Where’s Waldo?: Using Neurofeedback as a Training Technique for Discerning Clutter

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Abstract

“The primary mission of a sniper is to deliver long-range precision fire on key selected targets and targets of opportunity. The secondary mission of a sniper is the collection and reporting of battlefield information” (Army Sniper Association, n.d.).

This dissertation is begun from an epistemological approach, since analysts must examine and explore the complexion of reality, the quality of knowledge and the methods that are used regarding new, technological, methods in research. Intelligence is an organization, a process, and a product. Intelligence, in this case, may be considered as a set of methods and techniques that have been developed and are currently used by all the national security agencies. In this case, it is possible to assess the scientific quality of intelligence in order to distinguish both art and science as parts of the same paradigm. Inferences from the Church Committee and the 9-11 Commission reports have suggested that intelligence as a tradecraft may be studied through the lens of science, with the purpose of assessing the scientific value of the current methods, tools, and individual skills. This assessment then leads to several recommendations on reorganizing new strategical plans that will facilitate a better understanding of a specific situation, the problems faced, and the best way to solve the problem. The problem identified here is how clutter is identified, what features and attributes are relevant, why it is a problem, and how to recognize it.

This dissertation provides the basic characteristics of neurofeedback training as it applies to identifying objects in visual clutter and how this can affect the ability of military personnel and law enforcement officials to efficiently do their jobs. Clutter, in this sense, refers to a confusing or disorderly state or non-related collection of items in an uncontrolled environment; a sort of visual pollution. The parameters will include neuroanatomy and neurophysiology in the training of military and law enforcement officers. Also described in this paper will be the
fundamental brain changes that can occur in the course of neurofeedback training, how these brain wave changes are evident in ongoing measurements, and how these changes are developed in the law enforcement officer.

Neurofeedback is the direct training of the brain’s ability to function, in which the brain learns to function more efficiently. Brain function is able to be measured from moment to moment, and the information gathered is then reported to the trainee. Neurofeedback is a gradual process and can be applied to any aspect of brain function that can be measured. Neurofeedback is training in self-regulation, whereas, biofeedback is applied directly to the brain. Self-regulation is an important process of good brain function; therefore, it allows the central nervous system to function better. Neurofeedback is based upon scientific doctrines that have been established and documented over more than 40 years of research (Collura, 2003). By and large, measurements identify brain states via recorded electrical activity.

Furthermore, there is an ability to guide a trainee’s brain to accomplish and maintain advantageous states. These improved states allow a trainee to better recognize specifics in clutter within a visual field, such as a cluttered desk. Ultimately, the brain is able to learn and adapt to the aspects of organizing clutter. This ability to navigate clutter can have intense and beneficial effects for intelligence personnel in the fields of Human Intelligence (HUMINT), Geographic Intelligence (GEOINT), Open Source Intelligence (OSINT), as well as others in fields of military and law enforcement agencies.
Dedication

I dedicate my dissertation effort to my family and many friends. A special feeling of appreciation to my loving and devoted parents, William and Victoria Hangstorfer, whose words of encouragement helped see me through some rough spots. They have always been my champions! A special thanks goes to my mother, whose support helped me to be successful. Her persistent edits, rewrites, and demands for improvement made me a better writer and student. Over my many years in school, she has been my supporter, confidant, and constant push to better myself both scholastically and personally.

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Chapter 1: Introduction

Target identification and field reports are the top two responsibilities of snipers, making it increasingly important to train them both physically and mentally for the job at hand (Army Sniper Association, n.d.). Neurofeedback training and brain mapping are influential focusing methods that will successfully increase the functioning of the brain and, in return, enhance the effectiveness of discerning clutter during fast passed missions.

In 2013 President Obama revealed The Brain Research through Advancing Innovative Neurotechnologies, otherwise known as “BRAIN Initiative”. This major research project is designed to map the inner workings of the brain with the aim to probe and investigate ways people think, learn and remember. The BRAIN Initiative objective is to develop “new technologies that can record the activities of individual cells and neurons within the brain” (Jackson, 2013).

Neurological research is leading the charge in technological and contemporary approaches to better the American Military. Previous research, discussed later in this dissertation, explains how Neurofeedback can be utilized to quantify brain activity and how subsequent methods will be able to assist military and law enforcement men and women to counteract the encumbered fog of war.

The brain, due to its plasticity and malleable nature, can transform. This phenomenon is known as Neuroplasticity. It is the ability of the human brain to change as a result of personal experiences (Liou, 2010). The brain is capable of this because nerve cells or neurons are interconnected in neural networks. Brain Plasticity refers to learning by adding or removing neural connections or adding cells called neurogenesis. Research has shown that exercise and socialization contribute greatly to the brain’s ability to generate new cells, form neural networks, communicate better, and self-regulate (Cotman & Berchtold, 2002, pp. 295-301). Once new
connections have been formed they may last a life time. Thus, the improved overall functioning, once embedded in the new connections, is permanent (Kirk, 2010).

Defining Clutter and Neurofeedback

Where’s Waldo? (Figure 1), selling over 58 million copies, has been a game played by many youths (Matheson, 2012). It is a hide-and-seek type of game where a person must find a lanky man wearing a red and white striped outfit hiding among many others in different places, such as a carnival, picnic area, or mall. This sounds simple enough. However, when played, it is very hard to find this one man hiding in, seemingly, plain sight. The clutter in the picture is extremely overwhelming and it can take some time to find Waldo.

