and affect behavior. For example, exposure to violent media is known to increase aggressive behavior (Anderson & Bushman, 2001; Bushman & Huesmann, 2006; Carnagey, Anderson, & Bushman, 2007), and exposure to smoking and drinking in movies increases the chances that adolescents will engage in these behavior (Dalton et al., 2003; Sargent, Wills, Stoolmiller, Gibson, & Gibbons, 2006). What are the pathways through which influence translates into behavior? How do people move from sympathy to violence? In what ways might attention and behavior be shifted away from violence to more prosocial ends?

One limiting factor in addressing the questions above is that people often lack conscious awareness of the factors that cause them behave in certain ways and to change their behavior. Self-reports of individuals' attitudes and intentions explain some, but not all of the variance in their later behavior (Armitage & Conner, 2001). Neuroscience methods complement existing tools from psychology, sociology, communication science, political science and other social science disciplines by offering a window into psychological processes as they unfold (for example, in the moments that influence takes hold) (Falk, 2013; Lieberman, 2010). Leveraging this ability, neural responses to health messages have been used to predict subsequent behavior change that was not explained by other measures (Berkman & Falk, 2013). It is not yet known whether parallel prediction would be possible with respect to violent media, extremist messages or other relevant social inputs that might similarly predict aggressive or violent behavior. The neural mechanisms that have predicted health-relevant behaviors, however, suggest insights for neuro S/T.

MPFC, self-related processing and valuation

As noted in earlier chapters, there are many reasons why one might join an extremist group or engage in behaviors that seem unthinkable from the outside. These might include revenge, status, love, and fear, but the heart of such motivated actions are the values and relationships that individuals hold nearest and dearest to themselves. How do individuals calculate such value? Research in social neuroscience and neuroeconomics has identified brain systems that calculate implicit self-relevance and positive valuation (Bartra, McGuire, & Kable, 2013; Denny, Kober, Wager, & Ochsner, 2012), and found that both rely on ventral portions of the medial prefrontal cortex (MPFC). Neural signals from this brain system also strongly predict behavior change in response to messages in the real world (Berkman & Falk, 2013). For example, in one of the first studies to predict real-world behavior change using neural activity, Falk and colleagues (2010) found that neural activity in MPFC predicted changes in the study participants' behavior better than the participants' own attitudes toward the behavior in question (sunscreen use) and their intentions to change that behavior (Falk, Berkman, Mann, Harrison, & Lieberman, 2010). Subsequent research replicated similar findings in more motivationally relevant and difficult-to-change behaviors (e.g., smoking cessation) over longer time periods (Falk, Berkman, Whalen, & Lieberman, 2011). In addition, Chua and colleagues (2011) replicated the finding that MPFC responses predict behavior change and found that messages tailored to the individual elicited significantly higher responses within this brain region (Chua et al., 2011). The new media environment is optimized for tailoring messages; given that tailoring is known to directly increase the effectiveness of messaging, and seems to operate in part through the MPFC, this may be one strategy that would leverage new technological capabilities and increase the power of influence and deterrence. On a broader (mass media) scale, neural responses in MPFC in response to messaging in small groups of people have also predicted large scale media effects, above and beyond what is predicted using participants' self-report projections of which ads are likely to be effective (Falk et al.; Falk, Berkman, & Lieberman, 2012).

Together, these results highlight the importance of connecting with targets of influence at the level of implicit self-relevance and value and also highlight the possibility of using neuroimaging technology to design and select high value messaging and to predict relevant behavior change. In addition, antecedents of this value signal may be fruitful in informing influence and deterrence efforts. For example, MPFC integrates inputs from multiple brain systems, including both fast, emotional responses (e.g., within the limbic system) and more deliberative reasoning (e.g., within lateral prefrontal cortex). It is likely that the MPFC is an efficient predictor of behavior change because it outputs a summary value signal that takes into account multiple factors simultaneously (i.e., integrates emotional and cognitive responses to output a subjective value of an action to the self). Critically, this integration seems to occur outside of conscious awareness and the resulting signal predicts behavior change that is not predicted by other data sources (e.g., people's self-reported intentions to act). Given that emotional inputs are often as strong or stronger than deliberative reasoning, below I review selected key emotional drivers of behavior and the corresponding brain systems that may affect the value signal computed by VMPFC (for a more in depth review of brain systems likely to affect and be affected by influence, see (Falk, Way, & Jasinska, 2012)).

Approaching social rewards

Seeking rewards is one key emotional driver of behavior (Berridge, 2012). The brain's reward system responds both to primary rewards (such as food and sex) as well as to more abstract social rewards (such as receiving positive social feedback or increased social status) (Izuma, Saito, & Sadato, 2008; Zink et al., 2008). In parallel, a growing body of literature suggests that social signals powerfully shape responses to otherwise neutral stimuli within the reward system—for example, learning that peers believe a female face is more attractive increases young men's reward response to that face (Zaki, Schirmer, & Mitchell, 2011) and believing a wine is more expensive not only increases subjective ratings of the taste, but also the brain's reward response (Plassmann, O'Doherty, Shiv, & Rangel, 2008). These effects are especially strong in young adults—in one study, the mere presence of other teens sensitized neural reward responses to risk taking, a behavior that is often used to garner social acceptance in that age group (Chein, Albert, O'Brien, Uckert, & Steinberg, 2010). In parallel, neural measures of teens' cognitive control resources predict reduced susceptibility to risk taking when in the presence of a risk averse peer, but in the presence of a risk promoting peer, the effects of such cognitive control resources are washed away (Cascio et al., under revision). These findings may be especially critical for neuro S/T—it is well established that teens and young adults are capable of deliberative reasoning, but in the presence of other teens, faster and more powerful emotional responses take hold.

Avoiding social punishments

Likewise, avoiding punishment and social exclusion can powerfully drive behavior. Brain systems that encode the distress of physical pain also respond to exclusion and social loss (termed "social pain"; (Eisenberger, Lieberman, & Williams, 2003; Eisenberger, 2012; Kross, Berman, Mischel, Smith, & Wager, 2011)), likely due to the fact that being excluded or separated from the social group had very high costs from an evolutionary standpoint. Consistent with strong motivations to avoid social punishment or exclusion, young adults who show the greatest neural sensitivity to exclusion are also most susceptible to risky social influence in the presence of peers (Falk et al., in press), and young adults who are excluded take steps to regain acceptance by changing their attitudes, preferences and behaviors (DeWall & Richman, 2011; Dewall, 2010; Maner, DeWall, Baumeister, & Schaller, 2007).

In the context of neuro S/T it is also important to note that there are individual differences in sensitivity to both rewards and punishments, which are in part culturally determined, but which are also likely driven by gene x culture interactions (for a review, see Falk, Way & Jasinska, 2012).

How ideas spread

Finally, it is important to consider not only the perspective of the person being influenced but also the potential for each actor to influence others. Neuroscience research on the spread of ideas suggests that those who are best at recreating their preferences and beliefs in the minds of others tend to use brain systems implicated in perspective taking (e.g., the temporoparietal junction) more when they initially encode ideas (Falk, Morelli, Welborn, Dambacher, & Lieberman, 2013; Falk, O'Donnell, & Lieberman, 2012). It is likely that this initial lens allows such individuals to not only encode the idea, but also to socially tag it in ways that make it easier to transmit effectively later on. Of interest for neuro S/T, recent pilot data from our lab also suggests that the social structures in which individuals are embedded (i.e., properties of their social network) may change the tendency to engage such brain systems. This is a particularly important area for further inquiry as it has implications for the ways that we structure organizations and command chains to optimize or deter the spread of ideas, as well as how we respond to ideas that have begun to spread in other contexts (e.g., deterrence of the spread of extremist messages).

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2.5: Neuroscientific Considerations of Trust and Influence: Jorge A. Barraza, Ph.D.

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Abstract

Influence is a social process. Social cues dictate how an *influence target* attributes trust or truthiness to an *influence source*. As such, influence is not purely calculative (or "rational") as a myriad of both cognitive (thought) and affective (emotion) factors are involved in the process. The neuroscience of trust provides a framework for examining how emotions, pre-existing beliefs, and individual differences can impact influence at individual and group levels. In particular, the hormone oxytocin illustrates that influence can have ancient roots in our evolutionary development as a social species. Some highlights of this research are provided with a discussion of their implications to deterrence.

Introduction

Whether an influence strategy utilizes force, coercion, or more "diplomatic" means, these decisions rely on valuation processes operating under conscious awareness. The neurobiology of trust provides an opportunity to illuminate this hidden process. Trust is generally viewed as a *behavior* that makes one party (influence target) *vulnerable* to another party (influence source). Trust occurs when the other party is deemed to be credible or trustworthy. An influence target will ascribe trustworthiness if he or she believes the influence source is 1) competent and consistent (*ability*); 2) caring, empathetic, or sharing a common goal (*benevolence*); or 3) objective, fair, and honest (*integrity*; Mayer, Davis, & Schoorman, 1995).

Neuroscience research has generally used social dilemma games to study trust (e.g., investment/trust game), whereby an individual can place him or herself at risk of financial loss in order to cooperate with another party. In these studies it is assumed that all parties are fully informed about the rules of the games. As such, this body of work can inform us about trust in settings where *benevolence* and *integrity* are important, but not when *ability* is a driver of trust (for instance, the ability of the influence source to carry out an agreement).

