Advancing Forensic Interrogation Techniques to Combat Terrorism and Enhance State Security

DISSERTATION

Submitted to the Graz University of Technology,
Faculty of Computer Science,
for the attainment of the degree of
Doctor of Engineering Sciences (Dr. techn.)

By

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Graz, 29th August, 2013

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vorgelegt an der
Technische Universität Graz,
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Abstract

The development of functional Magnetic Resonance Imaging (fMRI) and the significant role that it plays as an interrogation tool has not been previously researched. No established standard exists to accurately differentiate lie and truth that can be evaluated in combating terrorism. The work presented in this doctoral thesis is to investigate whether this forensic tool may or may not play an effective role in extracting relevant information from suspects. The literature within the fields of lie-detection is reviewed. Two novel experimental paradigms were carried out described in this thesis. In the first experiment we used fMRI to detect what specific regions were reproducibly activated when we replicated F. Kozel et al.'s 2005 research to reproduce prior group brain correlates of deception. The second study resembles a counterterrorism scenario to identify whether deceptive and honest responses can be differentiated between two groups (freedom fighters and freedom activists) to evaluate deception and to ensure that innocent suspects are not incorrectly classified as terrorist. The results offer compelling evidence that this technology has the potential to work for deception detection in the real world. This thesis suggests that, although fMRI may permit investigation of the neural correlates of truth, however, it may well be misleading to determine who is innocent when both groups have activation in similar cortical areas (due to different factors affecting brain regions that are related to lie) while interrogating about terrorist activities. This thesis has not sought to rule out absolutely the use of neuroimaging as an interrogation technology. Rather, the intention of this work is to raise serious concerns that must be addressed prior to moving this technology to real-world application. This way, in near future, fMRI can be used as a reliable method of lie detection. The aim of our research is to show that this neuro-imaging forensic tool can be an important, helpful, and successful tool for state security from an employee screening and interrogating perspective. Another main contribution of this thesis is to propose recommendations, best practices, and guidelines that can address scientific, social, ethical, privacy and general public concerns with fMRI. This work could revolutionize police work and is likely to provide significant benefits to society. This thesis is a major contribution in the field of interrogating suspects and a basis for further studies in lie detection. The strengths like feasibility, realism and free choice of subjects in our paradigm can be helpful in designing more valid experimental frameworks in the future.

Kurzfassung

Die Entwicklung der Bildgebung mittels funktioneller Magnetresonanztomografie (fMRI) und deren potentiell bedeutender Rolle als Vernehmungswerkzeug wurde bislang noch nicht erforscht. Es existieren keine etablierten Standards, um im Zuge der Terrorismusbekämpfung Lüge und Wahrheit genau von einander zu differenzieren.

Die Arbeit, welche in dieser Dissertation präsentiert wird, folgt der Aufgabenstellung, ob diese Technologie einen effektiven Beitrag zur Gewinnung relevanter Informationen von verdächtigen Personen darstellen kann oder nicht. Die Literatur innerhalb des Gebietes der Lügendetektion wurde aufgearbeitet. Zwei neue experimentelle Paradigmen wurden ausgeführt und werden in dieser Arbeit beschrieben. Im ersten Experiment wurde die fMRI-Technik verwendet, um zu ermitteln welche spezifischen Gehirnregionen aktiviert werden, indem die Forschungsarbeit von F. Kozel (et al. 2005) aufgegriffen und mit dem Ziel spezifische Korrelate aktivierter Gehirnregionen zu reproduzieren, erneut ausgeführt wurde.

Die zweite Studie ähnelt einem Anti-Terror-Szenario, um zu ermitteln ob betrügerische oder ehrliche Reaktionen innerhalb von 2 Gruppen von Probanden (Freiheitskämpfer und Freiheitsaktivisten) differenziert werden können. Die Zielsetzung hierbei war Betrug zu identifizieren und sicher zu stellen, dass unschuldig Verdächtigte nicht fälschlicherweise als Terroristen klassifiziert werden. Die Resultate geben überzeugende Hinweise darauf, dass diese Technologie über das Potential verfügt, um in der realen Welt zur Betrugsdetektion eingesetzt zu werden.

In dieser Arbeit wird darauf hingewiesen, dass es möglicherweise zu irreführenden Ergebnissen kommen kann, obwohl die Bildgebung mittels fMRI die Darstellung von neuronalen Korrelaten, welche mit Wahrheit in Verbindung stehen, erlaubt. Dieser Umstand muss in Betracht gezogen werden wenn beide Gruppen während eines Verhörs aufgrund terroristischer Aktivitäten Aktivierungen in gleichen kortikalen Arealen zeigen (aufgrund verschiedener Faktoren, welche Gehirnregionen beeinflussen, die mit Lüge in Verbindung gebracht werden). Die Zielsetzung dieser These war es nicht die Verwendung der Neuroimaging-Technik als Verhörmethode auszuschließen. Vielmehr war die dieser Arbeit zugrunde liegende Intention, ernstzunehmende Belange aufzuzeigen, die angesprochen werden müssen, bevor diese Technologie in der realen Welt angewandt werden kann. Die fMRI-Technik kann in naher Zukunft als zuverlässige Methode der Lügendetektion angewandt werden. Die Absicht dieser Forschungsarbeit war es aufzuzeigen, dass Neuroimaging für den Bereich des Verhörwesens und des Mitarbeiter-Screenings ein wichtiges, hilfreiches und erfolgversprechendes Werkzeug darstellen kann. Ein weiterer wichtiger Beitrag der vorliegenden Arbeit ist es Empfehlungen und Guidelines anzubieten, welche für wissenschaftliche, soziale, ethikbezogene, datenschutzthematische und öffentliche Belange in der Arbeit mit der fMRI-Technik

von Bedeutung sein können.

Diese Forschung kann die Polizeiarbeit revolutionieren und möglicherweise für die Gesellschaft von großem Nutzen sein. Sie stellt einen großen Beitrag im Bereich des Verhörwesens dar und soll Basis für weitere Studien im Arbeitsfeld der Lügendetektion sein. Die Studie war durch unkomplizierte Durchführbarkeit ausgezeichnet und Probanden konnten einfach rekrutiert werden. Diese Umstände geben Hinweise darauf, dass in Zukunft zuverlässigere experimentelle Rahmenbedingungen für weitere Studien geschaffen werden können..

To my loving parents and family.
Their support, insight, guidance, patience and kind wishes always,
craft the success for me!

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CHAPTER 1 Introduction and Motivation

September 11th has marked an important turning point that exposed new types of security challenges and disclosed how terrorists' pursuit of their long-term strategic objectives. It includes attacks on innocent civilians and critical infrastructures that could result in not only large-scale human casualties but also profound damage to national power and prestige. Following these terrorist attacks in New York, governments have waged a global campaign against terrorists groups in order to ensure national security. A crucial part of this campaign has been intelligence gathering with different methods of interrogation techniques in order to extract allegedly necessary information from suspected terrorists and employees to undergo any level of security screening. However, the fear about investigating suspected individuals has reached new heights and put pressures upon the law enforcement agencies for screening and reliable interrogative methodologies to find out whereabouts of terrorist groups and a prior knowledge of their practices. On the other side, the interrogation of prisoners at Abu Ghraib and at Guantanamo bay have shocked the public and provoked the collective conscience of the society [6]. Civil society, theologians and scholars have condemned the harsh and traditional methods used by the intelligence operatives that include both physical and psychological torture [72]. The law enforcement agencies need to know whether any pragmatic technique of obtaining information actually works to avoid the creation of more enemies and maintaining the integrity of the state. However, there has been no objective interrogation method and scientific way to discriminate between truthful and deceptive statements [72]. It is also very difficult to uncover concealed information in terrorist's mind with these methods.

The objective of the criminal justice system is to implement technologies that can identify the line of attack as we can better prepare ourselves to extend our defenses and protect the nation [6]. Towards this end, efforts are invested for centuries by investigators, intelligence officers and psychiatrists to accurately identify perpetrator. Methodologies include torture, polygraph and tools like PSE (Psychological Stress Evaluator), VSA (Voice Stress Analysis), EEG (Electroencephalography) and SVA (Statement Validity Analysis'). The law enforcement agencies have invested billions of Euros in different technical measures for years. However, none of these techniques have yielded optimal results and are not entirely suitable for detecting deception and concealed information in the brain of the terrorist suspect. Furthermore, no established standard exists to accurately differentiate lie and truth that can be evaluated in combating terrorism. This thesis investigates the possible uses of functional Magnetic Resonance Imaging (fMRI), in interrogation and employee screening based on our robust research paradigms and experiments. Our research identifies that this tool may prove to be an effective deterrent for extremists and avoiding the prosecution of innocent subjects, thus, freeing up governmental resources. Another goal of our innovative methodology is the implementation of fMRI in real life situations to find whether if this technology enables intelligence operatives to detect suspicious behavior indicators to provide real-time decision support.

The development of fMRI and the significant role that it plays as an interrogation tool has not been previously researched. The current research introduces a first step towards advancing a novel experimental interrogation paradigm that aims to apply a number of reliable and practical applications of fMRI within a rule of law and human rights framework. The motivation of the current research in this thesis is to develop the forensic interrogative methods for law enforcement agencies to extract valuable information from suspected terrorists as well as screening of employees in critical situations. The aim is to combat terrorism and to establish an appropriate level of trust at employees, effective monitoring and ensuring that malicious insiders do not pose a foreseeable risk to critical infrastructure. A consistent practice of performing background checks and evaluating individuals based on the information (such as past employment, previous criminal convictions, drug related problem and verify credentials) obtained through fMRI can reduce insider threats in critical infrastructures. This prototype is applied in such a way that implications of interrogative methodologies may become a reality for mining of knowledge from potential suspects. The motivation is to assess whether it is possible to judge a suspect if he/she has personal information of places, people and important knowledge that would nonetheless be useful in intelligence interrogation. Furthermore, the ability of this technology to find whether an individual know a particular building in the town or he/she has personally seen any particular terrorist such as Ayman Al-Zawahiri or other knowledge such as terrorist training camps. The purpose is to show recognition of key objects, if possible and facilitating the release of those who do not. The ultimate goal of our innovative methodology is the implementation of fMRI in real life situations that may serve the cause of human rights by providing an innocent person the means to scientifically prove his/her innocence. This truth verification tool has potential to replace torture and aggressive existing interrogation strategies.

Another motivation of this dissertation is to counter ethical, social, privacy and general public concerns and harmful consequences of this forensic technology by presenting a set of ethical and professional guidelines and recommendations that may substantially reduce the risk of unethical use of this tool. Based on the current validity of our experiments, this work supports the possible uses of fMRI in truth verification process and argues that it may give individuals their human right to present to the world with their version of the truth. This work ensures the limits of the state/organization's right to peer into an individual's thought process with and without consent, to define the parameters of a person's right to ensure that fMRI scans do not pose more than an appropriate threat to cognitive liberty. The significance of this research is to ensure that implementation of fMRI may not to rise to the conscience shocking level and will not injure substantial liberty interest and the proper use of such information in civil, legal, forensic and security arenas. Our research is a first step towards maximizing the benefits of this emerging technology while minimizing the harms. We hope it could benefit from a shift in direction - focusing rather on the development of evidence-based methods that could lead to the conduct of more analytical interrogations to combat terrorism and the extraction of innocent's involvement in the terrorist act. Finally this work explains that ambiguous and confusing results of this technology may present many new human rights and ethical dilemmas and could result in potentially disastrous outcomes. The intention of this work is to raise these serious concerns that must be addressed prior to moving this technology to real-world application. This study has a number of strengths that should be highlighted in the context of how fMRI technology can be moved towards a practical application. This way, in near future, fMRI can be used as a reliable method of lie detection.

1.1 Problem Statement

Good interrogation is the best weapon in the war against terrorism as it separates signals from noise [90]. Failure of previous interrogation techniques to properly use tacit knowledge during interrogating the terrorists routinely inevitably leads to ineffective technology [90]. During interviewing, the gross definition errors to identify the terrorist attack cause serious problems and unsuccessful efforts with existing terrorism prevention efforts [47]. Existing lie detection techniques and protocols have also been plagued by investigator' failures to recognize the difference between knowledge-based, scientifically derived preventive efforts in terrorism scenario. Those interrogating procedures for terrorism prevention are unfortunately often guided by a general sense of vulnerability as well as old techniques such as polygraph and torture [47]. Furthermore, those assigned to implement interrogation strategies often do not know what types of criminal or terrorists to look foil and they often they practice the same interviewing techniques routinely used around in a cookie-cutter style [41]. These preventive efforts are easily thwarted, easily disrupted, time consuming and costly. It renders the available procedures used by prevention agencies around the world and leaving counter-terrorism agencies unnecessarily exposed to terrorism [41].

Secondly, in author's 10 year professional experience as a law enforcement investigator, he has applied many of interrogation techniques in his daily work in criminal investigation, such as torture, polygraph, VSA, SVA and PSE. But author found that these practices seem to assume they'll apply equally to all kinds of criminal suspects. Yet, in his work, he found that people are different with respect to human nature and their act. Investigators have to utilize these facts routinely in a very direct and practical way to understand the motives of an individual personality. However, there is a need to refine the process of interview and interrogation for the varied types of personalities and characters. In this thesis, we will encounter in perfecting the art and science of interrogation with fMRI to gather critical information in criminal investigations. However, the effectiveness of fMRI investigations will be largely a product of how well an interrogator will read a suspect and then modify his/her style and methods to best capitalize on the subject's act and its characteristics. In this thesis, we will encounter in perfecting the art and science of interrogation with fMRI to gather critical information in criminal investigations. However, the effectiveness of fMRI investigations will be largely a product of how well an interrogator will read a suspect and then modify his/her style and methods to best capitalize on the subject's act and its characteristics that is not present in existing studies.

Thirdly, previous lie detection studies with fMRI are based on study design that remotely resembles a real-world situation, those results offer no compelling evidence that fMRI will work for deception detection in the real world. The experience of the research participants in previous studies seems to be different from lying as the counter-terrorism agencies or criminal justice system would perceive it. The undergraduate participants knew they were involved in an experiment and they have to follow the orders to lie. Subject also knew that most harm being detected in a lie might be is to get the lesser payment for taking part in the research experiment that is not really of great consequence to compare to a terrorist lying about participating in a terrorist activity. Another basic problem with earlier neuroimaging paradigms to detect lie is that no established standard exists to accurately differentiate lie and truth to establish a measure against which the reliability and validity of an fMRI can be evaluated and to ensure that innocent suspects are not wrongfully identified. This issue raised a concern how the use of MRI in lie detection could even be tested in the real world scenario. Note how different this is from a terrorist or criminal suspect telling the law enforcement agencies that he/she had not taken part in a crime or terrorist act.