Figure 2. Where’s Waldo

Many find the scene depicted in Figure 1 to overpower the senses due to the fact that there are many colors, a sense of movement, and similar shapes making it hard to identify
Waldo. The American Heritage College Dictionary defines clutter as “a confused or disordered state, caused by filling or covering with objects.” Clutter, therefore, degrades task execution (Rosenholtz, Li, Mansfield, Jin, n.d.). These factors of identification will be discussed in detail later in the paper.

Military analysis and field engagements, in theater, are also filled with important pieces of information that are, like Waldo, hiding in plain sight. “… Excess and disorganized display items can cause crowding, masking [and a decrease in] recognition performance due to occlusion” (Rosenholtz, Li, and Nakano, 2007, p.1). Just as the brain must scan and seek the picture for Waldo, the military brain must do the same while also classifying what is useful and what is unimportant information.

The question is: How does one find the most important thing hiding in a cluttered area? Ironically, clutter can be found in a number of different models used for organization, such as a link analysis chart as seen in Figure 2. Many aspects of creating models like these are taken from Open Source Intelligence (OSINT), which is information found, selected and acquired from available public sources, and Human Intelligence (HUMINT), which is information collected from human subjects. Field clutter is evident in Iraq and Afghanistan, along with airport security check points, and within Special Weapons and Tactics (SWAT) team missions. Therefore, one can see that the psychological aspect of organizing clutter is exceedingly important in intelligence analysis. The main challenge is to define clutter. “The first and most important step an analyst can take is to understand the problem in detail” (Clark, 2010, p. 24).
Figure 3. IntelCenter Islamic State (IS) Organizational Wall Chart v1.4

An all-inclusive, yet detailed and unambiguous, definition is needed to understand the psychological aspects of clutter. For years, researchers have been trying to develop a definition of visual clutter. Philips and Noyes (1982) expressed in their research on clutter that it is easily experienced, but much less easy to define. The problem is quantifying clutter found in real objects. One person’s organization may be another person’s mess. It is the concept that there can be an organized chaos. This organized chaos is most evident in Figure 2. (Figure 2. is blurred and difficult to read, however its purpose is to show the multitude of relationships and the resultant clutter, making analysis difficult). While looking at the model it seems confusing with
different colors, lines, connections, wordings, and arrows. It is organized in the sense that without it the concept would be harder to explain. The additional lines in Figure 2 cause difficulty for tasks involving lines defining the meaning of “like clutters like” first developed by Phillip and Noyes in 1982. “Counting the number of objects does not take into account the appearance or organizations of the object” (Rosenholtz, Li, and Nakano, 2007, p. 8). It can be argued that all objects will not be treated equally and that they have no clear individual meaning (Neider and Zelinsky, 2011, p. 2 and Henderson, Chanceaux, and Smith, 2009, p. 1). This theory will be discussed later in more detail.

For the most part, the ability to see clutter is defined as visually unwanted objects that make it more difficult for something to be located effortlessly with the eyes. Mack and Olivia (2004) describe clutter “as a measure of subjective visual complexity.” Rosenholtz, Li, and Nakano (2007) discuss set size, or the number of objects in a given area, as a focal point in identifying how cluttered a scene truly is. Since “in natural images, where the experimenter does not control the display, determining the number of items in the display becomes extremely difficult even given a reasonable definition of what constitutes as an item” (Rosenholtz, Li, and Nakano, 2007, p. 2). For example, is a mountain range one item or does it breakdown further to include the trees on the mountain range, the boulders, and the animals? When discussing informational clutter, the amount of information that is available within an organization is immense and potentially overwhelming. This situation of information overload is an odd predicament because we are built to learn things so we can take care of our lives. Humans, especially those in the military and law enforcement, are naturally inclined to take in information and, in return, take what is gathered to ensure safety and wellbeing.

It is essentially important to maintain information corresponding with an organization’s dynamic business or intelligence information needs. This is accomplished by aligning...
information strategies with business strategies (Blahunka, 2008). For example, providing multifaceted predictive analytics requires different technologies and expertise than does delivering relatively straightforward historical information. Each law enforcement agency has its own way of dealing with and organizing information.

There is, generally, a deficient understanding of what clutter is. What “features, attributes, and factors are relevant?” Why is it a problem to some and less to others and how is it acknowledged by the human brain (Rosenholtz, Li, and Nakano, 2007)? Many subjects that were studied by Olivia, Mack, Shrestha, and Pepper (2004)“indicated that complexity depended on the quality and variety of objects, detail, and color, as well as higher level, more global concepts like the symmetry, organization, and openness of the depicted space” (Rosenholtz, Li, and Nakano, 2007, p.8).

**Historical Examples of Clutter**

The best defense is a strong offense. Variations on this expression can be attributed to many sources throughout military history, dating as far back as Sun Tzu and *The Art of War* (1913). Historically, there has always been conflict in the gathering of intelligence leading to information clutter. Analysis of information is at once America’s foundation and the most destabilizing factor of our time. However, it is also the underpinning of many other countries as noted by the historical quest to acquire information by all. Fueled by the Cold War, the need to detect small, highly maneuverable and stealthy targets in all weathers (Hughes, n.d.) was important to tactical strategies in collecting data on Russia. Clutter sources include the ground, natural and man-made objects, and atmospheric phenomena. Operations in history were often inhibited by clutter since there were a massive number of undesirable visuals within targets of interest (Dorf, 1997).
During WWI and WWII, investments in information tended to be a black hole because there was no way to determine if the information was cluttered with denial and deception. In many situations, it was extremely difficult to separate out specific, quantifiable benefits from the clutter of information in both written and visual form. A 3-D reconstruction after an attack in Warsaw, Poland during WWII showed little to no definition of the area, as seen in Figure 3.