The Neuroscience of Trust

Biological events, primarily occurring in the brain, have been shown to be involved in the formation of trust. Key in this body of research is the relationship between oxytocin and trust. Oxytocin is an evolutionarily ancient hormone produced in the brain. It is implicated in a wide range of positive social behaviors (e.g., trust, reciprocity) and emotions (e.g., empathy) among strangers (for review see Barraza & Zak, 2013). The link between oxytocin and trust has been examined using multiple methods including direct modification of levels in the brain (e.g., Kosfeld et al., 2005), via changes in circulating oxytocin in blood (e.g., Zak et al., 2005), with brain imaging technology (Baumgartner, et al. 2008), and through genetic studies (e.g., Reuter et al., 2009). Our understanding of this relationship began with a landmark study indicating a direct causal relationship: experimentally increasing oxytocin in the human brain increased trust toward strangers (Kosfeld et al., 2005). Research to date now indicates that oxytocin influences the perception of social information below conscious awareness (lower order processes), particularly by increasing attention given to social information (thinking about the "other") and by lowering social threat. The proceeding highlights some of the key findings and conclusions related to influence.

First Impressions Bias Future Interactions

Aggression is a useful but costly strategy. This effective short-term strategy can ultimately be costly for future cooperation. A priori social knowledge can heavily impact the subjective (and neural) assessments of trust in others (Delgado, Frank, & Phelps, 2005). Oxytocin will not increase trust when past history leads to an initial evaluation of the partner as untrustworthy (Mikolajczak et al., 2010). The reverse also appears to be accurate: when trust initially exists, it takes much longer to "spot" an untrustworthy partner (Delgado, Frank, & Phelps, 2005; Baumgartner, et al. 2008). As such, ensuring that first encounters create positive evaluations will be beneficial to future influence attempts.

Trust is Socially Risky (and Rewarding)

Influence operations involve both uncertainty and risk for the influence target. The neurobiology underlying trust may promote risk behavior by shifting attention to positive social outcomes.

This has been shown to be entirely different from non-social risk decisions, like gambling (Kosfeld et al., 2005). It appears that trust is different from engaging in risky choice itself, but is an action based on considerations about the social uncertainty involved. Why? Brain imaging studies suggest that humans experience trusting others as rewarding, which may act to reinforce future trust/cooperation (e.g., King-Casas et al., 2005; Krueger et al., 2007; Rilling et al., 2002). Indeed, the "reward" neurochemical dopamine has a strong positive relationship with oxytocin in the brain (Baskerville & Douglas, 2010). Thus, people make themselves vulnerable not just because the outcome is potentially rewarding, but the act of trust is intrinsically rewarding.

Trust has Ingroup/Outgroup Distinctions

Trust involves both coordination with and a preference to affiliate with group members. Oxytocin appears to increase preference for one's in-group (see De Dreu, 2012). However, there is <u>no</u> consistent support for oxytocin promoting antisocial behavior toward an out-group (see van IJzendoorn & Bakermans-Kranenburg, 2012). Oxytocin may promote in-group bias when there are zero-sum relationships between groups, specifically where cooperation with the in-group would be a detriment to the out-group. Support for this interpretation is found by other scientists (Israel et al., 2012) who find that oxytocin can promote out-group cooperation in tasks that allow for the mutual benefit of groups. It appears that trust is sensitive to in-group/similarity cues, but only when the framing of the conflict is zero-sum.

Trusting in Mass Communication

The pace by which social information is shared by known and unknown others is dramatically accelerated by new technologies and social platforms. The process by which this information is ignored, counter-argued, or influential to actors may include countless factors. Influence may occur under conscious awareness, or may occur over an extended period of time, and thus may not always be amenable to traditional observation tools. There is evidence to suggest that the amount of emotional engagement with a message (public service announcement: PSA) can indicate message effectiveness (sacrificing personal money to the "cause" communicated by the PSA). Both subjective engagement with the message and the costly action (viewed as message influence) are associated with greater oxytocin in the brain (Lin et al., 2013). Similar effects for oxytocin are found for donating to charities after being presented with a persuasive appeal (Barraza et al., 2011; van IJzendoorn et al., 2011). As such, the neurobiology of trust is also involved at a more macro-level with mass communication techniques.

Individual Differences can Impact Trust

Trust occurs at an individual level, varying by situation. However, the propensity to trust varies from person to person and from culture to culture (Cesarini et al., 2008; Fukuyama, 1995; Johnson & Cullen, 2002). Trust also varies at a national level, with lower GDP countries showing lower levels of interpersonal trust for government and neighbors alike (Zak & Knack, 2001). We should be cognizant of personality (or group predispositions) affecting the dynamic between influence target and source. For instance, oxytocin appears to be involved in trust in leadership and organizations. Oxytocin leads certain individuals (Democrats) to be more trusting of politicians from both parties, and the federal government in general, when compared to those on placebo (Merolla et al., 2013). It is possible that individual differences more prevalent in this group (e.g., openness to divergent opinions) provide wiggle room to influence their attitudes toward political figures. If this is the case, there may be "soft targets" of influence that could be identified by certain psychological predispositions.

Conclusion

No single hormone, no single neural or autonomic state can be expected to align perfectly with abstract multi-faceted concepts like trust. Nevertheless, our understanding of the neurobiology of trust has been greatly informed by oxytocin. The neurobiology of trust can provide insight into a fundamental human capacity with real world implications.

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2.6: Neural prediction error is central to diplomatic and military signaling: Nicholas D Wright, Ph.D.

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Summary

This paper can help U.S. policymakers to cause intended effects, and avoid unintended effects, on an adversary in a diplomatic or military confrontation.

- The neural phenomenon of "prediction error" provides a tool to *increase* or *decrease* the impact of our actions.
- A prediction error framework forecasts widespread and important effects (inadvertent escalation, surprise etc.); and it simplifies across existing strategic concepts so it can be operationalized without additional analytical burden.
- I discuss historical cases, doctrine, a China-U.S. escalation scenario, and make policy recommendations (Table 1).
- Understand prediction errors and use them as a tool to implement and interpret diplomatic and military signaling.

Introduction

To manage crises and escalation, or to conduct deterrence operations, it is necessary to forecast how an adversary will decide to respond to our actions. A core insight from neuroscience is that when we make an action, the impact it has on the adversary's decision-making is crucially modulated by the action's associated "prediction error".[21] This prediction error is simply defined as the difference between what actually occurred, and what the adversary expected. The bigger the associated prediction error, the bigger the psychological impact of the action.

Prediction errors and insider knowledge causing inadvertent escalation

One reason that prediction errors matter is because they can cause inadvertent escalation. I illustrate this by a simple case, where we aim to make a calibrated response that is tit-for-tat (i.e. is an action of the same impact). Can we respond in this symmetrical tit-for-tat manner, even when we want to and in ideal conditions?

[21] From simple tasks (Niv and Schoenbaum, 2008), to more complex social interactions (Behrens et al., 2009), it is central to how humans understand, learn and decide about the world.

Consider two individuals who take turns to apply physical force to one another's hands in a lab.[22] They have each been told to apply the same force to the other participant that had just been exerted on them. But what actually happens is a large and rapid escalation in the force applied, which increases over one third each turn. This is simply a case of implementing tit-for-tat, but there is inadvertent escalation. Why? We constantly use models of the world to predict events that will occur. We have "insider knowledge" of our own actions. When we make actions we use our "insider knowledge" to help predict and cancel out the events they generate. So, to us applying the force it is largely predicted, but the recipient does not have such insider knowledge and so experiences a stronger impact. Thus each action in turn has a stronger impact on its recipient than its originator, causing inadvertent escalation.

Thus we predict the effects of our own actions, so they have more impact on the adversary than we understand, or perhaps intended. This helps understand the impact of the Soviet action of placing medium and intermediate range nuclear missiles on Cuba in 1962.[23] To Soviet decision-makers the action was not markedly more provocative than previous actions by the two sides. For example in the late 1950s the U.S. had placed intermediate range missiles in Turkey, the UK and Italy. As Premier Khrushchev said in his memoirs: *"the Americans would learn just what it feels like to have enemy missiles pointing at you; we'd be doing nothing more than giving them a little of their own medicine."* (Taubman, 2003) In keeping with this Soviet conception of the action's level of impact, whilst they clearly employed secrecy in placing the missiles, this was limited, for example with Soviet units plainly and prominently displaying their unit insignia. But the action had a strikingly asymmetric psychological impact on the U.S. that was on the receiving end. As President Kennedy said during the crisis: *"Offensive missiles in Cuba have a very different psychological and political effect in this hemisphere. ... All this represents a provocative change in the delicate status quo both countries have maintained."* (May and Zelikow, 2002)

How would this affect a near-term China-U.S. confrontation over Taiwan or the Senkakus/Diaoyus? In any such China-U.S. confrontation, a key factor will be the use, or threatened use, of Chinese conventional ballistic missiles. These capabilities are in general better understood by the Chinese themselves than by the U.S.. Further, in any specific use, the Chinese would naturally have greater knowledge of when, where and how they would be used. For instance, a Chinese "shot across the bows" of a U.S. carrier would likely be more unexpected for the U.S. than China would anticipate, and so would be a bigger signal on the U.S. than

[22] This example involves applying force (Shergill et al., 2003), but the same principles are seen with other actions e.g. making tones (Weiss et al., 2011). Note this escalation here does not result from an idea of the other's intention, for example being seen even on the first turn.

[23] I present one example due to space limits but others include: the Anglo-German naval rivalry pre-WWI; Morocco Crisis 1904-5; and build-up to Crimean War in the 1850s.

understood by China. China has never used such conventional ballistic missiles before, and U.S. understanding of their doctrine is uncertain, so this could trigger inadvertent escalation.[24]

The policy implications are: firstly, when making actions, they may have greater impact on the adversary than you understand; secondly, when receiving actions, they may have greater impact on you than the adversary understands; and third, this matters most when you have much greater "insider knowledge" of your actions.

Prediction errors exert diverse impacts throughout military and diplomatic confrontations

Inadvertent escalation from insider knowledge is just one example of prediction errors' widespread impacts - and a simple framework captures these far-reaching impacts. When you experience an event, its associated prediction error is the difference between what you expect and what actually happens (i.e. *prediction error = actual event – expected event*). This gives a simple framework to forecast an event's impact: the event can either occur or not occur, and either be expected or not expected (Fig. 1).