Finally, critics claim that this technology may present many new human rights and ethical dilemmas and could result in potentially disastrous outcomes. Despite the intriguing results of many fMRI studies, there are several concerns and issues of legal, ethical and privacy violations that may clash with questions of state security and human security that may raise with this technology, which must be addressed prior to moving this technology to real-world application. The human security issues raised by critics are complex and it is possible that this technology may be misused by some organizations. The challenge, therefore, is to forge a consensus on balancing the pursuit of human and state security to protect critical infrastructure. Consequently our aim in this research is to find a good combination of ethical guidelines that could ultimately become a general method for in interrogation and employee screening in critical situations and conversely decrease the extent to which it is misused or misunderstood.

We used a different deception paradigm that is closer to a real-world situation with freedom of choice and that is still untested for detecting deception. In this thesis we attempted to find how reliably accurate fMRI-based lie detection will be with diverse groups in realistic settings, with or without countermeasures. A major strength of our study compared to other laboratory is that the participants in our study were emotionally involved as they would be in a non-laboratory situation such as terrorism. Introducing free choice and flexible paradigm into our design provided us different and interesting results.

1.2 Research Focal Point

This thesis is focusing on the use of fMRI in interrogation room context. In this regard, the literature within the fields of lie-detection is reviewed and two novel experimental paradigms were carried out described in this research. In the first study, we successfully replicated F. Kozel's et al. 2005 research to reproduce prior group brain correlates of deception. This simple laboratory based fMRI deception testing paradigm consisted of stealing either a watch or a ring and participants were instructed to report that they stole neither object. Our second study attempted to approximate a paradigm that was closer to realistic scenarios than prior fMRI detection studies (instructed lies). This research paradigm increased the hidden motivations of participants to deceive, and attempted to increase the emotional involvement of subjects. We investigated whether fMRI can be used to detect concealed readiness to be involved in violent attacks by aiming at detecting the presence or absence of attack-related information in a suspect's memory. The purpose was to monitor closely simulating situations in which detection of a possible deception would be of critical importance, thus allowing to more accurately ascertaining the potential of fMRI in such situations to detect. We divided our participants in two groups (Freedom Activists-FA VS Freedom Fighters-FF (terrorists from the point of view of the interrogators)). One of the features of this study was the freedom granted subjects to choose any of the group that matches their personality best to commit rather peaceful protest or violent action against an oppressive regime. Only freedom fighters were instructed to hide their motivation as we can determine the neural signature for deception when they actively conceal their mission and mislead the investigator by false answers. The results in this thesis successfully reveal that there was no activation in both groups - while interrogating about peaceful activities (Truth>Lie and Truth>Control). However, during interviewing with terrorist activities (Lie>Truth), several regions were activated in Freedom fighters group in order to achieve the production of a 'lie' at the same time as withholding the truth. However, unexpectedly, our experimental findings identified evidence of similar regions activated in freedom activists group while interrogating violent questions in Truth>Control. Research revels that these areas are activated due to cognitive and motivational process such as recognition, anxiety and fear due to violent images that could be interpreted as these areas are not only involved in deception but a range of different physiological consequences. Thus, large similarities were observed in the degree of activation for each individual in both groups. Instructed lie and the real lie is also a significant issue that has been raised in this thesis.

This thesis suggest that an fMRI may permit investigation of the neural correlates of truth if an accurate and precise lie detection system will likely have to account for these dimensions in future studies that arise from the different types of cognitive processing involved in the different types of emotional responses. Our unique experiments found that different factors affecting brain regions that are related to lie include gender, ethnicity and culture consequences that necessitates high amount of attention to be paid to prevent premature application of the method outside of research environment. This research conclude that the use of fMRI in counterterrorism scenarios may play a vital role if social, cultural, and linguistic differences across participants in the understanding of questions and the meaning and appropriateness of deception that observed during lying versus truth-telling An accurate and precise lie detection system will likely have to account for these dimensions and exploit the variations that arise from the different types of processing involved in the different types of emotional responses. This thesis assumes that it would be a major contribution for further studies in this field because of the feasibility, acceptable external validity and subject's free choice in this study that may be help to design a more valid experimental framework in future.

1.3 Value of the Research

The development of this neuro-imaging technology in the intelligence and law enforcement establishments has until now not been documented for public perusal in a research study. However, this research is based on the assumption that a more professional and more efficient fMRI interrogation scanning service can be provided for law enforcement agencies if the experimental paradigm, operational circumstances, ethical, privacy and other issues are clearly outlined and understood. This can be achieved through this work as fMRI scanning trends and the practical utilization of this technology in counter-terrorism scenario have been examined, analyzed and clearly documented. This dissertation is unique, as a total of 31 original peer reviewed scientific journal articles on fMRI of lie detection/truth verification studies have been published. However, no comprehensive research has previously been published on the utilization of fMRI in counter-terrorism context. The historical developments and utilization of fMRI in the lie detection have received media coverage over the years but the significant developments in scanning suspects in high risk situation over the past 2 decades are not widely known.

Other unique part of this thesis is the issues raised by this lie detection tool such as description of ethical and legal concerns, issues of personal privacy, personal liberty and scientific concerns. This thesis suggests that investigators wishing to extrapolate findings from this advance tool must account for different types of lies, levels of reliability, subjectivity of interpretation, potentially confounding variables, external validity and complexity of brain outside the realm of laboratory studies. Furthermore, this thesis reveals that different factors affecting brain regions that are related to lie include gender, ethnicity and culture consequences that necessitates high amount of attention to be paid to prevent premature application of the method outside of research environment. This way, in near future, fMRI can be used as a reliable method of lie detection. This study has a number of strengths that should be highlighted in the context of how fMRI technology can be moved towards a practical application. This thesis also contributes to the interdisciplinary debate whether this technology may or may not play a vital role in extracting allegedly necessary information from suspected terrorists, to identify the missing pieces of the scientific puzzle. This need to be completed if functional Magnetic Resonance based technique has created anticipation of a breakthrough in the search for technology-based methods of interrogation. The significance of this research is to ensure that maintaining human security is as important as promoting state security. More importantly, we discuss the pros and cons of this neuro-imaging technique to ensure that both state security and human security are balanced in order to achieve the objectives of this research and that it does not lead to the conclusion that the use of this technology for employee screening is ethically dubious.

In this research, this dissertation attempted to answer many questions, such as:

1. Is it possible to have prior scan of suspected terrorists and employees?
2. Is it possible to distinguish innocent with terrorists?
3. Do certain people do better than others when given an fMRI test?
4. Does certain training or countermeasures effect the outcome of the fMRI test?
5. Is fMRI accurate and reliable tool for hiring and as an forensic interrogation tool?

Hypothesis of this thesis are:

1. Activation in DLPFC, DMPFC, IFG, ACC will be observed in lie>truth and lie>control in freedom fighters during violent questions as these regions are associated with the executive aspects of deception.
2. No or less activation will be observed in truth>control and truth>lie in freedom fighters and freedom activists during peaceful questions.
3. Pattern of prefrontal activity would differ depending on the emotional valence of stimuli.
4. Emotionally arousing violent images recruit more visual attention than do neutral pictures so violent images will recruit activation in the freedom activist groups.
5. Activation in Amygdala region will be observed in truth>control in freedom activists during violent questions.

1.4 Thesis Outline

This research report (dissertation) is divided into a number of chapters:

Chapter 1: Introduces the dissertation and covers the motivation, problem statement, aim and research focal point. This chapter also briefly discusses the value of the research.

Chapter 2: Discusses the literature review and studies done on lie detection to conduct follow up research. Literature review provides definitions, the history and major research work of the base concepts used for our research. This chapter also explains fMRI and operational analysis of this technology in the process of lie detection. This is necessary to understand the contribution and the experimental analysis conducted in subsequent chapters.

Chapter 3: In this chapter, the thesis attempted to replicate prior group brain correlates of deception using a mock sabotage crime paradigm; a similar version of the ring-watch testing was performed by Kozel et al., 2005 to determine whether higher MRI field strength and paradigm might allow for detection of deception at the level of the individual to improve on the consistency of individual results. This chapter explores the methodologies and paradigms of our experimental work in all experiments. Other aspects including the data analysis, ethical considerations, the integrity and quality of the research, confidentiality and obtaining of approval where appropriate are covered in this chapter.

Chapter 4: This chapter explores our second study. Our experiment resembles a counterterrorism scenario that identifies whether deceptive and honest responses can be differentiated between two groups (freedom fighters and freedom activists) to evaluate deception. It investigates whether fMRI can be used to detect concealed readiness to be involved in violent attacks by aiming at detecting the presence or absence of attack-related information in a suspect memory.

Chapter 5: Explains the results from experiments and testing of our methodologies with fMRI.

Chapter 6: Discusses the results and various issues that have emanated from the research, including the implications and prospects of fMRI testing to prevent crime in the workplace and its role as an investigation tool. The operational obstacles are also discussed, including the issue of counter-measures used by examinees, the difficulties experienced and the potential for expanding the fMRIt in law enforcement agencies.

Chapter 7: Propose recommendations, best practices, and guidelines that can address scientific, social, ethical, privacy and general public concerning the implication of fMRI as an interrogation tool. The importance of ensuring that ethical, operational and training standards, are complied with and upheld by interrogators is also discussed in order to challenge and dispel uninformed opinions and myths concerning the use of fMRI scanning, is also addressed. Future research work and research applications will be discussed in this section of the writing.

1.5 Scientific Experiments and Contributions

During the study, benchmarks of the study have been published as follows:

The first publication was done on our research is aiming for extreme measures to analyze and evaluate human threats related assessment methods for employee screening and evaluations using fMRI [93].

Second publication introduced a first step towards developing a novel experimental interrogation paradigm and methodologies that aims to apply a number of reliable and practical applications of fMRI for mining of knowledge from potential suspects [94].

Third publication is extended with introduction of fMRI to analyze, evaluate and investigate the insider threat in cloud security in sensitive infrastructures with employee screening [95].

Fourth publication is not from the core of the research method but it is done over the risks personal information management. It focuses at personal data sharing and publishing over web on different official and social portals [96].

Fifth Publication uses the Semantic Web and Linked Data technologies in the domain of terrorism informatics. It explored an integrated approach by building a proof of concept framework, which uses Semantic Web technologies to triplify and link the unstructured content of tweets with Linked Data clouds as structured data [96].

CHAPTER 2

Literature Review

2.1 What is fMRI?

The functional MRI is one of the most recently developed forms of neuroimaging and widely known and accepted in the scientific community as it does have a significant amount of scientific research behind its claims and validity [13]. fMRI is an increasingly popular neuro-imaging technique that was developed in the 1990s by Seiji Ogawa and has since become the preferred method for studying the functional anatomy of the human brain [100]. It involves placing the subject in a donut-shaped magnetic technology, which can identify subtle changes in electromagnetic fields [100]. An fMRI machine is a big, bed-sized, expensive piece of medical technology that generates high magnetic fields and thousands of times stronger than Earth's magnetic field as shown in Figure 2.1 [94].

Figure 2.1: A fMRI machine

The cylindrical tube of an MRI scanner contains a very powerful electro-magnet. The 7-Tesla MRI machine is the most powerful MRI machine these days for clinical and basic research in the world [94]. The magnetic field inside this machine affects the magnetic nuclei of atoms. A typical research MRI scanner - 3 Tesla has field strength of about 50,000 times greater than the Earth's field [110]. The powerful the field of this machine the stronger the degree of alignment. The tiny magnet signals from single nuclei add up coherently resulting in a signal that is strong enough to measure. This brain imaging technique has several significant advantages such as it is easy for the researcher to use. It has good temporal resolution and excellent spatial. It is safe for the subject as it is non-invasive and doesn't involve radiation [110].

2.2 How Does fMRI Scan the Brain?

An fMRI is based on MRI (magnetic resonance imaging) which makes it possible for medical personnel to map brain activity to detect the brain regions which are involved in a process, an emotion or in a task [13]. This technique is based on the concept that blood flowing through the brain carries oxygen (called hemoglobin) behaved differently in magnetic field than blood that has already released its oxygen to the cells. Hemoglobin molecules have a magnetic signal and also carry iron. It turns out that hemoglobin have different magnetic resonance in oxygen-rich blood and oxygen-poor blood [13][100]. This small difference can be measured by fMRI in signal that results from this increase in blood flow to pinpoint greater activity. When neurons are activated, the need for oxygen is over overcompensated by a larger increase in perfusion that increases the venous oxyhemoglobin concentration and decreases the deoxyhemoglobin concentration [13]. The measurement of blood volume, blood flow, and oxygen use is called the BOLD signal. When an area of the brain is in use, blood flow to that region also increases. Thus the intensity of the fMRI images increases in the activated areas and this is how the fMRI detects this physiological change due to the blood-oxygen-level-dependent, or BOLD effect [13][100]. FMRI studies do not look at neuronal activity directly but previous studies detect how blood oxygen level changes and assuming that this is connected to nerves firing [100]. The changes are represented onto a three-dimensional, computer-generated image of the person's brain [100]. In fMRI, examiners acquire data during experimental task that increases blood flow to cortical tissues and compare it to data collected during a baseline condition. The result analysis includes the subtraction of baseline state image from the active state image to create a functional brain map [81]. The introduction of fMRI is considered to be technologically superior to any another comparable imaging method such as PET (Positron Emission Tomography) [57]. In contrast with PET, functional Magnetic Resonance Imaging does not need the injection of radioactive labels into the subject. Secondly, fMRI has better temporal resolution (down to 2 to 3 seconds with rapid event-related) and superior spatial resolution (down to 1 mm3) than PET [57]. According to the director of the fMRI Research Center at Columbia University, this novel technology really opening the black box as it signifies a "quantum leap" over any previous technology for imaging the brain [91].

2.3 Experiments With fMRI

Scientists use two main ways of looking at brain using fMRI. One method can be used is to evaluate neural network to figure out what areas of the brain are connected to each other. No task is required for this kind of experiment. These researches are also called resting state fMRI. The other way fMRI can be used is to find specific areas of the brain that reply to some stimulus or task [77]. A subject lies on a horizontal stretcher which slides into a cylindrical cavity. Then subject slide headfirst into the large, cylindrical MRI machine and they are given earplugs to mask the sound as this machine tends to be very noisy. The subject in the fMRI machine might be presented a flashing screen which alternated between showing a visual stimulus and other times a blank screen. Subject is asked to perform a task that increases oxygenated blood flow and instructed to push a button (e.g., to answer "yes" or "no") whenever they see flashing screen with sentences, videos or images as shown in Figure[1] 2.2.