Figure 4. Warsaw, Poland (1944)

This photograph depicts the public domain of ruins of Warsaw, Poland. There is very little characterization of roads, homes, or the positions of opposing forces. During WWI one French solider described the cluttered scene around him:

“At every moment we are sprayed with clouds of earth and stone splinters. How many men are afraid? How many men are weak at the knees! …We are no longer in a civilized world. One suffers and says nothing… For hours these groans and supplications continue until they die before our eyes without anyone being able to
help them. I was overcome by dizziness, as if the earth were collapsing on both sides of me into an abyss (Barker, 2007).”

The anxiety and breathlessness of the speaker can be felt through his description of the scene alone. Similarly, by looking at Figure 4, which portrays U.S. military soldiers in WWII running into an uncertain area filled with smoke and debris, a feeling of uneasiness, unknown, and undoubtable, clutter, lies on the other side of the cloud of smoke. If the information gathered in this area was enhanced, the military members may have had an upper hand in gaining ground in Wernberg, Germany (WWII in Color, 2009).

*Figure 5. U.S. military soldiers in WWII running into a cloud of smoke.*
The anxiety of clutter conveys feelings of being overwhelmed, exhausted, and worried. Some cannot concentrate due to their intense internal focus. Others fixate about specific effects. Anxiety is easily detected if someone appears outwardly nervous; however, many sufferers appear calm on the outside, but their brain never stops. Most of the time military personnel are taught to internalize these feelings. They cannot stop thinking, and the constant internal chatter can get so bad that it interrupts their sleep and steals their quality of life. They do not live in the present, because they constantly worry about the future as noted in the French soldier’s comments. This scene in Figure 4 is a common scene in war. Running into the unknown is operational, but requires precision for the best outcome. Intelligence gathering makes the unknown more manageable and the recognition of clutter can then develop into an operational achievement.

Much of the development of information has been spent on a few key areas, such as improving the extraction of genuine signals from the background of noise and clutter, extracting more information from the received signal and its presentation to the military or law enforcement operative and combat system, improving the effective display of information, and increasing levels of automation in radar technology (Hughes, n.d.). These improvements give military offensives a stronger defense.

**The Harm of Clutter and Combating its Effects**

America must lead other nations in the pursuit of our common goals and shared security. International challenges and evolving complications must be understood before they become security crises. Neurofeedback plays a large part in helping to discern information clutter, mentioned above. With neurofeedback training, the trainee will be able to stay composed when put into a situation where the visual display has a potential to become overwhelming. Therefore,
the subject is more likely to be able to recognize a specific point of interest. The lowBeta waves of the brain will be activated to concentrate more on the specific work, and the Theta waves, which are part of the subconscious, will be minimized to allow full concentration on the task at hand.

Geo-spatial Intelligence (GEOINT) models are the epitome of visualization. They are the most widely used combination models that are comprised of location information that describes, evaluates, and visually represents physical features of an area (Clark, 2008, 78). As shown in Figure 5, “geo-spatial models can be very complex and may have many associated sub-models or collateral models” (Clark, 2007, 79). In the case of North Korea’s Weapons Program, Figure 5 is a representation of the area in which the nuclear facilities are located. It is already known that there is a facility in the city of Yongbyon; so, the next questions one must include are: Are there any other locations of nuclear plants and how large are they? And, where are the testing sites (Niksch, 2003)?

Figure 5 depicts cluttered visuals on foreign nuclear weapons, nuclear materials, and energy issues. The Department of Energy (Office of Intelligence & Counterintelligence) provides the Secretary, his staff and other policymakers within the Department, technical intelligence
analyses on all aspects of nuclear intelligence and, therefore, it is critical to understand the intelligence that lies within the clutter. These issues are evaluated in conjunction with the National Geospatial-Intelligence Agency (NGA) and the National Reconnaissance Office (NRO) which work together in analyzing this data (Office of the Director of National Intelligence, 2008).

The NGA provides timely, relevant, and accurate geospatial intelligence in support of national security objectives. Information collected and processed by NGA is tailored for customer-specific solutions. The NRO designs, builds, and operates the nation’s reconnaissance satellites. It can warn of potential trouble spots around the world, help plan military operations, and monitor the environment. Also, working closely with each department would be the National Weather Service. It is important to keep in mind that when dealing with radar and satellite images, weather and vegetation play major roles in the proper analysis of information.

Where information is needed, there will undoubtedly be clutter, and within that clutter, there is only more clutter. When an analyst devotes time and energy into a collection process, it is hard not to find confusing information tangled in photographs and models. To only make matters worse, there are a number of different agencies, as cited above, working on the same images and developing their own ideas about the information. Clutter is all in the eye of the beholder.

Clutter has the potential to hinder situations that require pinpoint precision. Hostage negotiation scenes are filled with clutter that works against the ultimate goal. Hostage take-overs have included schools, airplanes, and municipal buildings. Today, it is hard to watch the news without remembering the American crew being held hostage by pirates or to remember the gunman who entered the immigrant counseling center or the anniversary of the shooting at Columbine. In each scenario, there were scared people of all races, genders, and ages. There were cubicles, offices, and small hidden or remote areas. Sometimes the clutter was as small as
airplane seats and luggage compartments. Sometimes it was open space with imperceptible items. Sorting through these types of clutter, before acting, was necessary.