	Event not expected	Event expected
Event occurs	a) Associated with prediction error	b) No prediction error
Event not occur	(trivial case)	c) Associated with prediction error

Figure 1: Illustrating prediction errors (prediction error = actual event – expected event)

Strategic bombing in different scenarios illustrates the three interesting types of event in Figure 1.[25] First consider an event that occurs and was not expected, so has a large associated prediction error (Figure 1a). German air raids on London in the First World War using zeppelins were small-scale, but being so unexpected they had a large impact and caused panic – including demands to close factories and assaults on Royal Flying Corps officers.

Extrapolating from this, highly influential airpower theorists like Douhet in the inter-war period suggested more powerful and recurrent bombing would, largely through psychological impact, have a paralyzing effect and rapidly make adversaries collapse. So what actually happened? This

[24] Examples of U.S. actions that may have such effects are: shuttle diplomacy to regional capitals (Canberra, Manila etc.); or military force protection such as sending Aegis to the Taiwan Strait.

[25] Again, I use only this one example due to space limits, but there are multiple other cases for each event type. For excellent treatments of these strategic bombing examples see (Lambert, 1995) and (Quester, 1990).

illustrates an event that occurs but is well expected (Figure 1b). In the Second World War recurrent bombing exerted much greater destructive power, for example the "Blitz" on London, but being expected it had much more limited psychological impact than forecast.

Third, an event is expected but doesn't occur, so the absence of a predicted event leads to large prediction error (Figure 1c). In the Vietnam War, U.S. campaigns bombed North Vietnam very regularly, so the U.S. used prolonged bombing pauses as a conciliatory signal that were taken as such by Hanoi – the absence of the expected event was itself the intended signal.

Finally, the cases above involve punishing events, but prediction errors equally apply to positive acts. Consider the Egyptian leader Anwar Sadat in 1977. Egypt lost two wars to Israel in 1967 and 1973, after which he made conciliatory efforts. But it was the highly unexpected novel offer to speak in the Israeli Knesset that had a big psychological impact and opened the path to reconciliation (Mitchell, 2000). For application to recent Iranian nuclear negotiations see (Wright and Sadjadpour, 2014).

A simple prediction error framework encompasses many core strategic concepts

A prediction error framework subsumes and explains core strategic concepts. For example, the psychological impact of strategic surprise is an instance of prediction error. That is, an event has occurred but is not well predicted (Figure 1a). It is central to Chinese and U.S. doctrine, such as the U.S. Joint Operational Access Concept (DoD, 2012):

> *"**Maximize surprise** through deception, stealth, and ambiguity to complicate enemy targeting. **Surprising the enemy is always a virtue in war.** "* [Bold mine]

The Chinese "Science of Second Artillery Campaigns" (Second Artillery, 2004) writes:

> *"**Surprise** the enemy, act before the enemy, strike rapidly, catch the enemy by **surprise**."* [Bold mine]

But we must consider the political ends of actions as well as only warfighting, otherwise prediction errors may be a tactical virtue but a strategic detriment. Since 1945 the U.S. has fought limited wars not total wars, and this would very likely be so with nuclear-armed China. During limited confrontations warfighting cannot be the only consideration – for example the U.S. in Vietnam had to carefully design bombing campaigns to not unduly surprise China and the USSR (Quester, 1990). Only maximizing surprise loses the opportunity to use prediction errors as a tool in signaling.

More broadly, this framework subsumes and explains many strategic concepts. These include surprise, shock and awe, habituation, expectation management (e.g. counterinsurgency fm3-24 [Army, 2006]), learning and adaptability, and signposting. It provides a mechanism for inadvertent escalation, horizontal escalation and norms etc.. It applies across conventional warfare, strategic bombing, terrorism, diplomacy and to future effects of cyber, space and nuclear. I discuss some of these applications above and in Table 2, and others in future work.

Policy recommendations

Table 2 summarizes the policy recommendations flowing from this framework.

Conclusions

We must understand prediction errors to forecast the impact of our actions on others – and they provide a simple, powerful, operationalizable tool for U.S. decision-makers. I make practical policy recommendations based on this framework, which has two advantages for strategic practitioners: it forecasts effects widespread and important enough to be worthy of inclusion in strategic analysis; and it simplifies across important existing strategic concepts so it can be operationalized without additional analytical burden.

Take home: Understand prediction errors and use them as a tool to implement and interpret diplomatic and military signaling.

Table 2: Policy recommendations when we make actions, and also when we receive actions.

Making actions Core idea: Use prediction errors as a tool in signalling. Throughout crises and limited wars, the prediction error associated with an action always modulates its impact on decision-making – and the degree of impact should be an informed policy choice.		
1	*When preparing potential options for a decision-maker, for each option ask: "How unexpected will it be for the adversary?"* Specific instances include:	For each option describe its associated prediction error from the adversary's perspective and how that modulates its signalling impact.
a.	*Domain-specific effects*	Actions in certain domains are inherently less well understood by the adversary and so give larger prediction errors, e.g. zeppelins bombing London. In a near-term Sino-U.S. confrontation, e.g.: cyber, space or future conventional prompt global strike.
b.	*Cross-domain responses*	These can cause inherently more prediction error, because we tend to expect a response related to the original action's domain, e.g. in the Vietnam conflict the U.S. response to torpedo boat attacks was to attack that same boat class.[26]
c.	*Geography*	Distant responses likely cause more prediction error.
d.	*Novelty and first times*	These cause increased prediction error, e.g. Japanese Aegis deployed in a Taiwan crisis.
2	*Manipulate predictability*	In a Sino-U.S. confrontation, e.g.: signpost moving a carrier a day before to reduce its impact; alert U.S. forces without warning to increase its impact.
3	*Avoid simply maximizing surprise in doctrine*	
Receiving actions Core idea: Prediction errors are unavoidable, so we must manage their effects on oneself.		
1	*Manage effects of prediction errors*	Large impacts from prediction error on U.S. decision-makers should be considered when reacting. In a Sino-US confrontation, e.g. a cyber-attack on East Asian financial centres.
2	*Learning*	Prediction errors are the best material to improve our models of the world and the adversary.

[26] This is the case if there are multiple plausible domains for actions. This expectation relates to "the idiom of military action" (Schelling, 1966), where it is expected that "the punishment fit the crime in character as well as intensity". Of course, sometimes we may also have specific evidence of additional factors that instead determine the other's expectation, e.g. our previous promises to act in a certain way, our very well established behavioral patterns, or a specific way we know that the other uses to forecast events. Such general and specific evidence helps us characterize the other's expectations, and the key point is to use this to forecast the impact of our action by asking "How unexpected will this action be for the adversary?"

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2.7: When Deterrence Fails: The Social Psychology of Asymmetric Conflict, Clark McCauley, Ph.D.

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Abstract

The human capacity to care about groups, the emotions that follow from this caring, and the extent to which emotions triumph over self-interest—these together undermine deterrence when stronger threatens weaker.

- At the group level, deterrence requires a home address.
- At the individual level, deterrence requires that those threatened will put self-interest above group interest.
- In asymmetric conflict, both requirements are likely to fail.

The concept of deterrence became salient in international relations, notably in relation to discouraging nuclear attack with a credible threat of nuclear counter-attack. The foundation of deterrence is that the potential attacker must have a home address. If the Russians send nuclear weapons against the U.S., there is no doubt where the weapons came from and no trouble identifying Russian cities to target in return.

In asymmetric conflict, however, the attacker often does not have a home address. Guerillas and terrorist groups are difficult to deter because it is not obvious what place or persons to threaten with a return strike. This uncertainty is made worse by a related certainty: mistakes in targeting a weak attacker will produce new sympathy and support for the attacker. Such mistakes, often referred to as *collateral damage*, are much sought after by weak attackers who would like to use their enemy's strength to build their own. This strategy of *jujitsu politics* (McCauley, 2006) is open to weak attackers precisely to the extent that they lack a home address.

If states cannot easily deter non-state groups, perhaps they can deter individuals. The reach of a powerful state is likely to make the life of a guerilla or terrorist fighter unpleasant and brief. The Irish Republican Army famously warned potential recruits that they would most likely end up in prison and tortured--or dead. Why doesn't this grim prospect deter individuals from joining a militant group at war with a powerful state?

In broad terms the answer has three parts. Humans care about groups. We feel strong emotions depending on what is happening to a group we care about. And emotions get in the way of making rational choices to further our self-interest.

Group Identification

The phenomenon of identification is both wide and deep in human affairs. Identification with another means caring about the welfare of the other (McCauley, 2001). Positive identification means we feel good when the other is safe, prospering, and increasing, and feel bad when the other is in danger, failing, and diminished. Negative identification means we feel bad when the other is prospering, and feel good when the other is failing.

The human capacity for positive identification extends far beyond those near and similar to ourselves. We can come to care about the welfare of groups we have never met (Dallas Cowboys football team), even groups for whom we cannot name a single group member (South Sudanese). In these cases, our concern for the welfare of other goes beyond any economic value to the self. That is, our own material welfare is not significantly lowered or raised by change in the welfare of the Dallas Cowboys or the South Sudanese. Nevertheless, when what we care about is threatened, our emotions are engaged.

Emotional response to group outcomes

Anyone who has been to a sporting event can testify to the emotional reactions of fans to the progress of their team. When the team is advancing and winning, fans are joyful and proud. When their team is falling back and losing, fans are sad, ashamed, and perhaps angry at officials or team members who have made mistakes.