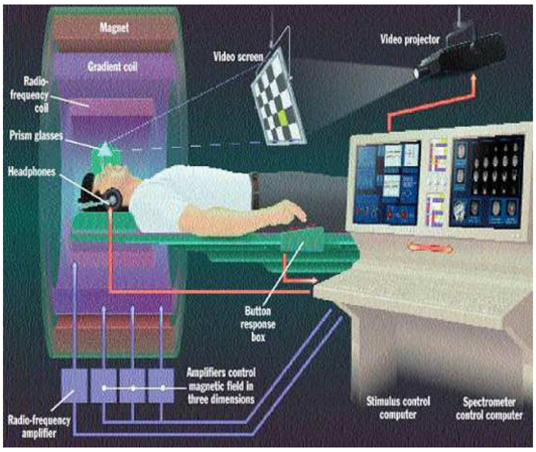


Figure 2.2: A subject under fMRI experiments

Meanwhile the fMRI tracked the signal throughout the brain and the signal taken are compared to the signal when the task is not been done. These signals go up and down as the stimulus is tuned on and off due to blood flow response. Scientists detect this activity on a scan in volume pixels, or voxels. Those orange blobs in the image above are actually clusters of voxels-perhaps tens or hundreds of them that represent brain activity related to the task [77].The result comes with a kind of image of what areas are involved with seeing the screen and then pushing a button box. The information received from fMRI requires lot of statistical analysis to become meaningful. They are asked to perform a task that increases oxygenated blood flow to a particular part of a brain. For example, a subject may tap his thumb against his fingers, to look at pictures or answer questions on a computer screen. The test can last anywhere from a few minutes to an hour or more. Because of the magnetic field, subjects must remove metallic items before entering the scanner. To enter the fMRI machine of this machine and people with pacemakers are warned not to go near fMRI machines.

2.4 Data Analysis

Data analysis is done to detect the functional activation of the brain areas and the localization which are activated in reply to the stimuli specified by the protocol [74]. The variations of BOLD signals are not easy to detect visually. The advanced statistical methods must be used to find voxels in which the signals changes w.r.t the paradigm. In the next step,

[1] `http://http://www.sinorad.com/en/cpjs2.asp`

the functional images are analyzed to find brain areas that are considerably more active in the course of the experimental relative to the baseline stimuli. The following steps are followed while analyzing fMRI data, which are divided into:

1. Pre-processing
2. Statistical analysis

Functional MRI analysis can be carried out with different software such as using SPM (Statistical Parametric Mapping software (`www.fil.ion.ucl.ac.uk/spm`), BV (BrainVoyager), AFNI (Analysis of Functional NeuroImages) (`afni.nimh.nih.gov/afni`), PLS (Partial Least Square), FSL (FMRIB Software Library) (`www.fmrib.ox.ac.uk/fsl`), AIR (Automated Image Registration) (`http://bishopw.loni.ucla.edu/air5/`) or MIPAV (Medical Image Processing, Analysis, and Visualization) (`http://mipav.cit.nih.gov/`). In this thesis data analysis was performed with SPM 8 software. It is a freeware and run under Matlab® written by the Welcome Department of Cognitive Neurology, London, UK. This software offers a simple one stop solution that is relatively affordable for processing, analysis and visualizing the data with good technical support. SPM requires Matlab to run.

2.5 Functional Magnetic Resonance Imaging: A New Research Tool

The detection of brain regions which are used during a condition is based on this effect and the signal in the activated voxels increases and decreases according to the paradigm. FMRI cannot detect absolute activity of brain areas. It can only map or detect differences in brain activity between several conditions [13]. The ability to detect and link brain activity to constructs decisions, behaviors and human processes has highlighted the potential of brain research for the social sciences [26]. An fMRI has been successfully used in the prognosis of diseases like schizophrenia and Alzheimer's, and the evaluation of drug treatments [57]. fMRI is also being applied in clinical and commercial settings and over the last decade and able to inform many unanswered questions in psychology [22], economics [22], IS [26], and marketing [67]. It has provided new insight in fundamental research to map more complex functions in normal and pathological conditions such as face recognition, specialized language functions, emotions and complex motor control [26]. In research settings, fMRI has been applied ranging from language comprehension to personality traits (happiness, sadness, fear, and anger), aesthetic judgment or political behavior and might even be able to detect whether we're telling the truth [26]. There is also potential for clinical functional magnetic resonance in drug development, understanding functional brain disorders individualization of therapies and pre-symptomatic diagnosis [26]. This technology has the great potential to be used as bio-feedback for conditions such as chronic pain [26]. There are also several neuromarketing companies such as Oxford start-up Neurosense and California-based Sales Brain using FMRI to gain insights into buyer thought and behavior [67]. With these rapid developments many researchers claimed this technology to be useful outside the laboratory settings. For instance, economics contexts, investing personality traits, mental illness, religious extremism, racial prejudice, suicidal thoughts aggressive or violent tendencies and lie detection [36]. The medical technology has come so far in recent years that it's now possible for imaging scans detect lies and yet a relatively new type of scan called fMRI takes the technology one step farther to get inside our brain to determine what we're thinking and feeling and to detect whether we're telling the truth.

This technique has emerged as more promising technology that aims to directly reveal if suspect's brain displays particular responses: Specially, when it is deal with specific information that could only be known to the criminal or terrorist [35]. This tool has potential to directly reveal deception and read out the contents of suspects' mind, including their intentions and memories to reveal recognition. Ruben Gur, a neuropsychologist at the University of Pennsylvania, states that fMRI scans can reveal cognitive tasks when a subject recognizes a familiar picture, face or place, no matter how hard he or she tries to conceal it [12]. This cognitive analysis technology could function as a hyper-accurate lie detector that is nearly impossible to deceive [35]. For instance, an interrogator could present a suspect with images of terrorist leaders, potential targets, or specific information that could generate neural responses if the subject were known with that pictured information [12]. This scientific technique provides intelligence operatives to focus their investigations on the suspects who actually commit terrorism and to determine if he or she has been to any specific place before. If a person was in any terrorist training camp, you can actually determine that [75]. On the other side, an information absent will provide support for the claims of innocence that individual is not guilty of committing any crime and has no knowledge specific to any particular group [108]. The imaging results can be used against the suspect at trial and prevent future tragedies. Thus, this machine is capable of witnessing the brain in action by tracing the way blood flowed and takes pictures that highlight specific areas of the brain activated during certain tasks [108]. Similarly, the primary goal of the current research is to develop a novel experimental paradigm with fMRI based interrogation techniques. The purpose is to maximize the likelihood of a true confession of a terrorist activity.

2.6 Functional fMRI: A New Way Forward in the Criminal Justice System

A Pubmed search, as of May 2013, was performed and supplemented by manual searches of bibliographies of key articles. A total of 31 original peer reviewed scientific journal articles on Functional magnetic resonance imaging (fMRI) of lie detection / truth verification studies were viewed [94]. The review provides a qualitative summary of neuroimaging findings on telling lies and truth conditioning and extinction of the included empirical studies. These studies were done by 22 different research groups that included researchers from 13 different countries (USA, UK, Canada, Australia, China, Japan, Netherlands, Switzerland, Poland, Denmark, Sweden, Germany, and Russia) [94]. In total, 723 subjects were used in these lie detection studies. 527 total subjects were used in lie detection studies that used 3 tesla MRIs which have more resolution than older MRI machines (such as the 1.5 tesla MRI used in 2010 USA v. Semrau legal case) [94]. Three journal articles analyzed the fMRI data with machine learning which uses pattern recognition and nonlinear statistics. 109 total subjects were used in 3 tesla MRI studies that also used machine learning to analyze results [94]. The addition of pattern recognition technology to fMRI has shown greater accuracy. Independent component analysis has recently been added to fMRI adding to accuracy of results [94]. According to Spence, this ground breaking research proves that fMRI has the potential to reduce the number of miscarriages of justice and capacity to address the question of guilt versus innocence. Proponents of this neuro-imaging technology hailed this machine as a next truth meter [108]. They conclude that because of the novelty of the physiological parameters being measured, this technology may be more accurate than other traditional lie detection methods (e.g., polygraph, see [105]). Since the first publication by [105] on deception detection by fMRI, various papers and studies [75, 105, 69, 68, 63, 5, 23, 79, 84] have reported different experiments in which subjects were asked to respond deceptively in some blocks and truthfully in others.

In these two studies, subjects were instructed to say yes when the truth is no and vice versa [105][84]. In another study, the task paradigm included spontaneous lies [75], for instance, the subject was instructed to say Chicago when the truthful answer is Seattle. Similarly [69, 68] studies were included feigning memory impairment tasks. In addition, lying about having a play card [75][63][23] and lying about having fired a gun [79] revealed that particular spots in the brain's prefrontal cortex become more active when a subject is suppressing the truth or lying. In some of the other experimental tasks, subjects were motivated by monetary incentives as they were told that they would double their reward money if they were able to deceive the fMRI machine. For example, lying about having taken a ring or a watch [59] and lying about the place of hidden money [61].

In above studies, subjects were asked to conceal their information by lying and press buttons to respond 'no' or 'yes' to specific questions. Though the answers varied from trial to trial but it was possible to determine brain activity in response to specific pieces of information. In spite of different paradigms employed in the laboratory settings and the content of the questions, brain activation was compared in response to deceptive answers to truthful ones. It proved that lying involve more efforts than truth and expose that specific brain areas respond strongly in generating deceptive responses. As with lying, several brain regions show significant increases and light up during scanning when a person sees a familiar object or image or during deception compared to truth telling as shown in Figure 2.3 [61].

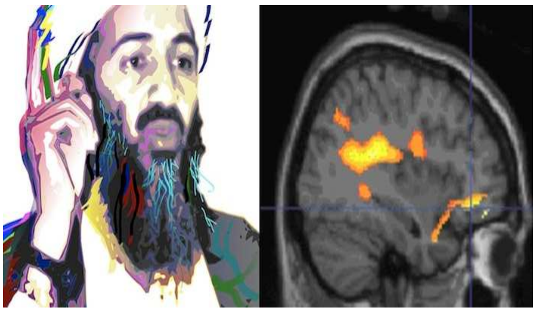


Figure 2.3: Brain activity during telling a lie.

For instance, dorsolateral prefrontal cortex (DLPFC), anterior cingulate cortex (ACC), ventroletral (VLPFC) and left and right cerebral hemispheres increases activity when people tell lies [11][84]. Similarly, during the interrogation phase, if a suspect is asked a question, the information to which is unknown then the specific regions of the brain is unusually active and it is presumed that suspect is lying; if, however, the same areas are no more active it may presumed that subject is telling the truth as shown in Figure 2.4 [61].

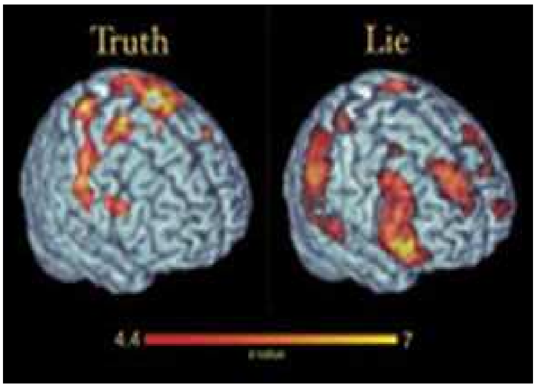


Figure 2.4: Brain activity during telling truth/lie

A recent study [78] reported on an experiment examining whether functional magnetic resonance imaging (fMRI) lie detection evidence would influence potential jurors' assessment of guilt in a criminal trial. Potential jurors (N= 330) read a vignette summarizing a trial, with some versions of the vignette including lie detection evidence indicating that the defendant was lying about having committed the crime. Lie detector evidence was based on evidence from the polygraph, fMRI (functional brain imaging), or thermal facial imaging. Results showed that fMRI lie detection evidence led to more guilty verdicts than lie detection evidence based on polygraph evidence, thermal facial imaging, or a control condition that did not include lie detection evidence. However, when the validity of the fMRI lie detection evidence was called into question on cross-examination, guilty verdicts were reduced to the level of the control condition. These results provide important information about the influence of lie detection evidence in legal settings.

In above experiments, this technology has been claimed to be 80 - 90% accurate by the researchers. Apart from above laboratory experiments, Sean Spence, who has pioneered the use of this ground-breaking technology, carried out a real-life experiment in 2008 [108]. He investigated the potential innocence of a woman who had been convicted of intentional inducing illness in a child (and later was sentenced to four years in prison (see [108]). Brain imaging technologies has also captured the attention of legal system to influence criminal justice system. For instance, in September 2008, a court in India allowed to use brain scan images in a criminal case. Aditi Sharma was convicted by a court for the murder of her former fiancé, Udit Bharati [78]. However, for the first time, a brain scan was used as evidence of a criminal defendant's guilt. This case marked the dawn of a new era for the use of brain scan technology in criminal prosecution. The court found that the brain scan proved that Aditi Sharma had experimental knowledge of having murdered Udit Bharati herself [78]. A variety of recent advances in neurological research and the development of this new technology claims to be a more accurately deception revealing tool for screening. It can be effective in distinguishing truth tellers from liars and to determine hidden conscious states of an individual, with accuracy greater than chance. Thus, unlike polygraph-which detects a person's emotional response to deception-fMRI measures person's decision to lie, as subjects cannot control their cerebral activity to avoid detection [20]. Not only has this neuro-imaging technology taken the attention of scientific communities and law enforcement agencies but it has also attracted interest of corporate world [65]. Two private firms: No Lie MRI and Cephos Corp trying to make the dream of perfect truth verification into a reality and have begun marketing since 2006. They offer high-tech lie detection services based on research comparing neuronal activation patterns [13].

There are, however, considerable variances and discrepancies between studies. Whereas some studies only report activation of prefrontal cortex circuits, others do not find these activations or observe activation within additional brain regions, such as the ACC. Results obtained from lie detection studies differ in many respects, for example, in the number or the type of activated areas and networks consisting of deception-related brain areas, such as prefrontal cortex, anterior cingulate are activated independently of design parameters. However, some neuroimaging studies do not report these findings. All original peer reviewed journal articles conclude the fMRI method works for lie detection and truth verification in individual humans. No original peer reviewed journal articles conclude that the fMRI method for lie detection and truth verification does not work for lie detection in individual humans. Scientists have had over 10 years to do a study to demonstrate fMRI lie detection does not work and no one in the world has been able to do so! The fact that these original peer reviewed studies have studied fMRI lie detection and truth verification with different methodologies, different types of study subjects, different software, and MRI machines from different manufactures adds to the robustness of this conclusion. This fMRI technology gains its power from the rich reproducible signal of information gathered by fMRI and the accuracy of the analysis is assisted by modern analytic technologies.