In hostage situations, to strategically place SWAT or other personnel at the optimal point of entrance, blueprints are used to acquaint hostage negotiators with a given area, as seen in Figure 6. While the blueprints of Columbine High School are detailed, they have little resemblance to the actual scene. Figure 7 shows the aftermath of the hostage situation in the enclosed setting of the cafeteria at Columbine. As the figures show, there is less clutter in the plans of the building than in the actual setting.

*Figure 7. Floor plan of Columbine High School*
Figure 8. Picture from Columbine’s lunch room

It is easy to see in Figure 7 how clutter can mislead visual understanding of the area. A simple propane tank could resemble a student in white clothing crouching down to hide. Other debris can take the ambiguous form of someone in need of help. The setting in Figure 7 can also create suspect identification problems for law enforcement. During the hostage situation at Columbine, the hostage takers were of the same demographic as the hostages. This created problems in identification and added more visual clutter to the situation. This set of circumstances gives rise to problems of identifying possible threats and possible suspects.

Situational crisis teams play a critical role in the coordinated community response continuum. Together, at the scene with military and law enforcement officials, crisis response teams have proven effective in helping victims obtain services and aiding the commanding officials assess the environment. The team methodology allows officers to attend to the criminal justice aspects of the case while the advocate can deal directly with the medical and social service needs of the victims.

During a time of chaos, it is important to develop structure to contain the clutter. The organizational skills of the situational crisis teams provide much needed structure. MAJ Von
Plinksy recalls a time when he was overseas and the situational crisis team was called in to help evaluate a cluttered situation. After an explosion had gone off, the situational crisis team was called in to deal with the critically wounded and organize a response team for the many more patients and situations presenting themselves. With the many patients including critical and non-critical, medical equipment, surgeries being performed in the open, doctors, military members, tables, and paperwork, organization was a priority.

The crisis team sectioned off areas by grouping the needs consistent with medical requirements and necessities. The medical response workers were given the scrubs, medical work clothes regularly worn in operating rooms, in line with their job title. In this case, the doctors were given blue scrubs, nurses were in yellow and other team members were given green. The color coding allowed easy communication between staff members and facilitated conversation for those outside of the medical response team. As a result of color coding and sectioning areas the crisis team was able to visually transform the clutter and alleviate confusion in a high stress situation. Establishing a base and containing the clutter allowed the military crisis team to handle the situation effectively and efficiently.

The same holds true for x-raying baggage at an airport. The x-ray is a useful tool for picking out anomalies and acquiring data on a found or suspicious object. X-ray inspection of any object will reveal its nature and can be deployed as a fast, confirmatory tool without the need to pick up the object. The Assistant Secretary for the Transportation Security Administration (TSA), Kip Hawley, uses the word “clutter” to describe the contents of personal baggage that is checked by the TSA (Press Office: Department of Homeland Security, 2006). As an example, clutter makes it difficult to decipher a hairdryer from a gun, a compact case from a C-4 package, a lipstick tube from a lighter. In addition, there are numerous other objects that are similar in shape and size, but drastically different in application. Figure 8 shows a baggage x-ray taken of
a passenger’s suitcase. Surrounded by all the clutter and poor visibility, it is hard to tell what the items are and which could be dangerous and which are innocuous.

Figure 9. X-rayed Luggage

Figure 8 does contain a dangerous, contraband item that should not be allowed on a plane. The inability to quickly pick out that item and mark the contents as dangerous could affect the safety and well-being of others. Below Figure 9 shows the handle of a gun sticking out from the other items covering it.

Figure 10. Identification of hazard.
Clutter has been shown to be poorly identified by the military when trying to access important information and fear of the unknown is a possible driver. As seen in Figures below, the unknown in clutter certainly can instill fear. It continues to cause identification problems when managing certain situations and information in present-day threats.

"Fear triggers the fight or flight response… While fear is not at all a desirable feeling, understanding the way we react to it is fundamental along with a basic understanding of the Central Nervous System is important" (MacDonald, n.d.).

Advantages of Clutter

On the other hand, just as clutter can thwart military operations, it can also work as an advantage within military operations out in the field. Bravo and Farid (2008) defined measures of clutter in their research within three distinct points. First, the subject must not be aware of the targets’ color or other features; second, the subject should not be able to predict where the target will appear; and third, the targets must be drawn from the same pool of objects as the distracters, so they are not especially salient. Each aspect of measure can be found while in a war zone. It is the characterization of hiding in plain sight as referenced by Where’s Waldo? in Figure 1, that comes into play in Figure 10 and Figure 11 which depict these defined measures of clutter that
military personnel experience when in a war zone.

*Figure 11.* Military soldier field testing new camouflage uniform (2012).
The clutter in both figures is a good example of each field described by Bravo and Farid (2008). The first aspect of clutter is to be unaware of color or features. Camouflage worn by the military is clearly designed to blend in with the surrounding area. In Figure 10 it takes a second or two to realize that there is a person in the picture amid the rubble of the surrounding buildings. In both figures, the military are in uniforms that blend with their specific surroundings making them assimilate with the background. The rigid rock and grey coloring in Figure 10 and the smoke and up-blown dust in Figure 4 adds clutter to the immediate area making it harder to locate a target. The coloring allows the military to hide well within the dilapidated housing and crumbling rock. The second condition of clutter regards not being able to predict where the
target will appear. Snipers look to hide in buildings, so they are obscured from view. They do not want other militia knowing their location and thus they become part of the clutter. The appearance of a target is unpredictable to the enemy. The third condition of clutter is that the object must not appear to be prominent. This makes the necessity of hiding and blending with the surrounding areas most important. Military personnel must make themselves an integral part of the area so as not to be a distracter. Clutter, such as camouflage, can easily be used to military benefit, if it is properly understood and employed.