The physiological depth of these emotional reactions has been shown in studies of testosterone levels of competitors and fans (McCauley, 2001). Saliva assays show that tennis and chess players experience increases in testosterone before and during competition; after competition, winners show increases in testosterone and losers show decreases. Saliva assays of fans watching their team in a sports bar show parallel results: fans of the winning team show increases in testosterone after the game, whereas fans of the losing team show decreases.

It seems likely that reactions to political conflicts also show emotional effects. There were reports of celebrations in Arab countries after the 9/11 attacks on the U.S., although direct measurement of emotions was not available and no one assayed the testosterone levels of Arabs in the streets. Similarly there were reports of celebrations in the U.S. after Usama bin Laden was killed, although again direct measurements of emotions and testosterone levels were not available.

Negative emotions in response to intergroup conflict are also salient. News reports in the U.S. after 9/11 emphasized fear of flying and fear of additional attacks, although anger was evident in the U.S. war on terrorism that followed 9/11. U.S. shame at having been humbled by Arab nobodies was largely suppressed, although relief from this shame may have helped power celebrations of bin Laden's death.

Thus group identification can be the occasion of both positive and negative emotions, depending on what is happening to the group we care about. But what do emotions have to do with risk taking?

Emotion as antidote to material self-interest

In a now-classic book, *Passions within Reason,* economist Robert Frank (1989) argued that the evolutionary significance of emotion is to provide an antidote to self-interest. Many human goals require trust and a credible commitment to do what is not in our own self-interest. Notably, sacrificing for the group is not in an individual's self-interest: better to be a free-rider on the sacrifices of others. But groups whose members will sacrifice for the group can win against groups of self-interested individualists. Emotion makes the difference.

Consider the commitment value of anger. If you and I both know that I am stronger than you, and if you are governed by rational self-interest, you will do whatever I say. But if you get angry, you might take a swing at me despite my greater strength.

In intergroup conflict, a similar kind of commitment effect occurs. Anger over maltreatment of a group I care about can lead me to attack those I perceive as hurting what I love. This is how rational choice, self-interest, and deterrence fail at the individual level: outraged individuals will attack a powerful state despite credible threat of pain, prison, and death.

If this seems an extremist perspective, consider the alternative offered by rational self-interest. When nothing is worth dying for, only the material is worth living for: whoever dies with the most toys wins.

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Chapter 3: Cognitive Implications of Operationalizing Neuroscience and Neurotechnology in Influence and Deterrence

3.1: Introduction: Maj Jason Spitaletta

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This chapter discusses the cognitive implications for influence and deterrence through Cyber-Based Communication Technology (CBCT). Disruptive technologies are most often discussed in market terms, but many in the national security environment discuss their potential impact. The intersection of emerging CBCT and human biology including both psychological and neurobiological dimensions of behavior has the potential to be such a disruptive technology. The National Academies Press's 2008 "*Emerging Cognitive Neuroscience and Related Technologies" identified* a number of national security implications for neuroS/T , however, the internal consequences of such technology are insufficiently understood. Chapter 3 attempts to address some of the operational, ethical, and neuropsychological consequences associated with the adoption of disruptive neuroS/T

As Giordano & Benedikter describe, advanced integrative scientific convergence (AISC) has transformed the interplay of theory, technology, and tactics to better understand and influence human cognition. This interplay is fraught with scientific, operational, and ethical hard questions that require thoughtful consideration before CBCT become the primary contested domain in modern warfare. This is particularly relevant when considering the benefit CBCT provides by connecting individuals to the point where, for the first time, technology can reach into one's home, bedroom, car, public spaces, etc. to discover information about people. Approximately 2.5 billion people are connected to the Internet. Some users are well protected, but many are not. Moreover, there are an estimated 7 billion mobile devices in use. The ubiquitous presence of mobile devices has whetted the appetite for targeted advertising in the commercial sector, which is driving research in behavior tracking and device matching. Algorithms exist today that can determine where an individual lives, works, and travels through his devices even though he has never connected them. This is the future not only of spyware and hackers but also of e-espionage. This kind of device tracking and monitoring has the potential to reveal motives and patterns of thinking or behavior months or years before psychoanalysis can yield results.

Absent additional psychometric and demographic data, it is not only difficult to determine without direct access, but the appropriate mitigation steps or countermeasures may be too idiosyncratic to be practical. Nevertheless, primary research identifying the underlying neural correlates of specific psychological reactions to violent extremist stimuli delivered online may help provide a more empirically valid means of countering the radicalization process.

Neuroimaging in one tool that may someday help determine a person's responsiveness to radicalizing messages and videos online. Messages come from the cyber domain that influence what we do on an individual and group level. Predicting how a person will respond to them is difficult. Self-report techniques that ask about attitudes and intentions can explain about one-quarter of subsequent behavior. However, how a person's brain responds to a radicalizing stimulus can be more predictive than self-report. Neuroimaging offers a way to get information from the brain that one could not get from other methods. However, as Trachtenberg, FitzGerald, Collmann, and Giordano acknowledge, the vast amount of data produced by global interconnectivity presents an enormous challenges to intelligence analysts and Military Information Support Operations (MISO) specialists to perceive, comprehend, and project the behavior of their desired targets. Cyber enabled human intelligence (HUMINT) and cyberspace counterintelligence has emerged as a discipline that requires not only the personal integrity, deductive reasoning, and interpersonal skills the field has always required but also the ability to contend with the vast amounts of data provided by CBCT. As Chapter 3 discusses, the inherent operational, ethical, and neuropsychological challenges of neuroS/T must be thoughtfully considered so that they are implemented effectively and in a manner congruent with our national political objectives and our national values.

3.2: Integrative convergence in neuro S/T…On the engagement of computational approaches in neuro S/T and deterrence: James Giordano, Ph.D. and Roland Benedikter, Ph.D.

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Convergence as de-limitation

Historically, neuroscience has employed anatomical, chemical, and physiological approaches to develop "tools-to-theory heuristics" to formulate ever more detailed understanding of the brain. The conjoinment of approaches and disciplines is certainly not new to science, and such "technique and technology sharing" has canonically been, and remains, *de rigueur* in much of scientific practice, and this underscores the multi-disciplinarity of neuroscience. But when purposively employed to meet intellectual challenge(s) and/or technical impediments, the capabilities and advancements achievable through such inter-theoretical and –technical cooperation have become increasingly synergistic (and not merely additive). This process, advanced integrative scientific convergence (AISC), is not simply a technical sharing, but is a paradigmatic approach to fostering innovative use of knowledge-, skill-, and tool-sets toward de-limiting existing approaches to question/problem resolution; and developing novel means of addressing and solving such issues (Vaseashta, 2012; Giordano, 2012a). In this way, AISC enables (a) concomitant "tools-to-theory" and "theory-to-tools" heuristics, and (b) translation of both heuristics and tools to operationalizable practice. The AISC model is being employed within neuroscience to engage and direct genetic, and computational (i.e. cyber) methods and advancements in the creation of new neurotechnologies, and uses that assess and affect the structure and function(s) of the brain, and by extension, human cognition, and behavior.

The AISC approach is important given that many current methods are constrained by factors including 1) a lack of specificity of techniques (e.g. neuroimaging and neurogenetics), and 2) difficulties of matching certain types of neurologic information (e.g. - from neuroimaging, neurogenetic studies) to databases that are large enough to enable statistically relevant, and meaningful comparative and/or normative inferences. Current and planned uses of AISC approaches in neuroscience are aimed at overcoming these (and perhaps other) constraints. These developments are rapidly advancing. Therefore it is reasonable to assume that assessment of neurological structure and function, and manipulation of neural activity has become, and will continue to be increasingly validated, valued and publically accepted, as these means improve and are made available. As noted elsewhere in this report, a variety of influences, including public need and desire, political initiatives, and the market will drive and ensure this valuation, and establish the call and impetus for further development and/or sustained use.

In many ways, AISC approaches to, and in neuroscience have gained momentum, and the concept of an "advanced integrative convergent" approach in the neurosciences is something of a *fait accompli*. For this reason, questioning *if* this paradigm will be employed would be of little value. Instead, inquiries should be more rightfully directed at what the AISC approach will yield, how AISC will affect the speed and breadth of innovation and discovery, and in what ways outcomes and products may change operational practices – including those of deterrence and influence.

AISC: potential in practice - and problematic

However, analytic breadth or depth is not being matched with interpretability, which leads back to the challenge of 'specificity' and sensitivity. Thus, it is important to query whether advanced computational image translation, and computer-based statistical parametric modeling/analyses will provide the means with which to actualize neuroimaging as a legitimate technique that can be operationalized within deterrence and influence initiatives. Furthermore, basic heuristics have been expanded to an essentially iterative "theory-to-tools-to-theory-to-tools" paradigm that is a powerful mechanism and medium through which to facilitate (if not enable) the capability of extant neurotechnology.

For example, both genetics (in general, and more specifically neurogenetics), and neuroimaging tend to be limited by a lack of available data with which to make 1) intra-subject, temporal comparisons (e.g. using amassed time-point and/or lifespan data); 2) small group and cohort inter-subject single- and multiple-time point comparisons; 3) single subject and cohort-to-population comparisons; and 4) population-to-cohort and/or -subject normative inferences (Giordano 2012a; Wurzman and Giordano, 2012). Current iterations of computational technology and cybersystems maximize storage and retrieval through parallel processing and are scalable and customizable Vaseashta, 2012). In addition, the "cybersphere" creates a nexus for the dissemination, exchange and acquisition/engagement of information from science and technology, and as such is a medium and forum for (iteratively advancing) scientific convergence, integration and socio-cultural influence. However, it is important to note that as presently construed, the development of these databases focuses on priorities of the NIH, not of the DoD; neuroimaging databases exist for disease states, but not necessarily for neural variables that would be wholly relevant to (non-medical) national security and defense initiatives, such as those envisioned for influence and deterrence operations. Thus, capabilities have developed to the point where the DoD should re-address the importance and value of funding and/or collecting databases that focus on neurobiological (and psychosocial) factors relevant to operational ends (Wurzman and Giordano, 2014). This would change the emphasis to how AISC should be brought to bear on establishing new databases with specific purposes that a cyber-system (utilization, development and utilization) can support.