CHAPTER 3 Study Design and Research Methodology

In this thesis two studies were conducted with similar research methodology and protocol in all experiments. In the first study, the thesis attempted to replicate prior group brain correlates of deception using a mock sabotage crime paradigm; a similar version of the ring-watch testing was performed by [59] to determine whether higher MRI field strength and paradigm might allow for detection of deception at the level of the individual to improve on the consistency of individual results. In the second study, we investigated whether fMRI can be used to detect concealed readiness to be involved in violent attacks by aiming at detecting the presence or absence of attack-related information in a suspect's memory in a counter terrorism scenario.

3.1 Study Design 1 - Replication of Functional MRI Study

This study was conducted in a laboratory paradigm using a different location and a different scanner performed by [59] involving subjects giving truthful and deceptive answers. The purpose is to detect deception in the brain where the lies are generated. Our experimental study provides further support for the feasibility of using fMRI to detect deception in our third study and determines if the ring-watch paradigm can be used to predict which participants had valid mock-crime determinations. Complete details of this replicated study protocol are published in prior work of [59] and we did not vary from the core methods used in that experiment. For the testing paradigm, 4 healthy, right-handed adults were chosen to "steal" one of two objects (ring or watch) and place it in their locker. In this experiment, two subjects took a ring and the other two took a watch). Participants were scanned while being visually presented with a series of questions and were instructed to tell the truth or to lie while being imaged in a 3T MRI scanner. Subjects were given an incentive to conceal which object they took and respond as though they took neither object. Functional MRI analysis was performed in the same manner as described in [59]. Using the data from subjects, an analysis model were designed that detected deception of the subjects. Participants were given a 16GB USB as an incentive and an additional 10 euros if KK not be able to tell when participants are lying in the fMRI scanner. This extra incentive provided motivation for participants when lying. All participants received the additional 10 euros.

All experiments in study 1 and 2 were conducted at the Technical University of Graz, Kopernikusgasse 24, 8010 Graz. The Karl-Franzens-University Graz (Institute of Psychology) shares a magnetic resonance imaging (MRI) with Graz University of Technology. This 3-Tesla magnetic resonance tomograph (Siemens model Skyra) is exclusively dedicated for scientific purposes. For this study, the exclusion criteria that are generally preferred for an MRI Investigation will be used (e.g., claustrophobia, not MR-compatible Transplants, Pacemaker, Insulin pump, Middle ear implants, cardiorespiratory and orthopedic disorders, neuropsychological or sensory impairments, etc.). The MR measurements were performed with the help of trained staff (Dr. Karl Koschutnig).

3.2 Materials and Methodology

6 healthy volunteers (4 male and 2 female, aged 21 to 24 years) were recruited from the Technical University of Graz to participate in the study, they all were university student. Two subjects (male) were eliminated with excessive motion and inadequate number of correct responses and who did not follow strictly to the protocol. After obtaining written informed consent as approved by the ethics committee of the Medical University Graz (See Appendix A), participants were pre-screened for fMRI safety. A pre-MRI screening form, medical history, physical exam, and a urine sample were obtained for a drug urinalysis and a urine pregnancy test (e.g., if the participant is a woman with child bearing potential). Subjects were screened with a Clinical Interview for DSM-IV Axis I Disorders (SCID-I), medical history, a brief physical exam and a pre-MRI screening form were given to ensure that participants were healthy and safe to have an MR scanning.

Exclusion criteria included nicotine use, claustrophobia, any medication within 5 half-lives of procedure, history of a significant central nervous system disease, history of a psychiatric disorder except simple phobia and previous inability to tolerate an MRI. It was ensured that subjects do not have any metal implants (not including dental fillings), and irremovable medical devices such as fixed hearing aids and presence of shrapnel that would make an MRI procedure unsafe or prior knowledge of the paradigm. Prior to scanning, a urine sample was obtained to test for drugs of abuse as well as pregnancy testing was given to a female subject if it was positive. All subjects were also evaluated with Temperament and Character Inventory, the State-Trait Anxiety Inventory (STAI) and an Annette Handedness Scale. All subjects were right handed as indicated via the Purdue Pegboard as well as the Edinburgh Handedness Inventory. None of the subjects had a history of any neurological disorder. Subjects were free of psychotropic medications with normal and corrected visual ability. This study was conducted in accordance with the latest Declaration of Helsinki[1]. These subjects were scanned during daytime.

3.3 Procedure

The fMRI scanning procedure was thoroughly explained to the subjects prior to the experiment, such as instructions, T1- and T2- weighted structural scans and the mental rotation task. This process was demonstrated on a computer outside the fMRI scanner Lab, and subjects completed a test run. A familiarization task outside the scanner was obtained to

[1] `http://www.who.int/bulletin/archives/79(4)373.pdf`

ensure that the instruction was understood properly. The first 4 minutes of an interview were used to establish a structural map of the subject's brain. After that fMRI scanning, data were gathered by asking the interviewee a series of questions.

3.3.1 Procedures Before fMRI Scan

The fMRI study must contain the procedures, study instructions and self-reported behavioral data that participants perform before the scanning session or obtained outside the fMRI scanner. Subjects were provided the important information about the experimental procedures such as lack of movement, all activities that require close inspection to take place outside the fMRI scanner as well as the time constraints of the fMRI in terms of cost. Subjects were provided all required familiarization that was needed for students to participate in the study.

3.3.2 Specifying Procedures During fMRI Scan

During an fMRI session, participants entered the fMRI scanner and lie down comfortably on their back in an MRI scanner. The structural images of the brain were acquired during the first 3-5 minutes. The anatomical images provided a high resolution of the brain over which the functional Magnetic Resonance Imaging data can be overlaid and to identify where this data should be collected. Brain activations were obtained for comparison across conditions during the 4-second time period whereas the participants were reading and processing measurement item (before pressing the response button). It assured that temporal separation between brain activation while reading the stimuli items and measuring the behavioral reaction. The second reason is to avoid brain activity due to body movement while responding to the Likert-type scales. The participants undertook the tasks following the trial design and functional data were collected while subjects replied to experimental stimuli. During this time scanner recorded the BOLD signal all over the brain in less than 2 second intervals. The thesis defines the procedure in a way that may allow other researchers to replicate the experimental protocol.

3.3.3 Experimental Conditions and Trial Design

The experimental task was broken down into experimental conditions and then governed by the trial design that detailed how these conditions are shown that aimed to ask subjects to actively perform a task and passively activate a selective brain region [75]. This paradigm was built to contrast brain activity between a baseline (control) task and an experimental task. The purpose of the baseline task is to reduce the source of noise, movement, and decrease the spurious brain activation due to visual stimuli and thus isolate brain activation only connected with the experimental stimuli.

3.3.4 Instructions for Subjects

The test will take approximately 30 minutes during which you will lie on your back in a narrow "tunnel" with your head in a head coil which at times will be making loud banging and beeping noises. The best way to do this is to just relax. Since it is quite noisy in the scanner, we will be providing you with earplugs to block the noise. There is an intercom system that we will use to communicate with you throughout the study. When the scanner is not running, you can just talk back to us normally. You will also hold a ball in one of your hands that you can squeeze at any time to abort the experiment if you feel not well (note however that we will not be able to use the data in case you squeeze the ball).

During the scan you will be able to read questions appearing on a screen above you. The questions will start automatically and advance automatically. When you are done reading each question, please press the button on a button box that we will be giving to you (Yes or No buttons) to indicate your answer during the interrogation. As a freedom activist, please always tell the truth during the interrogation.

We haven't had any issues with this, but we are requested to tell you that subjects with claustrophobia might experience problems inside the tunnel. These subjects are advised not to participate in this study.

The scan is not dangerous, so there is no cause for alarm, but if you feel uncomfortable, go ahead and press the squeeze-ball, and we'll abort the study.

It is important for the experiment that you *do not move your head and body as much as possible while being scanned*, as otherwise the data will very likely be unusable.

3.3.5 What to Wear

Before you enter the scanner you must remove all metal objects including earrings, glasses and bras with metal. We suggest you come to the test wearing no metal and clothing that have metal in or on them. You will be asked to remove your shoes and everything from your pockets including loose change, cell phones and credit cards. There will also be small lockers in the changing room.

3.3.6 Safety Checklist of Prohibited Items

- Jewelry (however, gold or silver rings on fingers ok if they cannot be removed)
- Bobby pins and metal hair clips
- Underwear with metal parts
- Smartphones, pagers, Blackberries etc.
- Credit cards, RFID cards
- Coins, metal objects in pockets
- Shoes with metallic parts
- Special dental implants

3.3.7 Behavioral Study

Before executing the fMRI protocol in the fMRI scanner, a traditional behavioral study with a similar protocol was executed. The purpose was to ensure that participants there are included in this study properly performed the experimental tasks and fully understand the experimental tasks, perceive the manipulations, and accomplish the tasks properly.

The Motor task was also performed as this task enabled the participants to become aware with the scanning environment and to get familiar with their responses of "Yes" and "No respectively. Questions were presented visually in deception task. This practice facilitated in this study in a way that protocol is clear to the subjects during the experiment. Another purpose of our behavioral study was to ensure the experimental validity within and outside the scanning environment with the same procedures, that behavioral responses and behaviors are not biased by the scanning environment and to test the veracity of the experimental tasks, otherwise, a concern could have been raised that the fMRI scanner may have changed or altered the participant' responses. As [113] argued that "researchers should seek convergent validity by linking fMRI data to other behavioral measures." After completing the screening, eligible subjects were scheduled for the fMRI scanning portion of the study.

3.4 Specifying Procedures

After signing consent (see Appendix B), subjects were given written instructions outlining the study and they were provided all related information (see Appendix C) as well as consent about our database (see Appendix D). On the day of scanning, volunteers were again screened to ensure that they are safe to enter the MRI machine and the instructions were reviewed. The investigators presented for the scanning process were Farhan Sahito (FS) and Koschutnig Karl (KK). The subjects were instructed to go to another room by Farhan Sahito and steal one of two objects (watch or ring) in a drawer and hide it in the cupboard locker. After the participants done this task, they were asked to practice the questions outside of the scanner with FS present but with KK absent. During this study FS was aware of which object the participant took before scanning. However, KK never saw any of the subjects did not know which item they had stolen and knew nothing about their determination of when they were being deceptive. The features of this paradigm and methodology confirmed results support the slight impact that bias had on the outcome. FS ensured that the subjects carried out the procedure properly, and KK was experimentally blinded to which object was taken by 4 subjects. In the next stage, subject was trained to reply the questions in a scanner machine as if she/he had not taken any of the objects. For the lie detection task, three types of questions were visually displayed to subjects in scanning machine:

1. "Watch" - questions about whether they took the watch
2. "Ring" - questions about whether they took the ring
3. "Neutral" - general questions with clear yes and no answers

We made slight change in the wording for several watch ring and neutral questions because of the different location. The subjects were trained to respond the control and neutral questions truthfully and answer as lie to watch and ring questions as if participants had not stolen any or both of the objects. Before imaging was performed and entering in the scanner, the task was demonstrated to subjects and any questions were answered. Instructions stressed speed and accuracy. After participants completed the practice, an event-related approach was used for item presentation and analysis. During functional

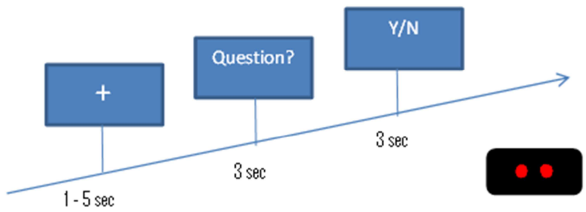


Figure 3.1: Questions were presented in this functional session in randomized order. Participant has to choose the alternative that corresponds the solution. Response time were measured from the onset of the presentation of the alternatives

MRI, 60 sentence questions (Watch = 20, Ring = 20 & Neutral = 20) were presented (see Appendix E) in pseudo-randomized order with each item presented only once.

3.4.1 Duration of fMRI Study

These questions were presented in an even related fMRI design consist of 3 runs with 20 questions each. Each question was presented for 3s to ensure that participants had enough time to answer it and to obtain a high activation rate. Participants were requested to press index finger for answering "Yes" and middle finger for "No". After the presentation of the response option, an inter-trial-interval of 1-5 seconds with a fixation point (s; average presentation time of 4 s) was presented, followed by the presentation of the question (i.e., Did you steal a watch from a drawer?) for 3 seconds (Figure 3.1). Together with three to four minutes for obtaining the anatomical brain images of the subjects in the beginning of the scanning session, the total time of the task presentation was 30 minutes and the total time subjects spent in the fMRI scanner was less than one hour. Within the scan-free time the responses were recorded and then transcribed by the investigator for further analysis.

3.4.2 MRI Data Acquisition

Imaging was performed on a 3.0 T Tim Trio Scanner (Siemens Medical Systems, Erlangen, Germany) using a 32 channel head coil, parallel to the bicommissural plane was acquired, covering the whole brain. Field maps were created from a double echo gradient-echo pulse sequence and images were obtained in thirty four slices in descending order. To minimize head movement, participant's' heads were stabilized with foam cushions. Participants wore ear plugs as protection against the scanner noise. BOLD-sensitive T2*-weighted functional images were obtained using a single shot gradient-echo (EPI) pulse sequence (repetition time (TR) = 1,750 ms, echo time (TE) = 25 ms, flip angle = 90, matrix size =64 x64, field of view FOV =192 mm, slice thickness = 3 mm, slice gap 0.9, 30 slices per volume). Responses were acquired by means of a response box (Current Designs, Inc, Philadelphia, USA), located in the subject's right hand. Responses were given with the left or right index fingers. Participants watched the screen through a mirror attached on the top of the head coil. Answers were given via a button response box. The first 2 volumes after each scanner pause were discarded to allow for allow for signal stabilization and T1 equilibration effects, resulting in 872 volumes. Visual stimuli were presented using the Software Presentation[2]

[2] http://www.neurobs.com/menu_presentation/menu_features/features_overview

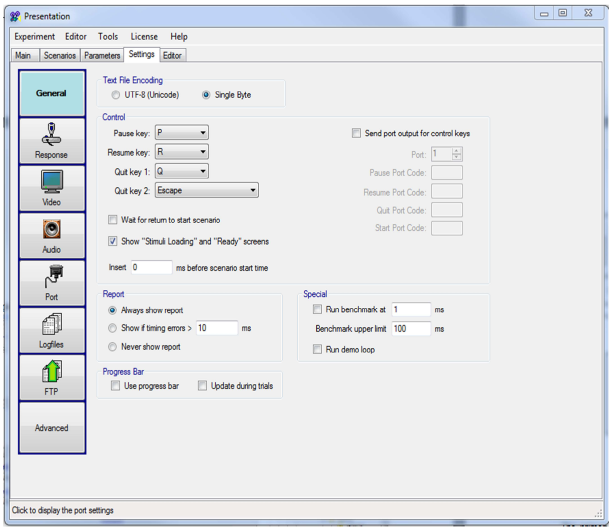


Figure 3.2: Presentation software was used for a stimulus delivery and for experimental control in our experiment. This software runs on Windows to collect fMRI data with a diverse range of applications such as timing verification and the best possible timing accuracy. In this study, all stimuli were presented using Neurobehavioral Systems Presentation version 71.