Famed photographer, Simon Menner, recently publish his work entitled “Camouflage” using both German novice soldiersand experienced snipers to hide in plain sight. The soldiers were instructed to camouflage themselves, but directly point their gun at the camera and, in essence, at the viewer (Rosenberg, 2015). Figure 12 and Figure 13 are just two of the many photographs shot by Menner. Figure 14 and Figure 15 are added to show the reader where the soldier is hiding for edification. Further discussions in this dissertation will prove how crucial Neurofeedback is to discerning this fog of war.

Figure 13. Novice German solider hiding in plain sight.
Figure 14. Identifying the novice German soldier hiding in plain sight.

Figure 15. Experienced German sniper hiding in plain sight.
Figure 16. Identifying the experienced German sniper hiding in plain sight.

Experiments conducted using different visual fields and parameters help give insight into the psychological process that occurs when searching through clutter. Real-time research has been conducted using subjects and calculating the time it takes these subjects to find a certain object. As one would assume, research shows that it takes a person longer to locate the keys in Figure 16 as opposed to Figure 17 (Bravo and Farid, 2004).

Figure 17. Unorganized purse
Figure 18. Organized layout
Before visually seeing the keys, a person already has an idea of what keys look like. When the object that is being sought does not vary over occasions, it is easier for a person to develop an internal illustration. Take for example a citizen of a third world country, where there are few cars, who probably has never seen keys. Even if he were given a picture of keys just before being asked to locate them, it would take him a longer amount of time to search and locate the object than those with an internal illustration. This could be true regarding objects even when neatly arranged as in Figure17.

Clutter depends on three main factors: the colors of the surrounding areas, the number of objects in the visual field, and the recognition of the object, something one can internally see. In Figure 16, the color of the keys is similar to the color of the purse and other objects making the keys more difficult to locate. In Figure 17, the number of objects in the visual field is limited to ten, allowing for swifter identification of the keys. These factors can then be aligned to the clutter found in military settings. And, in turn, this association may help in the faster and more efficient focus and retrieval of information in a given setting.

More rapid focus of a target can be noted in research conducted by Edward Callaway, as well as Jane Huttenlocher and other colleagues. When engaging in an action like shooting guns, the bypasses of categorical divisions of space can be seen in a different set of responses within the brain. Ed Callaway, Ph.D. at the Salk Institute has now discovered two different types of nerve cells that deliver the right kind of sensory information (ScienceDaily, 2005). Callaway’s work with the visual cortex in rats supports the discovery that the neurons in the brain are “wired” and “talk” with discrete, excitatory neurons. They also keep a correct balance of chemical signals and often exclude other surrounding neurons (ScienceDaily, 2005).

Ed Calloway asserts “the inhibitory neurons are not just brakes, but they can be used to steer.” Neurofeedback training, for example, guides these neurons that will facilitate the
trainee’s focus on what is needed to be seen, rather than all there is to see. If the reader revisits Figure 1 there are plenty of other issues one can focus on rather than trying to locate Waldo. For example, there is a young boy pulling back the curtain of a woman undressing, there is a person pick-pocketing a wallet, and, in addition, there is a woman running in the crowd flashing everyone and a man stripped down doing his laundry. Figure 18 displays the representative form of the connection of the inhibition around clutter to four supervisory functions and the motor control they direct (Barkley, 2007).
Figure 19. Connection of the Inhibition around Clutter
There is much potential in viewing visual clutter as a disorder of self-regulation. It influences psychopathologists to improve models of how self-control arises and to examine where clutter disrupts the normal process of discerning specific scenes in the field. By taking an evolutionary or adaptive standpoint in the direction of self-control and its allied executive functions of behavioral, inhibition can shed light on the nature of these comparatively exceptional human capabilities (Barkley, 2007).
Chapter 2: Literature Review

Anxiety is usually a person’s response to stress, which can come from psychological, physical, or environmental sources, like clutter. Once a person’s brain gets locked into a pattern of anxiety, it can be difficult to break. For military and law enforcement personnel suffering from anxiety, learning how to modulate or turn off chronic stress responses is situational and life changing.

A person’s visual coordination is inadequate when compared to its capability of processing the incoming information. “Advances in visualization research have provided a variety of techniques to deal with the problem of information overload” (van den Berg, Cornelissen, and Roerdink, 2009, p. 1). So what causes a scenario’s structures, characteristics, and dynamics to be a problem in locating an object for some and not for others? In addition, what role does the brain play when discerning the parts of the whole? These questions can be answered by the use of neurofeedback as a training technique. Neurofeedback is a sophisticated computer program that observes brain waves using computer software that can output a visual account of what is happening in the trainee’s brain. In the same way that biofeedback can control and monitor a person’s heart rate and blood pressure, neurofeedback can be used to control brain wave conditions (Taylor, 2010). The control takes place during a 45-minute neurofeedback session. Sensors are attached to the trainee’s scalp with EEG paste, which detects brain waves. It is a painless technique and does not involve the presentation of any voltage or current to the brain. It is entirely non-invasive. "Two of sensors will pick up the neuro electrical activity in the brain, while the third one acts as "ground". Because brainwaves are measured in micro volts (1/1000 of a volt), the signals from the sensors are sent to a neuro amplifier before being passed on to the computer. A sophisticated software program called Cygnet filters the signals (to eliminate unwanted stray electrical signals. The Cygnet program then converts the signals from
the brain into visual, auditory, and even tactile feedback” (Kirk, 2012). The computer response that a trainee perceives is one of several types of video games; all accompanied with suitable sounds. Responding to the images, the brain quickly learns and refocuses accomplishing new neurological connections in an attempt to keep up performance. By doing so, the brain is learning to regulate and stabilize itself. The neurofeedback clinician observes the brain in real time by monitoring brain waves and rewards shifts toward more applicable and constant brain states.