As with any form of science and technology, issues arise that can affect the utility and value of cybersystems. Although a complete review of the strength and limitations of cybertechnology is beyond the scope of this section and report, the (principal) practical and ethical problems that are most relevant to the neurofocal engagement of an AISC model can be classified as issues of

(a) inappropriate access, (b) inapt use/misuse, (c) data modification, and (d) "downstream" effects (e.g.- individual and group socio-economic and legal manifestations of accessed, misused or manipulated datasets; Giordano, 2012a)). These reflect underlying tensions between (a) accessibility and sanctuary; (b) privacy and protection, and (c) libertarian sentiments and calls for control.

Obviously, the speed, slope and valence of possible trajectories that any such advancement(s) might assume are variable, and dependent upon some calculus of 1) the capabilities and limitations of each of the constituent disciplines of AISC, 2) the viable proximate, intermediate and (conceptually) long-term outcomes and effects of employing AISC; 3) relative benefits, burdens, risks and harms that could be incurred through the use of specific AISC techniques and technologies, and 4) potential effect(s) upon, and influence(s) of external (e.g.- socio-cultural, economic and/or political) forces upon the conduct, tenor and utilization of AISC outcomes and products. Thus, any realistic appraisal of the AISC model requires 1) pragmatic evaluation of the capabilities of each and all of the constituent disciplines, and 2) grounding to the particular questions and/or problems of the point of focus (in this case, the utility of neuroscience to operational deterrence and influence).

Then need for realistic address and prudent use

The development and use of an AISC approach (designed to meet specific purposes of deterrence and influence, as addressed above) establishes a foundation upon which to realistically address, assimilate and appropriately frame scientific capability and information (e.g.- epistemological and technical gap identification, analysis and compensation); generate models to plot possible and probable outcomes; analyze viable alternatives; establish preference(s) for future status; and commit to prudent, iterative evaluation of any/all outcomes. Each and all of the constituent disciplines operational within a given AISC application manifest certain risks. In this light, we re-iterate that the use of a simple precautionary principle to govern the pace and direction of scientific effort is not recommended. This is because the intrinsic "character" of frontier science is shaped by change, and any benefit(s) that could be incurred by the use of cutting-edge scientific and/or technological applications tend to be viewed as proximate, while risks, burdens, and harms tend to arise after a period of time. Therefore, a more realistic – and useful – stance is one of preparedness, in which benefits, threats, and vulnerabilities are identified and assessed, and integrative models and methods of science, technology, and ethics are employed to target, mitigate and/or counterbalance these risks and maximize specifically defined goods (Benedikter and Giordano, 2012; Giordano, Forsythe and Olds, 2010; Giordano and Benedikter, 2012).

To summarize, many of the neuro S/T approaches currently tenable within deterrence and influence operations are limited (Giordano, 2012a, b; for overview, see: Giordano, 2014). Perhaps the most profound limitation, as noted in this report and elsewhere, is that attempts at defining and assessing neural substrates and mechanisms of cognition, emotions and behavior are challenged by both the caveats inherent and referent to each technology (Giordano, 2012b), and the ambiguities generated by the interplay of neurobiological and ecological phenomena and effects (Wurzman and Giordano, 2012). Incontrovertibly, neuroscience remains "an enterprise of correlation" (Chalmers, 2013), which poses both opportunities (for continued research), and challenges for the interpretation – and meaning(s) – of neuroscientific findings (in both research and practical use). Underlying these challenges are what Chalmers (1996) refers to as the ubiquitous 'hard questions' of neuroscience: namely, how 'mind' occurs in brain, how thought and emotions affect action, and what this infers for neuroscientifically-based and neurotechnologically-derived assessment, interpretation, understanding, definition, and prediction(s) of psychological and behavioral expression (Giordano and Benedikter, 2012; Giordano, 2012c; Giordano, Rossi and Benedikter, 2013).

In some instances, this has been viewed as "a factor but not an impediment" in that the goal is not to explore '*how*' brain evokes cognitions, emotions and/or behaviors, but to develop a large enough repository of (multi-factorial and multi-level) data to establish correlative patterns that satisfice (a) methodological validity (b) adequate probabilistic inference, and (c) reliability (this latter point speaks to legal issues re: Daubert standards of admissibility, possible use of Article IV, 403 of Federal Evidence in civilian law, and the justification of neuro S/T approaches under *jus in bellum*; for overviews see: Farahany, 2011; Brindley and Giordano, 2014; Giordano, Kulkarni, Farwell, 2014; Farwell, 2014).

Yet, even if attempting to side-step the "hard questions" of neuroscience, it will still be necessary to define, establish and formalize those conditions under which neuro S/T-derived findings (e.g. - neurocognitive and neurobehavioral patterns) would be valid, viable and of value (Brindley and Giordano, 2014; Casebeer, 2014). First, it must be noted that aggressiveness is not an explicitly diagnostic term or status. Second, aggressiveness does not necessarily evoke or culminate in frank inter-personal and/or social violence. Third, even a condition characterized by aggression, anti-social, and inter-personal violence - such as psychopathy - does not uniformly present such traits; fourth, predisposition does not infer expression; and fifth – and perhaps most importantly – correlation does not infer causality (Jotterand and Giordano, 2013). The aforementioned limitations and postulates are vital to consider in light of (a) increasing trends toward using neuro S/T approaches to define, assess and determine a variety of cognitive, emotional and behavioral characteristics, including aggressiveness and violence, and (b) calls to employ neuro S/T in these ways to predict potentially aggressive and violent behaviors (Casebeer, 2014; Giordano, 2012a-c; Giordano, Kulkarni and Farwell, 2014).

This prompts questions of whether a neuro S/T and its outcomes will be translationally viable in influence and deterrence operations. That is, will neuroscientific approaches deliver the results expected and afford anatomic and/or physiological correlation(s) to individual behavioral states, and populational variations. Any well-reasoned answer would dictate additional longitudinal studies, given the limited statistical power and potential for error of the currently available neurotechnical instruments; yet such research efforts would evoke further ethical concerns. As well – and not mutually exclusive - are questions about setting thresholds of (neurological) normativity while still allowing flexibility in categorization of individual variation and manifestations, as is inevitable when considering the reciprocity of genetic, ecological and even socio-cultural diversity. Toward these ends, the development and use of large scale data hierarchies – i.e. - “Big Data” - have been posited and viewed as providing viable resources to afford the informational capacity necessary to enable execution of the type and extent of assessments and analyses addressed in this report. However, this then generates both inquiry to the methods, power and actual utility and value of Big Data, and an examination of the practical, ethical and legal issues that the use – and misuse – of Big Data (approaches and outcomes) are likely to generate.

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3.3: Big Data initiatives' impact upon the use of neuro S/T in influence and deterrence operations: Rochelle Tractenberg, Ph.D., Kevin FitzGerald, Ph.D., Jeffrey Collmann, Ph.D., and James Giordano, Ph.D.

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We use the National Science Foundation definition of Big Data, as referring to "large, diverse, complex, longitudinal, and/or distributed data sets generated from instruments, sensors, Internet transactions, email, video, click streams, and/or all other digital sources available today and in the future". Given that "Big Data initiatives" involve the acquisition, analysis, and/or use of Big Data, these initiatives seek to support decision-making, with respect to groups within society or even society as a whole. Big Data can be used for the "prediction, preemption, presumption" of individual behavior (Future of Privacy Forum 2013). Hildebrandt (2011) sees the risk of a reification of human cognitive processes: Pattern recognition entails a solely statistical (atheoretical) conception of individual agency, leading possibly to the widespread use of "statistically inferred pre-emptive personal profiles." Helbing (2011) addresses various epistemological problems that can arise with the use of large data sets, including the causation-correlation problem, and misallocation/misinterpretation and misuse of correlative information in ways that presume or infer causality. As such, Big Data initiatives pose the problem of *epistemological integrity*. The problem of the validity of statistical analyses *of* Big Data does not only concern the analytically-oriented members of the scientific community; there is a challenge fostered by the analysis and interpretation of *any* data (e.g., Ioannidis, 2005; Goodman, 2014). Statistical analysis, or more specifically, inferences and decisions based on the analysis of big or small data sets, can be difficult to perform correctly. Unfortunately, this does not tend to affect interpretation or dissemination of results (Goodman, 2014). This is relevant in light of the aspiration to use Big Data in order to forecast and anticipate social change, as would be employed in operational deterrence and/or influence initiatives. Thus, the acquisition, use and analysis of Big Data can become a both a boon and a problem to the application of neuro S/T in general (see, for example, Ioannidis, 2005; Gelman & O'Rourke, 2014), and perhaps more specifically to initiatives of neurodeterrence. The problems are exacerbated by the fact that the use of Big Data is not limited to academic settings, with their traditional and well-established possibilities of professional feedback and control; a great deal of collection and analysis of Big Data takes place in political or economic institutions/contexts where the pressure to produce actionable – **not necessarily accurate** - data analysis might be high.

The challenges to epistemological integrity of Big Data will be propagated if not addressed more effectively than they have been to date. Recent large-scale investments in high-throughput basic and translational science agendas, such as the *Brain Research through Advancing Innovative Neurotechnologies (BRAIN*) initiative, provide considerable potential to use Big Data to define and shape the ways that neuroscientific information is incorporated and used in medicine, public life – and national security and defense programs (Giordano, 2014a,b).