(Neurobehavioral Systems, Albany, CA) for item presentation (Figure 3.2) and registration of behavioral performance (solution rate and reaction time) and back-projected onto a translucent plastic screen which was installed on the roof of the scanner bore. This experiment was designed with this software in scanning machine using goggles and responses were gathered using a response pad designed for use in the fMRI. All stimuli were presented as white on a black background and subjects were instructed to respond using same - different discriminations in both experiments (Figure 3.3). These experiments are subdivided into units called scenario. A scenario is a sequence of action performs by this software without interruption that has been specified in the scenario description and may contain one block or many. The Presentation control files were stored in text files.

3.4.3 Trial Design

Within fMRI methodology, the protocol must clearly specify the trial design to present stimuli. It includes the number of trials per condition, intervals between trials and trial duration. There are two major types of trail designs, a) Block design and b) Event related design (Figure 3.4). Block related design presents the stimuli sequentially within each condition in order to determine the differences between the two conditions by alternating the conditions as a boxcar of distinct blocks [50]. The "on" shows a period of stimulus presentations, and the "off" represent to a state of rest or baseline. This design is straightforward to analyze and has high statistical power due to the repetitive stimuli that generates a good effect on the resulting brain activations. However, this design may be difficult to control a specific cognitive state for the relatively long periods of each block [50]. However, information regarding activation response time courses cannot be obtained with this block. It's high predictability makes it inappropriate for certain cognitive tasks (e.g. oddball paradigm) [50]. On the other side, event related designs are not presented in

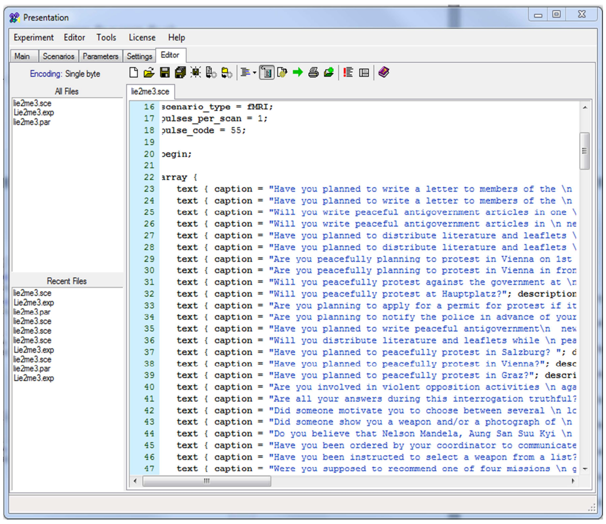


Figure 3.3: Presentation Control Language (PCL) programming was used to write a program to specify the stimuli and stimulus sequences within a scenario.

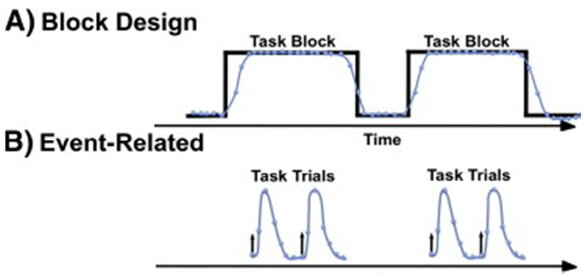


Figure 3.4: Block and event-related designs

set sequence. It associate brain processes with discrete and the presentation is randomized which may occur at any point in the scanning session [50]. Stimulus events such as words or pictures are presented one at a time and separated by an inter-stimulus interval of a specified length. Each trial can be composed of controlled or a subject mediated event that minimize anticipation and habituation effects. These advantages come at cost of lower statistical power. Both designs have their advantages and disadvantages However, if the different events are timed correctly and experiment is properly set up, event related design increases the statistical power and can be argued that than block designs temporal randomization of the intervals among successive stimuli must be used [50].

This thesis uses event related design to observe the differences in neural activity associated with each event and for the faster image acquisition. Though this design is complex than blocked design with irregular intervals that vary but to create the strategies and/or strategy types scientists are advised to use this design to develop the corresponding brain activity. In this thesis we wanted to create and measure distinct conditions that were contrasted to observe differential brain activity. An event-related approach was used for item presentation and analysis. Before imaging was performed and entering in the scanner, the task was demonstrated to subjects and any questions were answered. Instructions stressed speed and accuracy.

3.5 Specifying Experimental Tasks

3.5.1 fMRI Protocol

fMRI studies necessitate multiple trials or repetition to get statistically significant brain activations. Also, while fMRI scanning could theoretically last as long as necessary, an fMRI protocol should constrain the number of tasks to prevent participants from becoming disengaged from the study, to reduce fatigue and avoid getting similar activation throughout the study. Secondly, the experimental tasks should not be mundane to maintain similar brain activation throughout the study. Usually fMRI studies are about 30-60 minutes, conditional on the nature of the experimental protocol.

The basic objective of this study is to identify the specific area of brain activation in response to lie detection/truth verification task. Initially, a conventional design was used and subjects were instructed to lay inside the scanner doing nothing. Author observed the variations of the BOLD response related to spontaneous activity or resting state. This research engaged participants in an experimental task that was aiming at manipulating particular emotional processes by increasing the hidden motivations of participants to deceive, and attempted to increase the emotional involvement of subjects while the corresponding brain activations are recorded within an fMRI scanner. This paradigm was simpler to enable more straightforward link between the observed brain activations and the experimental tasks.

The strength of this experimental task is the training of the subjects in our novel paradigm as research environment like MRI is stressful by itself that involves frustrating procedures. A research environment, especially one such as MRI where substandard training procedure may lead to biased subjects. Furthermore, when it comes to lie detection this whole procedure becomes more demanding. A special case in lie detection studies is that many participants feel like being interrogated and they assume that their level of honesty is being tested especially in the case of autobiographical questions. To address this issue we familiarized our subjects with the equipment and experiment's procedure and we explained them the great objective of this study and specify exactly what aspects of truth and lie they shall pay attention during the scanning. We also ensured them the confidentiality of their personal data. This paradigm was simpler to enable more straightforward link between the observed brain activations and the experimental tasks.

3.5.2 Appropriate Contrasts

An fMRI data do not detect absolute levels of blood flow, but relative intensity of BOLD signal across conditions [88]. Since fMRI is based on subtraction logic between baseline condition and an experiment, the difference in BOLD signal in this experiment was an artifact of the fMRI protocol that created contrasts across conditions. fMRI protocols in this study created a good contrast between experimental condition and the baseline condition and between two experimental conditions such high and low. Actions like moving a toe, moving a jaw or finger, hearing a sound may spawn brain activation and thus it is necessary to build a contrast between the expected activation in appropriate brain regions. These motor, visual, auditory cortex are highly problematic and it is necessary to create contrast the control condition between the expected activation in brain areas except those due to experimental conditions otherwise all other spurious activations statistically suppress true brain activations and may rise the total level of brain activity. In this experiment the contrast was aimed by subtracting the experimental condition for instance, viewing and reading and replying to the measurement items for true and lie from the baseline condition. Such as a set of reports that is similar to study's measurement objects in terms of number of words and format types, which the participants read, processed, and was instructed to press one of the 2 buttons.

3.6 Data Analysis

3.6.1 Transferring Data from the Scanner and Converting it to Analyze Format

After completion of a series of images, the data from the Siemens Magnetom Skyra scanner were optimally displayed in the reading workflows and transferred automatically to the Syngo MR D13 database[3]. This software ensures a guaranteed performance for image transfer and used for viewing, manipulating, communicating, and temporarily storing medical images. Raw data acquired from the Siemens Magnetom Skyra scanner required several manipulations to allow statistical analysis on these data.

3.6.2 Fourier Transform of the Scanner's Raw Data

MRI scanner supplied neuroimaging data in a standardized medical image format called DICOM, apropprietary scanner format. The analysis was started with converting DICOM to a NIFTI format with SPM to view scans as most analysis packages such as SPM cannot

[3] http://www.medical.siemens.com/siemens/en_GLOBAL/rg_marcom_FBAs/files/brochures/DICOM/mr/DCS_magnetom4_8.pdf

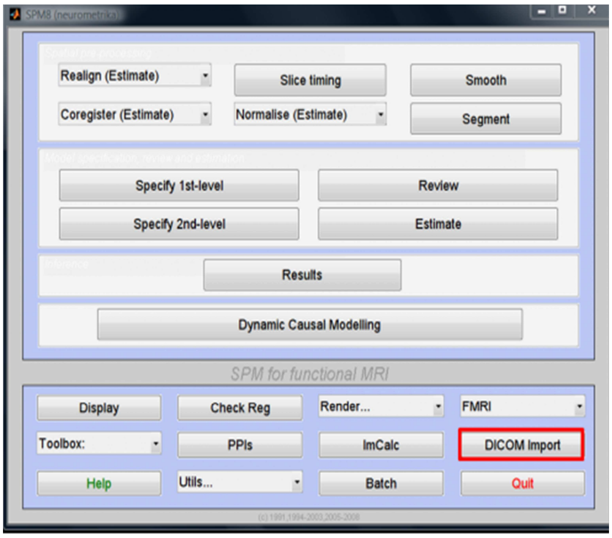


Figure 3.5: Conversion of DICOM

work directly with the original data. SPM has a tool that allows the conversion of DICOM (Figure 3.5). NIfTI is a modern incarnation of the Analyze format that is designed for scientific analysis of brain images that keep spatial orientation information and includes important information like the orientation of the image in a pair of files (hdr/img) or a single file (nii). SPM has a DICOM conversion utility and was accessed the conversion tool via the button DICOM import to display images (Figure 3.6).

3.6.3 Analyzing fMRI Data

The aim of the analysis of fMRI data in this study was to detect and the functional activation of the brain areas and the localization which are activated in reply to the stimuli specified by the protocol. The variations of BOLD signals are not easy to detect visually. The advanced statistical methods must be used to find voxels in which the signals changes w.r.t the paradigm. In this experiment, the functional images were analyzed to find brain areas that are considerably more active in the course of the experimental relative to the baseline stimuli. The following step was followed while analyzing fMRI data such as preprocessing.

3.6.4 Pre-processing

In terms of analyzing fMRI data, the pre-processing steps are routinely done prior to statistical analysis to ensure that images are properly slices, it increases BOLD contrast signal and to remove noise ratio such as variance from movement and scanner artifacts to overcome any biases. It allows comparisons among different anatomical brains across participants. The data in this research were analyzed with SPM8. It is important to know the details of the study such as, motion correction, repetition time and the slice acquisition were used in order to obtain valid and optimal results. Pre-processing includes the following key steps:

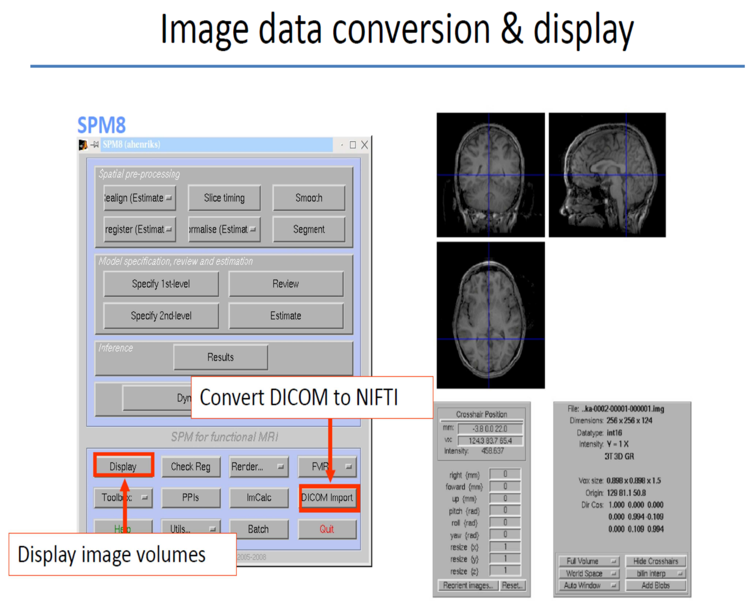


Figure 3.6: DICOM Conversion Utility

1. Motion Correction/Realignment
2. Slice timing correction
3. Spatial Co-Registration
4. Segmentation
5. Normalization
6. Smoothing

Motion Correction/Realignment

Subjects participating in fMRI study are instructed to not to move, However, sometime it is impossible to lie still for 1 hour in a scanner machine. During this study, different sources of motion were observed in our experiment, for instance, motion caused by respiration, movement of head was easiest motion source to imagine during the time-course of the experiment resulting in spatial changes in terms of where specific voxels correspond. Secondly, some subjects were uneasy in the head coil as they were engaged by the experimental task they performed that could result in noticeable changes in signal intensity across voxels over time [73]. Thirdly pulsation of the blood stream also caused shape changes in the brain. It is the most severe but also an unavoidable problem for statistical analysis of the data problem in experimental studies with fMRI [73]. It is assumed that each voxel signifies one exclusive location in the brain and the variation of intensity in the same voxel among frequent measurements of a time-series is mainly due to changes in cerebral physiology. If the participant however moved the time course of 1 single voxel may signify a signal derived from different areas of the brain and might show as ring activations around

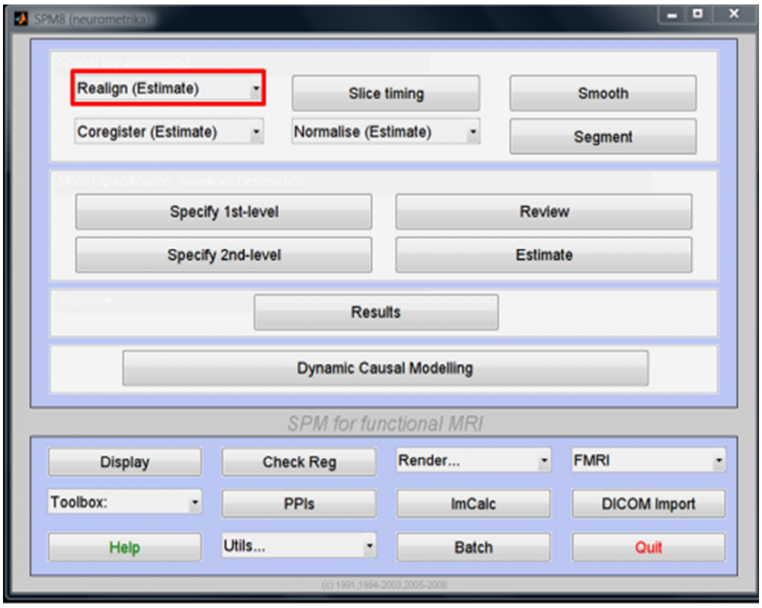


Figure 3.7: Realignment or motion correction in SPM8

the edges of the brain, rendering the assumption that a single time course for this voxel is studied false. It may be resulted from the fact that the intensity differences between adjacent voxels are particularly high at tissue boundaries between high and low intensity tissue, for instance, around the cerebrospinal fluid filled ventricles [73].