For example, “SimCity 4 is a civic simulator that allows a player to create unique virtual cities that can grow over time…” (Neider and Zelinsky, 2011, p. 4). Mark Neider and Gregory Zelinsky performed the following study to show exactly how an increase in visual clutter produced negative search times. It can be anticipated that using the same method for military and law enforcement officers would produce the same results.

In the study, three scene varieties were created: rural, suburban, and urban cities as depicted in Figure 18. Neider and Zelinsky used “realistic civic planning rules” when developing each city’s visual appearance “ultimately producing cities that varied in their degree of clutter” (Neider and Zelinsky, 2011, p. 4). As to be expected, the rural city would be the least cluttered, the suburban city would have an intermediate level of clutter, and the urban city would be the most cluttered.
Figure 20. Rural, Suburban, and Urban cities created in SimCity 4.

As stated above in discussing Figure 19, one person’s organization may be another person’s mess. The concept that there can be an organized chaos was neutralized by Neider and
Zelinsky. The two used rating echelons to obtain a “subjective measure of visual clutter” (p. 5).

First the photos from Figure 19 were unsystematically placed in a folder and then college students rank ordered these images, lowest to highest, for visual clutter. After the individual orderings were completed, a calculated mean for each scene type, reflecting the raters’ “normal” observation of clutter in each photo. Subsequent to this echelon, another set of raters used a 1-10 rating scale representing their observed change in clutter between images as shown in Figure 19. For example, of the 6 photos above (ordering from left to right), the observer might rate the change in clutter from photo 4 to photo 5 as a 7 on a scale of 10. Once more, after the individual ratings were completed, a calculated mean for each consideration of clutter change was identified.

The search portion of this study was conducted by yet another set of college students. The students were tasked with locating a Town Hall building, pictured in Figure 20, in each rural, suburban, and urban city scene. The constructed visual Town Hall was digitally inserted into the pictures; therefore, removing the involvement of the researchers whose placement may have subconsciously aided search behavior during location of the Town Hall.
The ability to monitor brain wave speed became available as computer systems evolved during the early 2000s. Practitioners utilized sensors that monitored brain waves and deposited the data back to the computers. The computer then generated a visual field of the brain wave actions in real time. It became apparent to neuro-practitioners that by monitoring the brain this way it was evident that brain wave function could change itself.

Reaction times (RTs) generally rise when a scene is more cluttered as in most complex search tasks. One way to observe and measure the rise is to compare RTs between scene types that differ in both subjective and objective clutter. In the results of Neider and Zelinsky’s project, they confirmed that targets in urban scenes took longer to find than in suburban ($p < 0.005$) or

Figure 21. Constructed Town Hall building represented in SimCity 4.
rural ($p<0.001$) scenes, with search in the suburban scenes also requiring more time compared to the less cluttered rural scenes ($p<0.001$). This finding replicates previous work showing longer search times for more cluttered visual scenes” (Neider and Zelinsky, 2011, p. 6).

The aforementioned work has shown that visual clutter negatively affects search performance (Henderson et al., 2009) (Rosenholtz et al., 2007) (Neider and Zelinsky, 2011). Neurofeedback can be utilized to learn about an individual’s search behavior, attempt to determine the best method of performance in a search task, and enormously change the brain to search in the most effective way possible.

Concerning the correlation among the empirically defined clutter and search tasks, search performance deteriorates as visual clutter increases and specific objects take longer to find in more cluttered. Neider and Zelinsky noted in their study that (as clutter increases so does the) variety of buildings appearing in a scene, thereby increasing the likelihood that one of these buildings will look like the target… As clutter increases, so does the probability of local background features matching the target, making the task of discriminating the target from the background more difficult” (2011, p. 12). Neurofeedback training guides neurons that will facilitate the trainee’s focus to search for the exact target, rather than all the similar targets. If the reader revisits Figure 1 there are plenty of objects and individuals who look like Waldo. Neurofeedback will allow the searcher to scan over the similar object and individuals faster; therefore, speeding up the identification of Waldo’s location.

The information above reveals how neurofeedback research fits into the larger field of Strategic Security. It can be seen that there is a sizable gap in the body of knowledge that makes up the larger field of Strategic Security. Clutter is everywhere. The patterns of clutter and their harm have been seen since WWII and have continued into today’s field of Strategic Security.
The research confirms the existence of clutter in the military and security fields. Shades of colors, field sizes, like qualities all distort and interfere with the work conducted by military, law enforcement and other agencies. “The U.S. intelligence community has the most resources and does the best systems planning. It innovates constantly and attempts things few other services would try” (Clark, 2007, p. 141).
Chapter 3: Methodology

The goal of this methodology is to verify existing neurofeedback techniques and develop and create new methods. “Naomi J. Steiner, director of the CATS Project (Computer Attention Training in Schools for children with ADHD) at Tufts Medical Center, and her colleagues found that computer-based attention-training exercises significantly improved the ability of kids with ADHD to focus and pay attention” (Mitchell, 2014). In this dissertation, the same technique, as used by Steiner, will be applied to military and law enforcement men and women to focus their attention on the aptitude for focus and attention.