Simultaneous attention must be paid to the validity and replicability of decisions and inferences derived from high-throughput technologies, albeit under a totally separate funding and reviewing mechanism (Big Data to Knowledge, BD2K http://bd2k.nih.gov/#sthash.ha2m4gI9.dpbs). These are just two examples of how epistemological challenges can arise when technological advances are developed and supported separate from the scientific impetus seeking to harness them.

Certainly, Big Data analytic methods enable the kinds of comparisons necessary to empower the use of neuro S/T in deterrence and/or influence settings (see discussion of AISC, above; Giordano, 2012a). As well, Big Data initiatives supporting large scale collection and archiving of neuroscientific data also may support a nexus for the dissemination, exchange and acquisition/engagement of information from neuro S/T, and as such is a medium and forum for (iteratively advancing) scientific convergence, integration, and socio-cultural influence (Vaseashta, 2012; Giordano, 2012a). However, as previously noted, the development and employment of variable scale databanks that that allow for rapid, real-time data acquisition, analysis, and utilization can also be employed outside typical academic venues, and can be used in contexts in which validity, reliability, and epistemological integrity generally may not be valued or even perceived to be relevant. Without validity, reliability, and integrity, these advances are undermined (Ioannidis, 2005; Giordano and Benedikter, 2012a; Gelman & O'Rourke 2014; Goodman 2014) because the "information" that is disseminated and exchanged is weak or false (Ioannidis 2005; Benjamini and Hechtlinger, 2014; Jager & Leek, 2014). Therefore, while the possibility of the acquisition, analysis, and/or use of Big (neuroscience) Data may promise some of the potential of the aforementioned neuro S/T, it will be important to assess, analyze, develop, and guide the use of Big Data approaches to neuro S/T-based information that can – and likely will – be engaged in deterrence and influence agendas and operations. Our group remains dedicated to these tasks.

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Chapter 4: Operational Implications & Applications of NeuroS/T Based Influence and Deterrence

4.1: Introduction: Maj Jason Spitaletta

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Conspicuous in its absence from traditional deterrence theory as well as rational choice analyses is the psychology of emotions. Emotions are among the most unique amongst human experiences. Our emotions exert both explicit and implicit influence on our behavior. Emotion makes people honest signalers. Emotions enable us to avoid the trap of rational choice where the stronger always rules the weaker with no impediment. As Hustus and Robbins indicated in Chapter 1, neuroS/T can contribute to the evolution of deterrence theory if it helps deny benefits, impose costs, and/or encourage restraint in a target. We overestimate what deterrence can do because we do not pay attention to the idiosyncratic psychological attributes of a target. As DiEuliis suggests (also in Chapter 1), neuroS/T can provide insightful context to the interpretation of human behaviors; a necessity in both human intelligence (HUMINT) and Military Information Support Operations (MISO). McDermott's point in Chapter 2 that deterrence is a fundamentally psychological phenomenon that is enabled by, but predates, modern technology is important as it helps explain the disconnect between modern deterrence theory which tends to focus on deterring state actors through technological means instead of the psychological processed of either heads of state or key leaders within non-state groups. This disconnect is further explained by McCauley's point in Chapter 2 that emotions may supersede self-interest and thus a deterrent strategy that fails to account for the emotional predisposition and/or state of a target, particularly in asymmetric warfare, is likely to fail. Appreciating the design requires of persuasion, emotion, and trust are priories in captology research. Understanding how to manipulate emotion states to increase the likelihood of persuasion and trust should be HUMINT and MISO research and development priorities. Barraza's topic in Chapter 2 is particularly relevant at trust is often a necessary component for effective source recruitment and target influence.

The USG's adversaries craft messages to support their campaigns continuously. Not only do they prepare for different scenarios and how to exploit them, individual have the authority to exploit opportunities. Their messages gain credibility because they are engaged in a long-term messaging campaign. Romero's compelling argument in Chapter 2 regarding the operational effectiveness of narrative transportation through nuanced messaging should serve a primer to modern CBCT influence tactics. Romero's claim that proper creation of narratives may be the optimal strategy in influencing targets predisposed to disagree with an argument (or source, specifically the USG) is gaining increasing support with empirical evidence and should be taken seriously by the MISO community. While the claims of Romero and Barraza are not necessarily mutually exclusive, further research is required to determine whether themes and messages should be optimized for narrative transportation or emotional engagement. The answer is unlikely to be simple, and will largely depend on the composition and/or a-priori opinions of the target audience as well as the psychological objectives; challenges which only strengthen the argument for more (and more ecologically valid) applied psychology and applied cognitive neuroscience.

Cyber-Based Communications Technologies (CBCT) are a means, not an end, in shaping social worlds by connecting people in distinct ways. CBCT provide individuals an option to either actively or passively access information that is consistently biased toward already expressed preferences and, thus, reinforces and strengthens their existing worldviews and limits the probability of their encountering information that is potentially contradictory or disconfirming. Online communities provide a medium through which individuals establish relationships for financial, spiritual, and social benefit. In Chapter 2, Falk identifies that social media is an ideal environment for tailoring persuasive messages. Of the various manifestations of CBCT, social media is perhaps the operational environment in which neurodeterrance will be most effective. Those that facilitate anti-social behavior are difficult to detect and interdict, but they represent a viable target. Synthesizing traditional methods of social influence with recent advances in neuroscience, cyberpsychology, and captology (the study of persuasive technology) can result in an advanced set of personalized persuasion tactics. Personalized persuasion tactics can be paradigm-changing capabilities in both HUMINT and MISO. To achieve the precision necessary for individualized persuasion, research designs with explicit concerns for ecological validity are required. In order to craft effective messages, one has to identify what a person is willing to believe. Therefore, one cannot start by crafting a message; one must incrementally prepare a person or an environment to make the communicated message credible. The following section (4.2) posits a fusion of Giordano's and Post's respective models to create actor-specific behavioral profiles in order to more effectively tailor messages. Once those models are developed for a specific actor, implementing Wright's recommendation in Chapter 2 to reduce the predictive error when attempting to influence a target can be readily incorporated into the doctrinal MISO process in Step 2 (Determine Effectiveness) of Target Audience Analysis (TAA) (See Figure 4.1).

Formulating research questions around the transition factors and the concomitant MISO applications is a step toward operationalizing findings from neurobiology and cognitive science experiments or captology case studies. As Giordano, Casebeer, and DiEuliis identify in their introduction to Chapter 2, knowledge gained from methodologically rigorous neuroscience research can provide understanding of how individuals' neural functions contribute to various cognitive (and emotional) states that are important to both individual and group decision-making and behavior. When facing a morally and legally unconstrained adversary, asymmetric advantage lies not necessarily in more sophisticated hardware but in more intelligent application of scientific and technological capability.

4.2: The Use of Cyber in Neuro S/T Based Deterrence and Influence: Maj Jason Spitaletta

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Abstract

The tactical manifestation of neurodeterrence will rely heavily on both tailored intelligence and Military Information Support Operations or MISO (formerly psychological operations or PSYOP). PSYOP/MISO has long been reliant on methods employed in social and behavioral science for target audience analysis, product development, and operational assessment (Spitaletta, 2013). Contemporary research in cyberpsychology and neuroscience, in conjunction with advances in persuasive technology, human computer interaction and leadership analysis can be used to develop tailored influence tactics that can be administered in cyberspace. Combining Post's (2011) actor-specific approach to tailored deterrence with Giordano's (2012a-c; 2014) neuroscience and technology (neuroS/T) framework provides a model for an approach to neurodeterrence operations. That model can serve as a model for additional applied research and ultimately, operational applications.

Introduction

The objective in warfare is to impose one's will on another, to change their minds (Linebarger, 1954). How better to change minds than to incorporate the scientific knowledge about the seat of the mind, the brain? Military Information Support Operations (MISO), formerly psychological operations (PSYOP), has historically integrated collection and analysis methods employed in social and behavioral science; those techniques can be augmented with the incorporation of neuroscience and technology (neuroS/T). Given the advances in cyber-based communication technology (CBCT), and the increasingly prominent threat of small groups and superempowered individuals, the logical operational environment through which to conduct MISO is cyberspace. The operational requirements of the information domain require advances in both intelligence and targeting. Tailored deterrence requires tailored intelligence, surveillance, and reconnaissance; a precise fusion of existing scientific and technical intelligence capabilities with applied neuroscience and psychological research.

Neuro S/T can enable access, assessment, and engagement (targeting) (Giordano, 2012a,b, 2014) of the target audience (see also, Giordano and Wurzman, 2011; Giordano, Kulkarni, Farwell, 2014; Wurzman and Giordano, 2014); necessities for tailored deterrence and influence operations. Giordano's (2012a,b; 2014) framework provides a useful model through which to examine the tactical utility of neuro S/T, particularly when combined with Post's (2011) argument for actor-specific tailored deterrence. The synthesis of approaches requires the fusion of scientific and technical intelligence and academic research to develop actor-specific models. These models can then be compared with the extant literature to develop tailored themes, messages, and delivery mechanisms (Spitaletta, 2013).

While distinct, the synthesis of Giordano and Post's recommendations fits logically within existing MISO processes. Figure 4.1 highlights the conceptual overlap between the Access, Assess, Target framework and the doctrinal PSYOP (or MISO) process. An underlying assumption of the forthcoming argument is that the target audience in such operations is the individual and therefore the fulcrum of assessment is informed by not only social science but also behavioral and neuroscience theories. Another underlying assumption is the current state of knowledge cannot necessarily be immediately operationalized and thus further applied research is required to ensure the framework is valid. Toward such ends, the incorporation into a working context of integrative convergent S/T approaches has been recommended and modeled (Giordano, 2012b,c; Vasheasta, 2012; Giordano, Kulkarni and Farwell, 2014).