Accurate movement corrections are very important in pre-processing as small movements may result in systematic effects and could create false positive brain activations [109]. Together these dynamics provide a complex set of parameters that should be considered when trying to correct for motion related errors. To overcome the problem of motion and for a valid analysis of fMRI data, different methods to correct motion artifacts have been developed and are now widely used for data analysis [109]. In this research we used motion correction in SPM8 in a way that identical set of voxels time-courses had to be sampled throughout the time-course of the fMRI experiment (Figure 3.7). Most motion correction techniques assume that the head is an object that doesn't change its shape in the fMRI machine and such method only correct for translations and rotations along the x, y and z axes that define a given voxel [73]. Realignment or motion correction is usually piloted by approximating the parameters of an affine rigid-body transformation that reduces the sum of squared differences among each scan, also a reference scan consuming the transformation by resampling the data through a certain interpolation (e.g., cubic spline, sine or trilinear) [109]. The function in SPM8 in this experiment aimed to remove movement artifact in fMRI by realigning a time-series of images acquired from the same subject (Figure 3.8) that can be stated as a rigid body registration method using a least squares approach with six degrees of freedom (three translations and three rotations). Nevertheless, there is always a possibility that non-rigid shape changes do occur in brain tissue due to the motion that occurs in brain tissue that a signal from a slice is sampled and because of pulsation of the blood stream results in an apparent shape change [109].

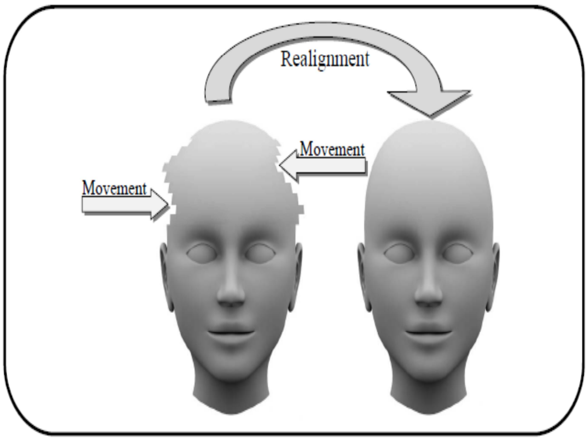


Figure 3.8: Time series of images

Slice Timing Correction

Since fMRI data analysis is essentially a time course analysis, exact timing is vital with respect to the stimulus presentation paradigm is crucial [104]. In our experimental paradigm, data set were commonly measured with repeated 2D imaging methods resultant in temporal offset between slices such as single-shot echo planar imaging sequences allow for acquisition times in the range of 50-150 ms. Whole-brain coverage is achieved by sequentially repeated image acquisition on a slice by slice basis and there was a slight time difference reliant on chosen acquisition pattern for a stack of individual slices [104]. As a consequence, and power of time series analysis the reliability may be compromised that results in in degraded sensitivity to detect activations and repetition times (TRs) ranging from hundreds of milliseconds to several seconds To compensate for this timing difference step, we used slice timing correction method, for instance temporal data interpolation in fMRI pre-processing phase. Slice timing correction (STC) aims to restore the appropriate relative timing information allocated to each slice [104]. The individual slice is temporally realigned in STC to a reference slice based on its relative timing using an appropriate resampling method. STC is currently included in all major fMRI software packages such as SPM [104]. In our research paradigm STC was performed using the standard procedure embedded in SPM8 (Figure 8) that offers tools to correct for slice timing and to correct any time lags in image acquisitions. It also corrects for the different timing in acquisition of different slices within the same functional volume. Slice timing correction mostly applied in event related paradigms when there is not much variance between slices and where the BOLD signal plateaus [109].

Spatial Co-Registration

The objective of spatial co-registration used in this experiment was that whole brain images were spatially realigned to each other because of the systematic differences in the images across whole brain scans of the subjects [109]. Another reason to use co-registration is because images that are in different modalities (anatomical and functional images) must be aligned to each other by aligning all subsequent images of each brain to the first image

Figure 3.9: Slice Timing in SPM8

of the brain volume [109]. In sum up, in our functional data analysis, this technique was used to align functional (EPI) data with structural (anatomical) data and to correct for subject movement artifacts. In this experiment SPM8 was used (Figure 3.10) to create a six-parameter rigid body affine transformation (3 rotations in x, y, z axes, 3 translations and in x, y, z direction).

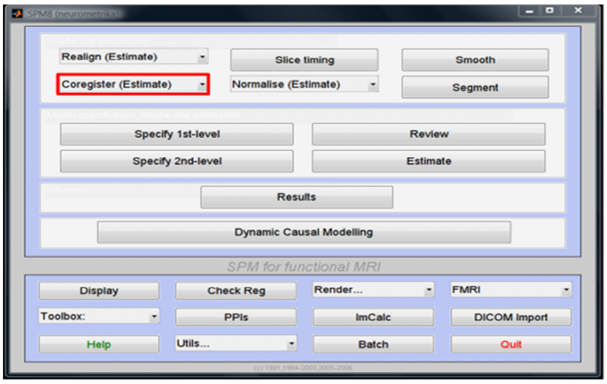


Figure 3.10: Spatial Co-Registration -1

The purpose was to generate a transformation matrix to define the rotations and translations in order to be applied to one image to spatially overlay it on top of the other image. The sessions are first realigned to each other, by aligning the 1st scan from each session to the 1st scan of the first session. In the next step the images within each session were aligned to the 1st image of the session because it is assumed that there may be systematic differences in the images between sessions. In addition, all co-registered functional images were aligned to the first image on a voxel-by-voxel basis and correction for head movement was done (Figure 3.11). The parametric estimation was accomplished by computing a transformation matrix that identified the higher resolution anatomical images and the transformation parameters to all images in analyzing fMRI data.

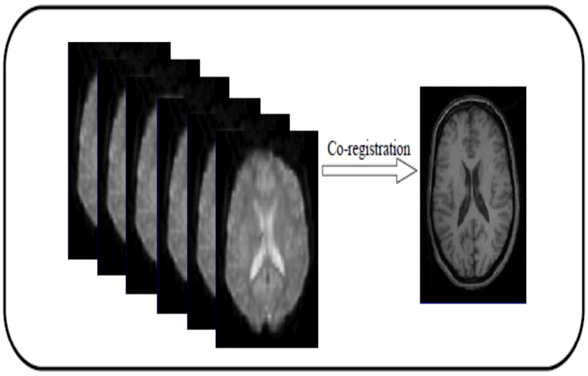


Figure 3.11: Spatial Co-Registration-2

Segmentation

Healthy brain tissue of a subject can be classified into three broad types using MRI data analysis - white matter, grey matter, and cerebrospinal fluid [109]. Segmentation is based on the MNI template and is calculated the transformation before segmenting to be used to in the next step of normalization of the EPI images [109]. In order for pre-processing to provide a meaningful interpretation of the results of source reconstruction, segmentation was performed using the SPM8 procedure in this study to assign the probability that each voxel fits to each tissue. This is the second step in indirect normalization and it was based on combining the probability for belonging to that tissue type and the prior probability that is resultant from prior probability maps taken from a great number of participants in this study (Figure 3.12).

Figure 3.12: Segmentation in SPM8

Normalization

The brain of every individual differs in size and shape [21]. For an individual analysis of subjects in order to compare brain activations across participants in this study, their brains had to spatially normalized to a template brain to account for structural differences in the participants' brains [21]. During an individual analysis, data analysis was done in this experiment with the regions that are active due to a task in a particular subject. However, while performing a group analysis in our study it was vital that all brains in the group are of the same orientation and size so that brains could be compared. More than one subject can be entered into one normalization step. All functional and anatomical images were then transformed into this MNI space using the normalization procedure embedded in SPM8. Normalization is a major step in preprocessing because it allows generalizations and group analysis and specify the template to which images are matched [21]. Normalization refers to scaling the data to a standard template brain to permit inter-subject comparison [21]. In this study data were normalized to a standard stereotaxic space. It was based on the MNI coordinates. All anatomical and functional images were then transformed into this MNI space using the normalization procedure embedded in SPM8 (Figure 3.13). This technique allowed computing a template brain model for this research's specific set of participants and accordingly normalizing the brain images on the custom-created template brain of each subjects.

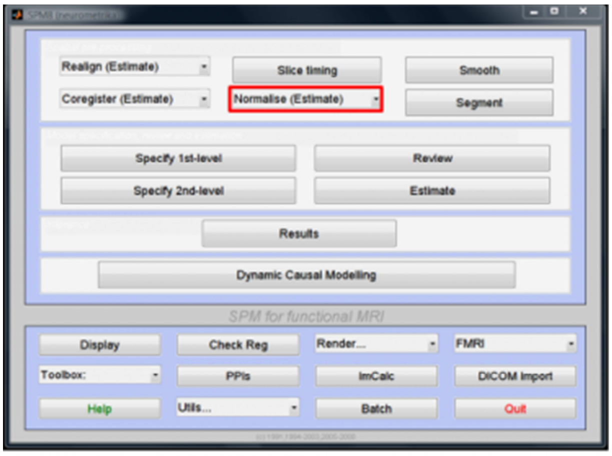


Figure 3.13: Normalization in SPM8

During normalization, the images were warped and functionally homologous regions from different participant were as close together as possible. Initially a MNI (Montreal Neurological Institute) template brain was selected as results per coordinate and compared with results in MNI space. Second step involves the minimization of the sums of squared differences between the original brain and the template brain. Thirdly, it involves the squared number of standard deviations away from the predictable parameter values. Normalization included the changing size of the brain using a linear parameter registration to match position and size of the template. By masking the original image, non-brain voxels are removed and could not disturb affine registration. Final step involved a global non-linear warping of the original brain to compare the SPM8 template that is based on a Bayesian framework to increase the smoothness of the warps.

Smoothing

The smoothing procedure in pre-processing applies a smoothing filter to the images [109]. Smoothing is a standard procedure embedded in SPM8 used for brain imaging analysis (Figure 3.14).

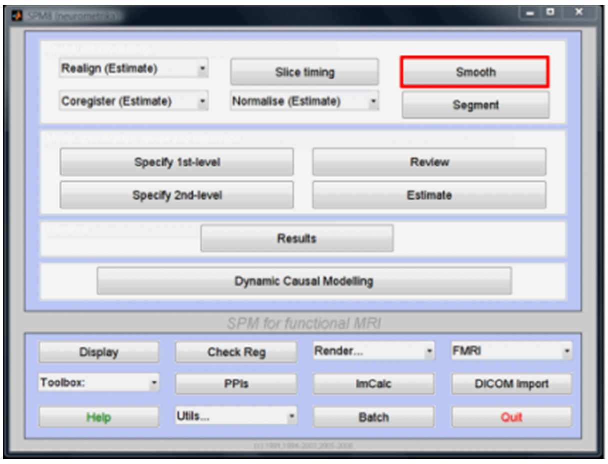


Figure 3.14: Smoothing in SPM8

In this study fMRI images were smoothed with a Gaussian kernel of 10 mm full width at half maximum (FWHM). The size of this kernel is determined by the full width at half maximum. Functional anatomy may differ across subjects, such as the location of brain functionality. Smoothing process helped with the group analysis with spatial differences in the subjects [109]. Secondly, in the data analysis, if we are interested in a specific region then sensitivity can be enhanced by smoothing to the diameter of the region to overcome spatial variance [73]. Smoothing is only applied when a group analysis is performed as it improves the signal to noise ratio by eliminating high spatial frequencies and overlap of activation between subjects is increased [73]. It is normally done by removing neighboring voxels by averaging each voxel with its neighbors. It substitutes the value of each voxel with a weighted value of its own value and weighted by a Gaussian function that falls with distance [73].

3.7 Data Analysis

In the data analysis, responses (index finger for answering "Yes" and middle finger for "No) and reaction times were acquired via Presentation software. Obtained data were examined to screen for irregularities and to confirm participant input in all tasks. Responses that were not answered, not consistent, or not as specified in the protocol were modeled as non-protocol events. Subject's responses were examined for irregularities regarding the correct answer per protocol. Response data acquired from the presentation software was converted to Excel files. These files were then subsequently imported into Matlab (The Mathworks, Natick, MA). Afterwards, response data from the presentation software were converted (using a Matlab script), into the onsets for the event-related SPM8 analysis. Responses that were not answered by the subject were identified as separate "non-protocol" events. Functional MRI analysis was prepared by using Statistical Parametric Mapping software. SPM 8 analysis was carried out using Linux Kernel: 3.7.1, Matlab version R2012a (7.14.0.39) and Windows 7. All data analyses were carried out blind to the actual tasks done by the subjects and this analysis was carried out in the same manner as in [59]. The 1st image was reoriented using the display function in SPM8 and each scan was adjusted to set with 0,0,0 coordinate using the reorient function in Statistical Parametric Mapping software 8. Preprocessing was done as defined in [59]. Initially, the reoriented images were realigned and unwrapped to correct head movement and subjects with movement of $>$3 mm were removed from this study. Slice timing was done to spot the differences when each slice was acquired. Normalization was performed with SPM EPI template and re-sampled to 3 x 3 x 3 mm voxels. The functional images were spatially smoothed with a Gaussian kernel (8 mm full width) at the standard of 2 to 3 times the output spatially normalized voxel size. The purpose was to ensure the validity of inferences and to correct the inter-subject variability.

Images were finally smoothed with a Gaussian kernel of 8 mm FWHM on the basis of the suggested standard and voxel size. The event related design for each condition (ring, watch or neutral) was convolved with the canonical form of the hemodynamic response that approximated the expected activation patterns. A high-pass filter of 1/100 Hz and an autocorrelation model (AR (1)) were employed (no low-pass filter and no global normalization were used). This whole process helps to adjust for inter-subject variations that persist after spatial normalization, reduce errors by spatially smoothing the data and ensures the validity of inferences on the basis of parametric tests [21].