Brainwave Responses

Neurofeedback “works through the principle of brain plasticity”, signifying that the brain can acclimate itself by responding to atmospheric provocations (Mitchell, 2014). Therefore, by using the brain’s ability to change in the frontal cortexes, neurofeedback training will be capable of teaching how to focus attention during visual clutter.

In neurofeedback, it is essential to increase the trainee’s low Beta wave and decrease Theta waves. By increasing low Beta waves, the trainee learns to focus more on the here and now, and by decreasing Theta waves the trainee learns to suppress the “fight or flight” response. When the trainee is awake and completely active, the brain waves operate at a level called low Beta where the waves primarily fluctuate between 14 to 30 cycles per second. The Beta level corresponds to a focus of concentration by the mind upon the outside or perceptual world. Theta brain waves occur when relaxing. The mind enters a region that correlates with a relatively large quantity of brain wave patterns of 4 to 7 cycles per second. Theta waves deal mostly with the subconscious part of the brain (O’Donnell, 2010). By controlling and changing these brain waves, the trainee will be capable of being more aware of surroundings and will be more
proficient in staying calm in high stress situations. At the same time as the trainee is able to stay calm in a high stress situation, he or she is more likely to be able to recognize a specific focal point.

**Computer Based Training**

Two types of computer training systems will be used to complete the focus training. The first, computer cognitive attention training, will utilize computerized brain exercises to strengthen crucial mental skills. These fundamental abilities include increases to short-term memory, improved hand-eye coordination and enhanced visual processing through successions of computer game activities. The second, neurofeedback, measures brain waves in real time and provides visual and auditory feedback that will facilitate the ability to harness concentration and attentiveness.

The training procedure relies on the principles of operant conditioning. The trainee straightforwardly engages in a video game or visual prompt and audio feedback that responds to the brain waves. When the brain is meeting the parameters set by the clinician, the video game’s response becomes the reward or feedback. Starting points are based on the brainwave scale within the training band and rewards are given when the threshold is exceeded. The fluctuating amplitude will be represented both visually and audibly. For example, when the subject exceeds the brainwave threshold, success would be indicated with a visual representation, such as a car travelling down a street, and an agreeablesound, such as a revving engine. The visualization and sound would be repeated regularly as long as the reward criterion was achieved. Over time, the feedback will be incorporated in ever more varied video animations. These animations will depict real world situations that may be faced by the subject. As subjects respond to the training, the Neurofeedback reward frequency can be increased following each session causing the brain to
work harder and ultimately respond faster. The reward frequencies are given back to the subject when low Beta brainvawedecrease and Theta waves increase. Changing the reward frequency will make the subject work harder to achieve the same results; ultimately making the brain work harder to alter its connections. This is extremely helpful because the reward frequency can be tailored to the subject’s need. Narrowing the reward frequency will make the brain respond faster over time and be able to adapt to varying situations.

The neurofeedback training only requires 20 sessions (Mitchell, 2014). "Adults use what we call metacognition; that is, they think about how [they are] thinking and learning" (Mitchell, 2014). Adults are aware of how they can use the skills to bridge their deficits causing an even greater increase of success in enhancing their mental skills.
Chapter 4: Discussion

Executive function skills relate to the brain’s ability to orchestrate what it’s about to do (Mitchell, 2014). Neurofeedback is a pioneering quantifiable analysis in which EEG measurements and performance intervention coalesce to reveal their applications when dealing with the fog of war. The impact of this dissertation aims to develop and improve the understanding of the applications of neurofeedback techniques that aid in visual discernment in a cluttered area.

Neurofeedback training will enhance the efforts put forth by the U.S. intelligence community. The relevance and impact is supported by the applications already constructive to its use in decreasing the effects of Post-Traumatic Stress Disorder (PTSD) (Othmer and Othmer, 2009, pp. 29-30 and Gapen, et al., 2016). In addition, applications of neurofeedback in Attention Deficit Disorder (ADD) and Attention Deficit Hyperactive Disorder (ADHD) have the same basis in controlling the mind as it does in controlling the visualization of clutter.

Neurofeedback provides physiological support and aids people in learning to change their responses to stress. With brain training, they can develop the skills they need to reduce or eradicate anxiety and apprehension in their lives, especially in military situations. Johnathan Walker’s results of guided neurofeedback training for anxiety in PTSD patients revealed clinically significant reductions in anxiety (Walker, 2099).
Chapter 5: Conclusion

There is a low tolerance for slow learning. Technology is becoming an increasingly popular tool to provide the content for learning since internet-based training has been made available to the masses. The above research has revealed that adult trainees, when properly instructed, are highly motivated learners who are adept at making positive changes to their own mental and cortical framework. Neurofeedback designers are creating formalized learning techniques that are computer-based and ensure that the content is directly applicable to the lives of the adult learner. Additionally, Neurofeedback is a powerful technique for calming and restoring the brain to a restful state.

Neurofeedback has been exhaustively researched in connection with PTSD and addictions. It is currently being used in Afghanistan with combat stressed soldiers. The program at Camp Pendleton for Marines returning from the war theatre, called Combat Stress Reset, makes heavy use of Neurofeedback training. Dr. Hanno Kirk utilizes Neurofeedback, Alpha Theta training, primarily for veterans with PTSD.