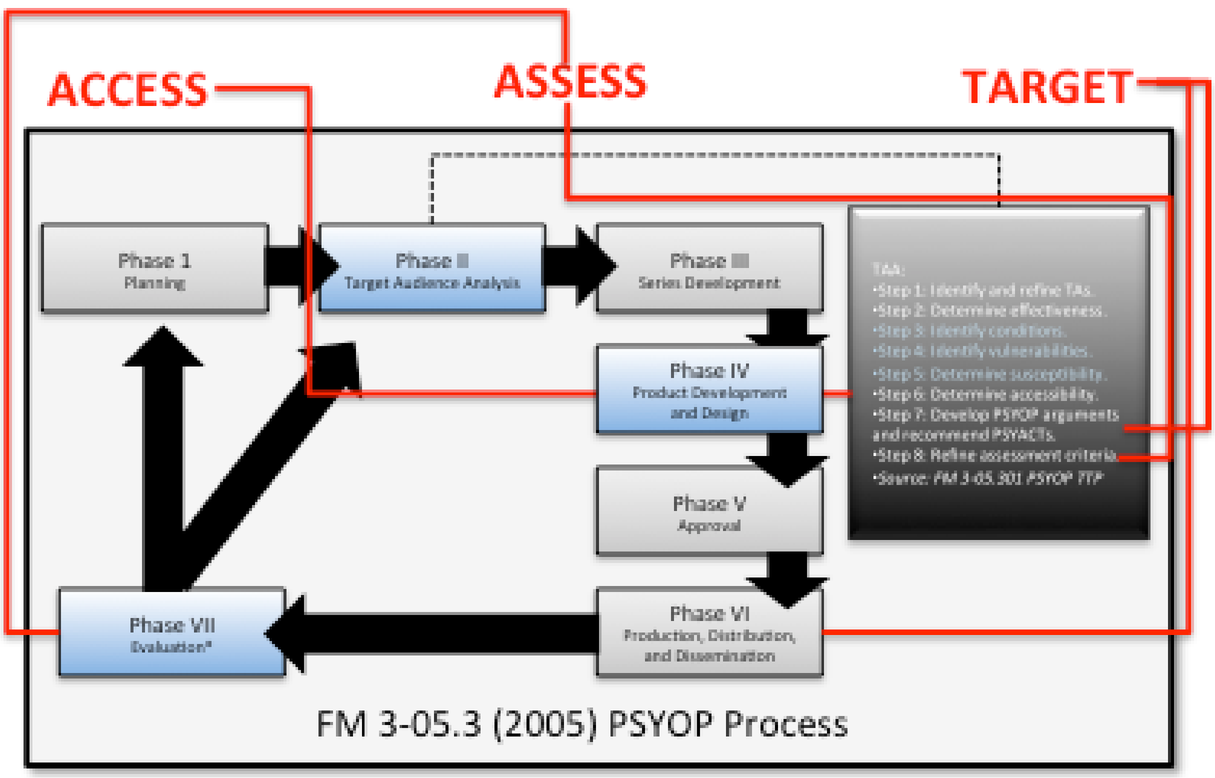

Figure 2: Integration of Giordano's framework and doctrinal 7-Step PSYOP process.

Access

Determining the accessibility of a target audience, the sixth step in the doctrinal target audience analysis process (Figure 2), identifies how a particular audience may be reached by various types of information technology (Spitaletta, 2013). The same CBCT that has increased the connectivity amongst individual can facilitate access to a particular target. CBCT provides greater anonymity, lower emphasis on physical attractiveness, and greater control of the time of interaction all without geographical restrictions (Guadagno & Cialdini, 2005). In Neuro S/T based influence, access must extend beyond the device to the user since the target is not only the technology but also the human-computer system and therefore offensive cyber operations that deter or influence need to extend beyond the technological to the biological, psychological, behavioral and social, a form of neural intelligence collection and analysis (Wurzman and Giordano, 2014). A significant challenge with cyber operations entails authentication and/or verification, as many of the targets of neurodeterrence operations will be essentially anonymous, except for a set of observable online behaviors. The ability to ensure positive identification of a potential target, across devices, is necessary to ensure precision in actor specific behavior models.

Assess

Refining assessment criteria is the eighth and final step of target audience analysis; however, evaluation (Phase VII of the MISO process) can be considered a continuous task when operating in cyberspace. Ongoing assessment is necessary in neurodeterrence as baseline metrics and post-intervention changes must be monitored and compared with empirical data. Since interactive influence tactics differ from traditional broadcast techniques (Guadagno & Cialdini, 2005), the target audience (individual) becomes an active participant in assessment process (Weyman, 2013). Since human-to-human access to the target is mediated through a computer, methods developed in one domain must be applied to cyber operations. This entails verification through experimentation and operational refinement. Among the methods that have potential applicability are those that comprise human factors analysis; group and population analysis, social network analysis, and individual and leadership analysis. Social network analysis and human factors analysis can be synthesized (Kinniburgh & Denning, 2006) with group and population analysis as well as applied neuroscience and captology research to provide intelligence personnel with a rich contextual understanding of an individual within his/her environment. Methods of remote personality assessment have been employed with success since WWII (Bos et al, 2013) and research methods from political psychology can be adapted to existing targeting approaches to provide actor-specific models (Post, 2011).

Two specific components of target audience analysis, vulnerability and susceptibility, can benefit from neuro S/T if existing methods are expanded to incorporate cooperative dynamics that reciprocally engage the human-computer system (Giordano and Wurzman, 2011; Howlader and Giordano, 2013; Rossi et al, 2013; Wurzman and Giordano, 2014;). Vulnerabilities are the needs, wants, or desires that arise from the conditions within the operational environment (Spitaletta, 2013); vulnerabilities are traditionally social, but can be extended to include cognitive and neurobiological. Vulnerabilities may be exploited through both the message content as wells as the dissemination mechanism. Susceptibility is the degree to which a particular message is likely to influence a target audience (Spitaletta, 2013). Susceptibilities are often identified through both primary and secondary methods in either background research and/or product testing. These approaches can be augmented by neuro S/T to identify one's elaboration likelihood requirement or information display preference (Kaptein et al, 2010) at a neuropsychological level to enable more precise susceptibility analysis (Stanney et al, 2011; Giordano, 2012a; Wurzman and Giordano, 2014). Each line of persuasion can then be evaluated based on its ability to influence both the target audience's behavior and neural response.

Target

Neuro S/T based deterrent and/or influence operations require themes, messages, and dissemination mechanisms specifically tailored to an individual's psychological vulnerabilities and/or susceptibilities and delivered to the device at the time when the effect will be greatest. Personalized technologies improve user experience by tailoring the interaction based on an individual's set of system preferences, interests, and/or other relevant data (Berkovsky et al, 2012); this approach can also be employed to change perception, objective reasoning, and behavior of a user (Spitaletta, 2013). Persuasive technologies advance personalized technologies by employing human-centered design along with user-defined settings and social influence principles to alter behavior (Fogg, 2002). Both personalized and persuasive technologies attempt to influence behavior (Berkovsky et al, 2012); synthesizing elements from each in conjunction with established methods of social influence holds potential to deter and influence in cyberspace. Contemporary microtargetting incorporates open-source aggregation to develop a demographic profile (Korolova, 2011), but few techniques take the intermediate step of creating an actor-specific model then tailoring the message accordingly (Hirsch et al, 2012). Creating an actor-specific model based on social, behavioral, and neural target data will enable much greater precision targeting.

Conclusion

Making neuro S/T based deterrent and/or influence operations in cyberspace a tactical reality will require increased analytic rigor and targeting specificity reliant upon both automated and human-in-the-loop processes (Chen et al, 2013). Deviations from empirically based methods, for expediency or tactical necessity, have limited the effectiveness of MISO (MacKay et al, 2011). As the literature on CBCT-mediated influences evolves, those empirically based methods can be refined; however, the state of the science is still somewhat immature (Guadagno & Cialdini, 2005). While existing neuro S/T has great potential to influence and/or deter targets in cyberspace, further research will allow planners to rely upon firmly established linkages between perception and actions when developing both their intelligence requirements and the desired psychological actions.

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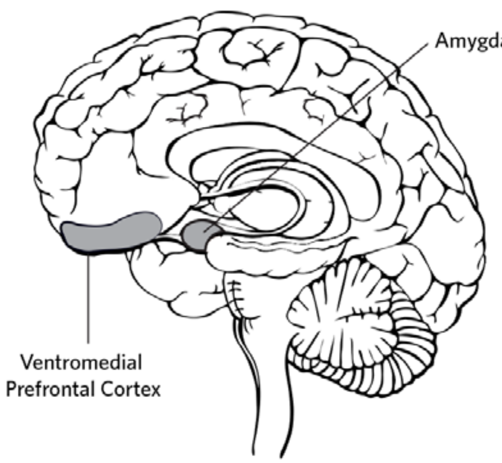
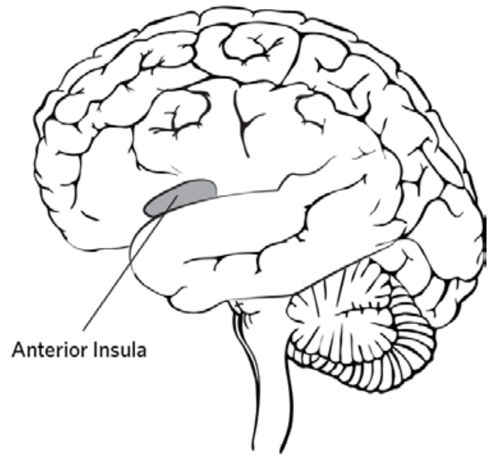
Appendix: Lexicon





Selected brain regions important in decision-making. The ventromedial prefrontal cortex is particularly involved in encoding reward values. The amygdala reacts strongly to fear. Insula cortex is related to losses, punishments and norm violations. See discussions of neuroeconomics (Dr Nicole Cooper, Section 1.2) and behavioral change (Dr Emily Falk, section 2.4).