The statistical portion of the analysis was also performed using a Matlab script. For the statistical analyses, one sample t-tests was designed to recognize a random effects analysis. Important activation clusters were detected with a height threshold of $p < .005$ uncorrected and with uncorrected voxel wise at $p < .001$ and level family-wise error (FWE) correction for multiple comparisons at $p < .05$. A general linear model within SPM8 was specified to estimated effects at each and every voxel at the first statistical level. Temporal derivative and events were defined as occurring when ”Yes” or ”No” answers was presented to the subjects. The motion-recorded parameters produced during the ”Realign” process were comprised as specified regressors. The non-protocol events were modeled with the hemodynamic response function and included as conditions. To reduce the impact of temporal dependence we used AR (1) and a high pass filter (cut-off frequency = 128 s) to eliminate the possible effects of low-frequency changes. Individual t-statistics activation maps were defined based on the contrasts of interest. For this protocol analysis, the contrasts were watch minus neutral and ring minus neutral. The number of significant ($p < 0.05$) voxels was determined in all clusters that corresponded to right orbitofrontal/inferior frontal region, right middle frontal and right anterior cingulate region. If the resulting value was "+ve" (i.e., greater brain activation corresponding to lying about the watch questions), it was considered as mock crime was committed. If the resulting value was "0", then it was named indeterminate. If the value was "-ve" (i.e., greater brain activation corresponding to lying about the ring questions) then the call was made that the no mock crime was committed.

In this replicated study, the number of significantly activated voxels for the watch minus neutral contrast was subtracted from the ring minus neutral contrast. If the resulting value was "+ve", then the call was made that the watch was taken. If the resulting value was zero, then it was called indeterminate. If the resulting value was negative, then the call was made that the watch was taken. The individual contrast images that we created at the 1st statistical level were then used to generate the group t maps at the 2nd level in a random effects model [73]. Cluster analyses were estimated for each group map at identical uncorrected threshold level of $p < .001$ with a spatial extent threshold of twenty voxels to correct for multiple evaluations [73]. The false discovery rate were used to decrease the chance of type II errors, as due to multiple comparisons, this study was using an extent threshold to help correct for type I errors [73].

For the individual data analysis, there was no attempt to correction for multiple comparisons, because we did not try to find whether there were significant voxels in the anatomic region but to identify the accurate detection of deception. The xjview[4] program was used to determine average t value for each cluster in each individual and the number of significantly activated voxels. Another program MRIcroN[5] was used to display the group fMRI maps.

3.8 Results

We investigated detecting deceptive versus truthful method to maximize the accuracy of responses. With the contrasts of Lie-minus-True, Lie-minus-Neutral and True-minus-Neutral, above clusters were used as ROIs for each individual analysis. The purpose was to generate the number of activated voxels and average t values for each region at various levels of significance ($p < .05, p < .01, p < .005, p < .001, p < .0005$, and $p < .0001$). Large differences were detected in the degree of activation for each subject. However, a single reference threshold of activated voxels was hard to accurately predict deception for the True contrasts (True-minus-Neutral) versus the Lie contrasts (Lie-minus-Neutral).

For the Deception task, the analysis revealed significant activation (cluster minimum=20, $p < .001$) in seven clusters. 14 brain regions were significantly activated with 5 brain regions were consistent with prior study of [59], such as: Cluster 1= prefrontal cortex; Cluster 2= right inferior frontal; Cluster 3 = right anterior cingulate; Cluster 4 = left middle temporal lobe and Cluster 5 =right middle frontal. For the 5 clusters, the activated voxels ($p < .001$) were generated for all participants enrolled in this study that clearly differentiated when an individual was being deceptive. It also revealed significant activations in different clusters. All three subjects had significant activation in three clusters (Cluster 1= prefrontal cortex; Cluster 2= right inferior frontal; Cluster 3 = right anterior cingulate). If the significance threshold was lowered ($p < .001$), then all four subjects would have activation in one of these three clusters. However, Cluster 2 was able to successfully differentiate when the subjects were being deceptive for 75% [3 of 4 $p < .001$] of the subjects, while the combination of Clusters 1, 2, and 3 achieved a higher accuracy of 95% [4 of 4, $p < .0001$].

In addition to these areas several others regions were also activated and these results replicated the 8 other group studies in deception detection. However, paradigm used in this study had no significant differences from those in the original study and this ring-watch testing study. According to many studies, the orbitofrontal cortex, the anterior cingulate and the dorsolateral prefrontal cortex are important for lying in humans and involved in

[4] `http://www.alivelearn.net/xjview8/`

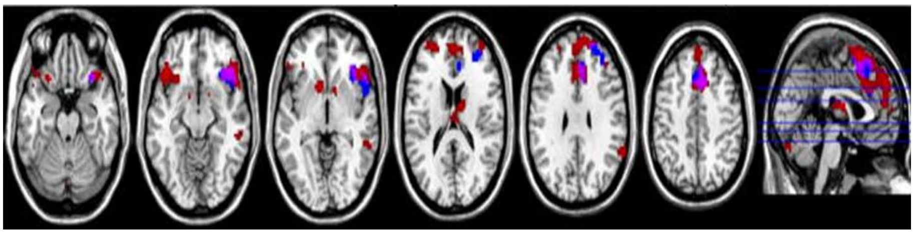
[5] `http://www.mccauslandcenter.sc.edu/mricro/mricron/`

Cluster	Region	BA	Hemisphere	Maximum t	MNI Coordinate x y z	Cluster Size (k)
1	Anterior Cingulate	24	R	3.93	12 14 41	876
2	Orbito Frontal	47	R	4.05	33 19 -11	534
3	Inferior Frontal Cortex	38	Midline	5.02	29 31 -9	179
4	M Middle Frontal	47	R	5.02	29 31 -9	316
5	Middle Frontal	46	L	4.59	-25 34 22	345
6	Dorsal Medial Prefrontal Cortex	9	L	5.02	14 47 0	202
7	Precentral Gyrus	43	L	5.27	-44 -2 12	176
8	Pallidum	6	L	4.51	-12 7 9	154
9	Middle Temporal	-	R	4.03	7 -18 7	98
10	Cerebellum	-	R	4.10	14 -46 -11	71
11	Inferior Frontal Gyrus	47	L	4.86	30 30 0	56
12	Ventrolateral Prefrontal	47	R	4.00	.39 9 -9	38

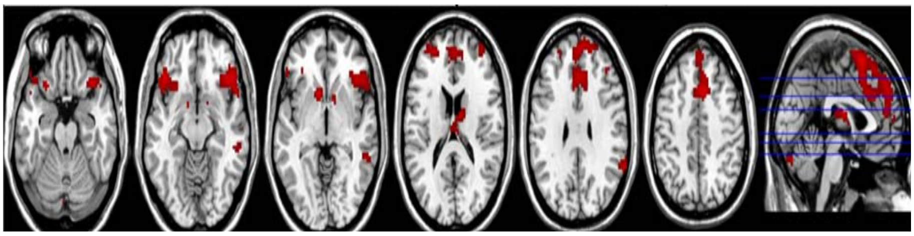
Table 3.1: Brain Regions associated with Lie Minus True (Threshold p $<$ 0.001)

response-inhibition, high-order decision making, and go/no-go tasks [107]. The anterior cingulate modifies the baseline behavior of the prefrontal cortex for deceptive responses [107]. Interestingly Dorsal Medial Prefrontal Cortex, Precentral gyrus, Pallidum, Middle Temporal, Cerebellum, Inferior Frontal Gyrus, Angular Gyrus, Ventrolateral Prefrontal, Supra Marginal gyrus are significantly activated in this study but did not activated in [59] (see Table 3.1 and Figure 3.15). These activations are successfully replicated areas of several lie detection studies (3-9). We had one different result than [59] such as the left middle temporal gyrus was not significantly active in our replication study as it had been in mentioned by [59]. This may be because of a different scanner. As hypothesized, the True-minus-Lie group map revealed no significant activation neither in any individual.
Individual t-maps were generated for the contrasts Watch-minus-Neutral and Ring-minus-Neutral. These two contrasts were applied to the 4 ROIs identified by in [59] for each individual participant in this study. The greater number of activated voxels ($p \leq 0.001$) was determined with these contrasts and detected the object about which the subject was being deceptive. In the next step, complete data were examined for quality, lack of significant image artifact, adequate number of behavioral responses and lack of excessive motion in order to complete the protocol properly. The lie minus true (group map analysis) was calculated to find if prior regions of significant activation replicated from earlier studies.

To predict the individual differences in activation, we combined all three clusters with the number of significantly activated voxels ($p < .001$) by subtracting lie contrasts from the true contrasts. In this regard, if resulting value was positive, we can correctly identify a lie. If the resulting value was negative, then it was falsely identified as a truth. However, it was called indeterminate if the resulting value was zero. The data was checked to ensure that responses were incorrectly answered or not answered and to ensure that motion$>$3 mm in our protocol. Subsequently two subjects with excessive motion, with inadequate number



(a) Lie minus true



(b) Lie minus True with ROIs

Figure 3.15: Lie minus true: with and without ROI)

of correct responses were eliminated as they did not follow strictly to the protocol. Both investigators (FS and KK) compared their results and if each reached a different result, participant was analyzed again from start. However, if the conclusion were still different then that particular participant was eliminated from the study.

This replication study was similar with prior study of [59] and likewise determination of clusters was not made on the basis of an anatomic location but on the group activation map. All datasets were locked and analysis was performed blind to participant groups and there was no possibility of any data analysis by anyone with knowledge of the group assignment.

3.8.1 Testing the fMRI Detection of Deception

Our methodology for detecting deception was successfully replicated with different scanner and location. As we recruited an independent group of four subjects to replicate the study, using the data from these four participants' we accurately detected deception for 75% of the subjects. We screened out one subject as he did the reverse of the instructions in many questions (because he did lie and tell the truth) as he was non German speaker. However, remaining 3 participants were correctly (100%) identified when being deceptive. There was no statistical difference between the accuracy rates obtained in our study (3/4) versus the previous study (28/31). One question was changed because of participants' confusion about the question and was eliminated from the analysis.

This study has successfully replicated the results of previous studies and achieved better results than kozel's et al study. These results provided this thesis a scenario, to build a good method of deception detection in our second study. Strength of this methodology is the analysis that drastically reduces any chance for bias. However, the only decision required of the investigator analyzing the data analysis to approximately detect the anterior commissure on the brain image. Author of this thesis performed the analysis independently in this study and compared the same data with an fMRI expert from Medical University of Graz. This data was also analyzed with the help of several neuroscientists and fMRI experts and arrived at the same results.

Debriefing Process - After subject was removed from the scanning machine, they were greeted by FS and was asked if they experienced any difficulty or if had any inquiry about this whole process or what just occurred. Finally subjects were presented a post scanning form specifically asked if the subjects felt that scenario was believable.

3.9 Functional MRI:A New Way Forward In The Forensic Sciences

Whether the prior testing model would hold true for a cognitive task on a different location and different scanner with a different group of participants was not known and required investigation to determine if we could replicate the previous findings. In this study, testing the different participants using different location and scanners has demonstrated that fMRI results can be consistent across different scanner as [59] was tested on 3 Tesla (T) Philips Intera MR scanner and this study were performed on 3-Tesla magnetic resonance tomograph (Siemens model Skyra). In the first study, 4 participants were scanned to determine whether or not these four subjects had committed a mock-sabotage crime. While being scanned in the MRI, subjects responded to visually presented questions. This thesis successfully replicated the method for lie detection using a mock sabotage crime paradigm within a cooperative individual on a different location and with a different scanner to predict which participants had valid mock-crime determinations. We have replicated the three regions of significant activation for Lie-minus-True in an individual as done by [59]. Three areas were activated as mentioned by [59]. However, majority of subjects were motivated to earn more money. No subject performed countermeasures and not much motivated with instructed lies and did not try to beat the test and did not take this task seriously. This study did not evaluate real life crime scenario (i.e., criminal or civil cases) or lies with severe monetary emotional or societal damages. In addition, the level of risk was relatively small. We did not study with a diverse sample with regards to age, occupation and ethnicity and this sample was without serious criminal histories and significant medical illness. This study was a critical step in the development phase of the second study of this thesis.

We conducted second study to create real life scenario determine how these factors impact on the ability of fMRI that might be unique and detect deception with a high degree of accuracy. [59] and our replicated study suffer from low specificity on this task for whether a participant committed a mock crime. We have same conclusion as [59] has defined that this technique would be helpful to ”rule out” a potential suspect (i.e., a person who did not commit the crime) but not very useful in ”ruling in” a suspect. This was an important validation step and this study was planned to address how robust these findings will be with different populations and testing scenario. The study scenario used healthy adult participants with a simple laboratory paradigm. However, when there is greater risk such as large financial risk or fear of going to jail, and individual with illnesses taking drugs and medications may result in a different outcome.

Furthermore, 2 subjects participated in this study stated that sated that the additional money or 16GB USB was a strong motivator, and two participant stated that they believed they were participating in a crime. Furthermore, to fool the investigator and potentially earn more money, three participants performed countermeasures imagining they did not steal any object by altering breathing, imaging a specific place and moving their toe and jaws. It was observed that subjects were not greatly motivated and did not took the task seriously as this study did not evaluate real-world scenarios or lies with severe emotional, societal, or monetary damages. The risk factor for these participants was relatively small compared with real world scenario in which lie detection would be needed (i.e., civil and criminal cases). Although this study had diverse sample with regard to age but this sample was without significant differences in occupation, ethnicities, medical illness and without serious criminal histories. Another important point is that, this study requires a cooperative participant. Any volunteer, who refuses to enter the scanner, randomly answers questions, refuses to answer questions, moves their toe, head, or jaw would not be able to be tested. However, experiment in a terrorism scenario to distinguish between freedom fighter and freedom activists would make a profound impact on test performance characteristics.

On the basis of these results this thesis designed further study to evaluate this paradigm in relation to real-world scenario to detect deception. A next step of this thesis in developing this method would include a second study in a counter-terrorism scenario in two different groups (i.e., freedom fighters VS freedom activists) to determine how these factors impact on the ability of fMRI to real world situation factors. The neuroimaging results of this comparison would indicate whether the scanning adequately works for this particular group, identifiable brain regions might be used to detect deception with a high degree of accuracy. This paradigm will be an initial first step in developing this technology for interrogation purpose that will likely be improved investigation techniques for law enforcement agencies to improve the accuracy of detecting deception.