“People process and react to terrifying events differently. These reactions depend on past experiences (past traumas), expectations of the present, and future concerns of a traumatic event happening again” (MacDonald, n.d.) Neurofeedback will benefit soldiers and law enforcement officials by training them to control their emotions and help them be capable of taking sensible steps even in the toughest, most terrifying situations.

The direction of new concern now is dealing with the clutter or fog of war that is an apparent and often experienced phenomenon (Phillips and Noyes, 1982). Major Richard Paz (2003) poses an interesting question: “What other visual technologies will enable users and planners to depict and communicate a plurality of ideas, concepts of simultaneity and concomitant event relationship?” Understanding clutter and how people process their
surroundings will give insight into developing better ideas and planning strategies for military and law enforcement use. Clutter can degrade performance. However, having a specific measure of clutter can help set a visual search field. This would, in turn, lessen the problematic search of baggage in an x-ray machine and help design models that eliminate visual clutter. A measure of clutter would allow better understanding of the intrinsic complexity of a cluttered model and thus allow a better evaluation of performance (Rosenholtz, Li, and Nakano, 2007).

Neurofeedback is still a “grey area” in science and further research is needed to understand its efficacy. Its usage as a training technique in a military setting still requires further exploration. However, as more results and additional research become available they will undoubtedly show that neurofeedback is a valuable training technique.

Neurofeedback is on the cutting edge of science and its use in the military could be exponential. As a starting point, neurofeedback can be implemented in straightforward tasks such as shooting at a target. In the future, neurofeedback can have more complex usage, as in the ability to isolate small objects in a cluttered setting. In each case, whether it is in the field of Human Intelligence (HUMINT), Geography Intelligence (GEOINT), Open Source Intelligence (OSINT), or others in aspects of military and law enforcement agencies, neurofeedback training can help agents, officers, strategists, and crisis management teams pinpoint potential threats. These threats range from targeting specific people in a group to identifying hostages and hostage-takers in a cluttered setting. Neurofeedback training will also help a trainee concentrate on tasks at hand, even when visual clutter is not an issue. Personal mental clutter may be an obstacle when trying to apply focus to the task at hand and neurofeedback techniques can be used to increase focus.

When actual situations arise, it will be beneficial to be able to measure the brain’s function in real time. Neurofeedback will give researchers the potential to see in real time the
brain’s mapping and understanding of clutter as a military member or law enforcement agent witnesses an event. The end result of this research is to enable military and law enforcement agents to improve their visual techniques, enhance their knowledge of their surroundings, regardless of clutter, and more efficiently conduct counterterrorist efforts through the use of neurofeedback.

**Recommendations**

Technology has become cheaper and more accessible to everyone (Day, Janus, and Davis, 2005). Yes, the implementation of Neurofeedback training can facilitate and support effective learning and brainwave exercise, but there are many challenges involved in implementing this technology. Unfortunately, only a few large-scale studies of neurofeedback have been reported in the literature. Recommendations regarding further research have yet to be implemented. These recommendations are summarized as follows:

1. Research and analysis requires external and methodical replicability of brain wave feedback methods and results. Ideally, this would include diverse subjects that are matched on key dimensions. This demographic is perfectly observed in military and law enforcement members. Many come from different areas around the world, they are of different ages and, yet, still have the common personality and mental factors innately found throughout constabularies.

2. The training durations and intervals for brain wave feedback required for therapeutic advantage need to be investigated further. Recent studies state that between 20 sessions (Kirk, 2012 and Mitchell, 2014) and as many as 40 or more sessions (Montagne, R & Inskeep, S, 2010), several times a week, are needed to establish long lasting results.
(3) Distinctly demarcated methods, outcomes and measures need to be established in pursuit of tracking the reliability and validity of the Neurofeedback training program. It is recommended that Congress meet with medical practitioners to define the parameters of the program to induce Neurofeedback benchmarks, optimal subjects for training and the length and frequency of sessions. Once the Neurofeedback program is established, the nature and timing of an evaluation plan would be used to determine the effectiveness of the proposed policy.

Neurofeedback training has the potential to be an integral training method for military and law enforcement officers. The ability of Neurofeedback, to detect brain wave functioning, makes it possible to better isolate and determine the source of the brain's activity. It is warranted that more focused research of this type be conducted for sake of further exploration of the capabilities and applications of the program specifically as a training technique to combat the fog of war.

The results in the research conducted by Huttenlocher et al. (1991), Bravo and Farid (2004 and 2008), Neider and Zelinsky (2011), and many others, described above in this dissertation, support the necessity of further investigation. The benefits of implementing Neurofeedback training in constabulary areas would aid in faster and more successful search and rescue matters, a more advanced ability to identify threats on an X-ray, and better techniques in camouflaging as well as uncovering the disguised and hidden in military situations.
Glossary Appendix

**Attention Deficit Disorder (ADD) and Attention Deficit Hyperactive Disorder (ADHD)** – are analogous mental disorders that are prominent in adolescence and carry through into adulthood. Symptoms include difficulty staying focused and paying attention, difficulty controlling behavior, and hyperactivity.

**Clutter** - a measure of visual disorder.

**Geographic Intelligence (GEOINT)** – is intelligence that is gathered by means of geographical photography.

**Human Intelligence (HUMINT)** – is intelligence that is gathered by means of personal contact.

**Neurofeedback** – is a type of biofeedback that uses real-time displays of brain activity to teach self-regulation of brain function.

**Open Source Intelligence (OSINT)** – is intelligence that is gathered by means of non-classified information open to the public.
References


Calloway, E. (2005). Brain’s response to visual stimuli helps us to focus on what we should see, rather than all there is to see. *ScienceDaily*.