Amygdala: The amygdala is a group of cells in the brain (i.e.- a part of what are referred to as the septal nuclei) located within the limbic system in the temporal lobe. It is involved in processing emotions and motivations, particularly those that are related to survival (such as fear, anger and pleasure, arousal and passivity.) The amygdala is also involved in certain types of memory storage in the brain, which may affect emotional responses to particular events.

Axon: a long structure of nerve cells (neurons) that conducts impulses away from the cell body and to the next neuron or muscle.

Captology: this is the study of particular technologies that attempt to influence, motivate, change or persuade particular behaviors. This includes research and development on computer programs and interactive technologies that are developed to alter behavior.

Cognition: the collection of mental processes that includes attention, memory, producing and understanding language, learning, reasoning, problem solving, and decision making.

Cognitive neuroscience: The study of biological bases of mental functions, that is of thinking. It draws on neuroscience, psychology, computational modeling and other disciplines.

Cyberpsychology: this nascent field is developing; it involves the study of psychological behaviors or manifestations that are caused by or affected by, technology.

Cyberspace counterintelligence: Measures to identify, penetrate, or neutralize foreign operations that use cyber means as the primary tradecraft methodology, as well as foreign intelligence service collection efforts that use traditional methods to gauge cyber capabilities and intentions.

Cyberspace : A global domain within the information environment consisting of the interdependent network of information technology infrastructures, including the Internet, telecommunications networks, computer systems, and embedded processors and controllers.

Cyberspace operations: The employment of cyberspace capabilities where the primary purpose is to achieve military objectives or effects in or through cyberspace.

Dendrite: any of the branching processes that conduct impulses toward the body of a nerve cell.

Diffusion Tensor Imaging (DTI) also called diffusion MRI: This is a type of magnetic resonance imaging that utilizes the differential configuration of water molecules in a biological tissue after application of a magnetic pulse. The magnetic "signature" displays diffusion of water throughout living tissues and reveals patterns that indicate directional movement of the water (i.e.- protoplasmic substance) in cells and cellular networks. DTI is used to reveal axonal pathways and networks (i.e.- tractographic depictions) within the brain and can illustrate connections between various regions that are shown to be active using other forms of neuroimaging (e.g.- fMRI, see below) and/or neurophysiological measures (e.g.- electroencephalography; see below).

Electroencephalography (EEG): The measurement of naturally occurring summated electrical activity in the cortical (superficial) layers of brain, obtained through the scalp using a set of electrodes (typically between 32 and 256). EEG provides poor localization but high temporal acuity; additionally EEG is relatively cheap and portable compared to other neuroimaging technologies.

Functional Magnetic Resonance Imaging (fMRI): This type of magnetic neuroimaging uses changes in the differential paramagnetic signal of oxygenated versus non-oxygenated hemoglobin as a measure of the flow of blood to various brain regions. It is an indirect (i.e.- "proxy") measure of brain activity in that it depicts blood oxygen-level demand and dependent (BOLD) signatures, rather than neurological activity, per se. Functional MRI provides good spatial acuity for localization of functions, but rather poor temporal acuity. Still, it is useful – and widely employed – to assess relative brain activity and to depict localization and involvement of certain brain regions in various cognitive, emotional and behavioral functions.

Frontal Cortex (FC): The FC is part of the cerebral cortex (most superficial six layers of neurological tissue in the brain) in either hemisphere of the brain lying directly behind the forehead; it receives input from all of the body's senses. The FC is also responsible for the brain's ability to create long-term plans (i.e.- what is referred to as "executive function"), control emotions and behavior, and is involved in creativity and decision making.

Genomics: Genomics is the study of the structure and function of genomes, which compose the complete set of DNA within a population or individual (see also, Neurogenetics and Neurogenomics, below).

Glia: sometimes called **neuroglia**, are non-neuronal cells that maintain homeostasis, form myelin (to insulate neurons' axons and speed transmission of neural impulses), engage immunological activity, and provide support and protection for neurons in the brain, and other parts of the nervous system. Central nervous system (CNS) glial cells are astrocytes (which link neurons to the blood vessels of the brain and spinal cord, provide metabolic support for neurons, and engage in certain types of cellular communications themselves), microglia (which perform immunological functions) and oligodendrocytes (which make myelin for certain nerve cells of the CNS); glial cells of the peripheral nervous system are Schwann cells (which are similar in structure and function to oligodendrocytes of the CNS, and which produce myelin for peripheral nerves).

Human Intelligence (HUMINT): A category of intelligence derived from information collected and provided by human sources.

Limbic System: a system of functionally related neural structures that emanate from the midline of the temporal lobes, which are involved in learning, memory, and emotional regulation. Limbic structures include the septal nuclei (including the amygdala – see above), fornix and hippocampus (which is directly involved in memory storage, acquisition and integration).

Magneto-Encephalography (MEG): this functional imaging technique uses magnetic fields to accumulate and measure local field electromagnetic impulses generated by superficial layers of the brain. Local electromagnetic fields of various cortical networks are sensed by magnetometers which can detect activity patterns; these are then converted into a spatial colorimetric map (through the use of serial statistical computational programs) to depict a colored representation of relative levels of cortical activity occurring in, and representative of certain (ordered or disordered) cognitions, emotions and behaviors.

Military Information Support Operations (MISO): formerly Psychological Operations (PSYOP), MISO are planned operations to convey selected information and indicators to foreign audiences to influence their emotions, motives, objective reasoning, and ultimately the behavior of foreign governments, organizations, groups, and individuals. The purpose of military information support operations is to induce or reinforce foreign attitudes and behavior favorable to the originator's objectives.

Neurodeterrence: refers to 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.

Neuroecology: A term developed to refer to the dynamic interaction of genomic, genetic and neurological (structural and functional) bases that are reciprocally interactive (i.e. -are affected by and affect) an organism's sensitivity, and responses to environmental variables and effects (including interactions with others, and various circumstantial variables, such as nutrition, climate, etc.). Neuroecology describes how various predisposing factors (of genetics and biological structure and function) will interact with environmental elements to shape and affect the cognitions, emotions and behaviors of individuals and groups. In this way the term provides a descriptive framework and useful construct for defining and plotting neurobio-psychosocial interactions, dynamics, effects – and accessible targets.

Neuroeconomics: An interdisciplinary field that seeks to explain human decision making (i.e. the processing of multiple alternatives and selecting a course of action) in the context of economics and neuroscience. It combines discoveries and research methods from neuroscience, experimental and behavioral economics, and cognitive and social psychology. It can also utilize approaches from theoretical biology, computer science, and mathematics. ***Neuroeconomics studies decision making by using a combination of these varied disciplines, avoiding the shortcomings of any single individual approach; as such it offers a parallel to "neurodeterrence" in similar framework.***

Neuroethics: Studies of (a) the possible neurological bases and mechanisms of proto-moral, moral and ethical thought, emotions, and behaviors (see, perhaps more accurately, neuroecology, above), and (b) studies and practices that address the ethico-legal and social issues arising in and from neuro S/T research and its use – and misuses – in healthcare, public life and national security, intelligence and defense.

Neurogenetics: The combined studies/practices of neuroscience and genetics; affording insights to the possible ways that genetics affect development, structure and functions of the nervous system, as involved in cognition, emotion and behavior (see Genomics above; Neurogenomics, below).

Neurogenomics/genetics: Studies and utilization of genomic techniques as directly applicable to neurological and psychological structures and functions (see Genomics, above).

Neuromarketing: the assessment of activity brain activity in response to commercial marketing stimuli in an attempt to create more effective marketing products.

Neuron: are electrically excitable cell types (of the periphery, spinal cord and/or brain) that process and transmit information along specialized pathways and networks that serve to relay information to the spinal cord and brain about an organism's internal and external environment, and which relay information from the brain (and spinal cord) to various effector organs (e.g.- glands, muscles) of the body to control an organism's behavior(s).

Neuroscience: the study of the anatomy, physiology, biochemistry, molecular biology, and pharmacology of the nervous system.

Neurotechnology (Neuro S/T): the combined approach of (a) engaging technical tools in the brain sciences, and (b) developing technical tools for the brain sciences that are useful and applicable to a host of endeavors, including medicine, public life (adaptive/assistive neuro S/T) and national security and defense. Neuro S/T is currently regarded as a unified enterprise that employs inter-dependent and interactive scientific (i.e.- informational, knowledge-based) and technical (i.e.- instrument, and tool-based) heuristics to mutually advance both domains of the field.

Neurolaw: The study and practice(s) of (a) the ways that neuroscience can (and perhaps should) be used in civil, criminal, military and international law cases, and (b) the use of law to guide and govern the scope and conduct of neuro S/T.

Neurotransmitter: a generic term that refers to any type of chemical produced by a nerve cell that functions in the transmission/conduction of information between such cells, and/or between nerve cells and effector tissues (e.g.- muscle, glands, etc.). Neurotransmitter(s) can affect activity in target tissues by (a) interacting with specific binding molecules called receptors (of which many differing types exist, each subserving distinct functions; thereby expanding the potential effect(s) that a single neurotransmitter can exert), or (b) modifying the structure and function of a target cell's membrane(s), thereby also inducing a host of potential effects. Nerve cells can produce a variety of different (types of) neurotransmitters, each with the potential to exert differing effects on other nerves or target tissues. In this way, it can be seen that even a fairly simple nervous system can incur a diverse – and thereby potentially complex – range of function(s).

Quantitative electroencephalography (qEEG): this is a type of brain mapping which can be applied to "raw" EEG measurements. Through use of particular mathematical algorithms, qEEG can compile electrophysiological data from individual EEGs, and create a topographical display, or map, of the brain's electrical activity, and thus, function.