CHAPTER 4

Study Design 2: Functional MRI as a Counterinsurgency Strategy

In counter-terrorism efforts the problem of definition is a crucial element that based on the currently accepted rules of traditional warfare as terrorism is one thing and a national struggle against occupation is another. Defining terrorism is not only a theoretical issue but it is an operative concern for counter-terrorism agencies of the first order to distinguish different nationalities ethnic communities. This study is helpful to reflect the theme of "One Man's Terrorist another Man's Freedom Fighter" as this statement is one of the most difficult obstacles in coping with terrorism. The conceptualization of this definition is usually a purely theoretical issue but in this paradigm we build a mechanism for law enforcement agencies to work out the appropriate set of parameters for the research they intend to undertake. That terrorism and freedom fighting are two extremes in the scale of legitimate use of violence. In this study the struggle for freedom for freedom fighters appeared to be the positive and justified end of this sequence, whereas terrorism is the negative and odious one for interrogators. For law enforcement agencies the idea that one person's 'terrorist' is another's 'freedom fighter' cannot be accepted such as to slaughter schoolchildren [82] The idea in this research to identify those terrorist as murder and indiscriminate killing is, of course, groundless. Secondly, to distinguish innocent from terrorist as this is one of the prevalent ways of terrorist to illustrate the cruelty and inhumanity and present them as innocent. The approach in this research is easy to implement and works well by involving personal experience and emotion as a means of increasing external validity. Given the prospect applications of truth verification paradigms, this study was made as close as possible to real world scenarios by increasing the hidden motivations and attempted to increase the emotional involvement of subjects to create more valid experimental paradigm. The purpose was to monitor closely simulating situations in which detection of a possible deception would be of critical importance, thus allowing to more accurately ascertaining the potential of fMRI in such situations to detect. In this study, we investigated whether fMRI can be used to detect concealed readiness to be involved in violent attacks by aiming at detecting the presence or absence of attack-related information in a suspect's memory. We designed a scenario to identify opponents willing to commit peaceful protest (freedom activists) or violent action against an oppressive regime (freedom fighters from their own point of view - terrorists from the point of view of the interrogators) and to gain knowledge about a planned, but not yet executed violent attack. In order to increase the relevance of the results for real world situations, test subjects were provided with an invented background story that allows them to more readily imagine themselves as freedom fighters or peaceful activists. We asked subjects to come with camouflaged at the time of scanning as making the participants as invisible to provide something of a psychological edge and to feel them as real freedom fighters.

We hypothesized that this research can distinguish between the trained terrorist and the peaceful protester. A trained terrorist posing as a freedom fighter will have information regarding terrorist training, contacts, plans, operations and procedures stored in his brain. An fMRI can detect the presence or absence of this information, and thus distinguish the terrorist from the innocent subject. In sum up, the difference between a terrorist who has been through a planning and an innocent citizen is the memory. So we have to measure scientifically that can differentiate the fundamental difference between an innocent person and a guilty person, and this difference is that a guilty person has committed the crime, and the record is stored in his brain.

4.1 Materials and Methodology

4.1.1 Selecting Subjects

12 Healthy participants, 21-25 years of age were recruited by an advertisement from the TU Graz University. Informed consent was obtained from all the participants in accordance with the guidance of Ethics Commission. After providing written informed consent, participants were screened to ensure that they are healthy, not taking any medications, and safe to have an MRI. Subjects were free of psychotropic medications with normal and corrected visual ability. All subjects were right handed. A behavioral performance criterion was conducted to ensure that participants there are included in this study properly performed the experimental tasks. [24] research's also explains how to calculate the number of subjects required for an fMRI study and [9] work is also detailed example of selection criteria of subjects.

4.1.2 Study Design and Research Approach

Subjects were given written instructions outlining the study. Subjects were given a briefing document (see Appendix I) explaining that they live in a hypothetical alternate-history Austria which is supposed to be controlled by an evil dictatorial and an oppressive regime. A government that routinely commits atrocities against its own population and those of neighboring occupied countries, including to the subject's friends and family members which had to be imagined as having been tortured, imprisoned, or even executed on political grounds by the regime. Real situations and behavior of historical and contemporary peaceful as well as non-peaceful opponents of such governments were be given as examples in a non-judgmental way, e.g., Nelson Mandela and Aung San Suu Kyi of the peaceful type, or George Washington and Che Guevara of the non-peaceful type. Selected participants were asked to select one of the behavior ([K] [L] or [M]) patterns that comes closest and best suits to their personality, such as:

1. They could choose to become an active but peaceful protester against the government [K].

2. They could choose to become a non-peaceful freedom fighter against the government [L] (where non-peaceful would mean attacks of a violent nature against infrastructure such as buildings or monuments, or even persons directly responsible for atrocities committed by the regime - however, no harming of innocent bystanders shall explicitly be acceptable as collateral damage by the freedom fighters themselves).

3. Participants could also chose [M] if they did not want to participant any of the group and they could remain neutral in this situation.

Among 28 participants; 8 selected [L]; 9 chosen [K] group and 11 students picked [M] as they did not want to participant in any of the activity against dictatorship and wanted to remain silent. Participants with [M] group were automatically dropped out from this study as they were not helpful and significant in our study. Of the 9 participants in freedom activists, 3 did not meet the criteria to be in [K] group. On the other side, of the 8 subjects in freedom fighters [L], 2 did not meet our experimental standards. The reasons for exclusion of subjects from these groups were varied such as structural abnormalities, excessive head motion and failure to follow the fMRI protocol and investigators did not agree on their calls. As [24] argue that the number of participants must be selected to ensure there are sources to calculate the required number of subjects and to ensure that adequate power of fMRI analysis for obtaining statistically-significant brain activations. In the last step we eliminated all those subject who did not correctly identified peaceful-violent and violent-peaceful testing.

The final sample comprised six participants for each group ([K] = 6 and [L] = 6) in the age range between 21 and 25 years and were correctly identified and classified in each group for our paradigm. The required sample size for fMRI studies is typically lower than behavioral lab studies because fMRI protocols include repetition in the experimental design that raises the power of analysis. All these subjects were healthy, normal/corrected to normal vision, right handed and motivated for their participation in our fMRI test session. The study was approved by the local ethics committee of the Medical University of Graz, Austria. All participant were pre-screened for fMRI safety (no medical implants, no metal piercings, no medical problems showed that none of our subjects should be excluded.

No significant differences were found in comparisons of ethnicity, activity chosen against the government (i.e., freedom fighter or freedom activist), gender, and years of education between these two groups. It was ensured that subjects of each behavior types are tested, by finding additional potential test persons until all slots of each of the two types are filled. Those subjects made their choice by selecting one of the options in a way that commits their choice but hides their decision to the experimenter. The option they chosen was reinforced by additional motivational texts either in the one or in the other direction: In the peaceful choice (see Appendix F) it was like with the quotation of Mahatma Gandhi: "Victory attained by violence is tantamount to a defeat, for it is momentary.", or, in the non-peaceful choice, e.g., through the quotation of Benjamin Franklin: "Those who would give up Essential Liberty to purchase a little Temporary Safety, deserve neither Liberty nor Safety.". However, subjects who chosen the non-peaceful behavior were additionally given the text (see Appendix G) that was also handed out to the subjects who chose the peaceful behavior, along with the instruction to use that text as background material during their "interrogation" in order to conceal their hidden non-peaceful plan. Both groups were assured that peaceful protest at this moment of time will be tolerated by the regime and not lead to recriminations (e.g., because of third party observers from United Nations and impending economic sanctions etc.) - protesters of the first behavior type should had not attempt to conceal their intended peaceful behavior, whereas freedom fighter of the second behavior type had to actively conceal their intended violent behavior (in order to be able to carry out their planned attack after their interrogation) and attempted to pass the interrogation as if they had chosen the role of a peaceful protester. In contrast, test persons that chosen the peaceful option were not allowed to read the additional instructions given to the non-peaceful group.

Subjects that chosen to play the role of a freedom fighter had to plan a violent attack, either against infrastructure such as buildings, monuments, or against persons those are directly responsible for atrocities committed by the regime. Subjects belonging to the peaceful protester group were not involved in the planning of any violent attack. They were however involved in non-violent opposition activities, e.g., open distribution of literature and leaflets, participation in peaceful political demonstrations, writing of peaceful antigovernment newspaper articles, and similar non-violent activities.

Instructions for freedom fighter contained information (see Appendix G) about possible attack location and persons directly responsible for governmental atrocities including a list of Austrian cities, months and weapons-and were told to circle any of the items or persons that have a special meaning, such as a place they have lived, the month they were born or any weaponry they are particularly fond of or familiar with. Instruction list was: *"I am informed that my resistance cell coordinator has chosen to attack buildings or persons in Vienna or Graz within the next six weeks. I am supposed to recommend one of four specific locations or persons-the regime's official party building, the palaces of important leaders of the oppressive government, the head of the evil internal ministry, a weapon's factory etc.- for the attack and four dates in the next 6 weeks during which the attack could take place. I'm given the pros and cons; and when I've made my decision, I'm told to communicate (in a secure way) to my cell's coordinator my recommendation and the reasoning behind it".*

After reading the descriptions and contained pros and cons of each potential choice, subjects were instructed to choose one type of form of attack, one location or person in Vienna or Graz, and one date on which to attack. Finally, subjects were instructed to compose a letter to the coordinator of their resistance cell describing the choices they have made. There were no explicit formal training or instructed item memorization in this protocol. In the next step, in a shielded room, subjects (freedom fighters) were handled 15 objects (maps, plastic guns etc.) according to a task list. They took one object after the other into their hands, looked at it in detail, and deposited it on top of a storage rack. Then, they packed all 15 objects attentively from there into a suitcase placed in the same room. For each participant, one object was randomly drawn from each of the 15 object categories.

Subjects in the peaceful group completed a similar task planning. Similarly information packet for peaceful protesters compromised of place and time for their protest in Graz and Vienna instead of a violent attack. The purpose was to correctly identifying peaceful subjects vs. non-peaceful subjects. Subjects in this study were given a week to decide to select either a violent attack or a peaceful protest action (e.g., peaceful subversive leaflet distribution) and then were scanned by fMRI. The study used three separate test blocks for three different categories of concealed information (location, date, and method of the planned attack/protest) in an attempt to increase detection accuracy and reduce false positives. Subjects were then given the additional incentive such as an additional high-quality USB-memory stick as a gift if investigator cannot tell when they will be deceive while in the scanner. This incentive provided motivation for subjects to attempt countermeasures when lying. After scanning, subjects completed a questionnaire about the study.

4.1.3 Activation paradigm

Subjects were trained to visually familiarize with the experimental conditions and procedures to enhance the task performance and to minimize the anxiety. Participants were also given instructions to both groups before the start of the scanning session. Such as for freedom fighters: "You should hide your motivation, your task and mission details and do not disclose it when you are interrogated, to make this mission successful. Your mission is to fake well, do it with skill and avoid detection." Analysis was done with both given advance knowledge of the probe (to identify individuals as knowledgeable about the attack) and without advance knowledge (to identify the details of the planned attack in addition to individuals involved in the attack). Additionally, this current study used three separate test blocks for three different categories of concealed information (location, date, and method of the planned attack) in an attempt to increase detection accuracy and reduce false positives.

4.1.4 Trial Design

A set of 60 sentences (see Appendix H) in pseudo-randomized order with each item presented only once. Visuals stimuli were used to both measure the two dimensions of lie and truth across the terrorist and peaceful related activities and to serve as repetitive stimuli to spawn activation in brain areas associated with the dimensions of freedom fighter and freedom activists.

4.1.5 Duration of fMRI Study

This thesis uses event related design to observe the differences in neural activity associated with each event and for the faster image acquisition. The reason an event-related design was used in this research was to distinguish freedom fighters and freedom activists for truth verification. The sentences were presented in an even related fMRI design consist of 3 runs with 20 questions each. Each question was presented for 3s to ensure that participants had enough time to answer it and to obtain a high activation rate. Participants were requested to press index finger for answering "Yes" and middle finger for "No". After the presentation of the response option, an inter-trial-interval of 1-5 seconds with a fixation point (s; average presentation time of 4 s) was presented, followed by the presentation of the question (i.e., Have you or your group planned to use an RPG-7 (Rocket Propelled Grenade) in your mission?) for 3 seconds.

4.2 Data Analysis

Data analysis, procedure, trial design, experimental conditions, MRI Data Acquisition, fMRI protocol and preprocessing was done as described in 1st study. However, to investigate neural activities associated with deception, contrasts of lie>truth and truth>lie were performed using two sample t-tests at the second level for all subjects (P<0.001). In the 1st and 2nd-level analyses, a conservative extent threshold of 20 voxels was applied. The peak voxels of clusters that exhibited reliable effects are reported in MNI (Montreal Neurological Institute) coordinates. Two analyses were conducted to examine to detect concealed readiness to be involved in violent attacks or peaceful protest by aiming at detecting the presence or absence of attack-related information in a suspect's memory (Terrorist VS Innocent). The analysis was carried out by means of a whole-brain, voxel-wise random-effects test comparing and across the entire sample of subjects. This investigation produced a great number of brain regions that displayed greater functional MRI signal during the deceptive compared to the true answers trials.

An uncorrected threshold of $p > 0.001$ were used to evade the reporting of large, interconnected clusters of activation that span multiple brain regions and to further constrain the analysis to the most significant activation. To isolate brain regions whose activation exhibited an interaction between accuracy (Terrorist VS Innocent), a paired-samples test was run. An initial uncorrected threshold of $p > 0.001$ was applied for this higher-order contrast. Using cluster-size thresholding, the resulting statistical maps were subsequently corrected for multiple comparisons and an initial voxel-level (uncorrected) threshold was set. Then, based on an iterative procedure and estimate of the map's spatial smoothness, the thresholded maps were submitted to a whole-slab correction criterion (Monte Carlo simulation) for estimating cluster-level false-positive rates. Furthermore, after thousand iterations, the minimum cluster-size that produced a false-positive rate. A cluster-level of .05 (5%) was used to threshold the statistical maps. This technique calculates the size that a cluster would need to survive a correction for multiple comparisons at a given statistical level. In this analysis, only activations whose sizes meet or exceed the cluster threshold are acceptable to remain in the statistical maps. Results will be discussed in the next chapter.

4.3 Specifying Procedures After fMRI Scan

According to [25] it is strongly suggested to replicate the fMRI protocol to compare the corresponding behavioral data before and/or after the fMRI session and within and outside the fMRI scanner depends on the study's procedures. It is recommended that a dependent variable that involves an actual behavior of the subject may be captured after the fMRI session. The purpose is to identify that all subject had similar behavioral responses within and outside the fMRI machine and to test the veracity of the experimental tasks [25]. Secondly to ensure that the experimental protocol was clear to the subjects, they understand the manipulations, perceive the experimental tasks, and perform the tasks correctly (relative to the control or baseline condition). After completing the fMRI scanning session, participants were asked to perform additional jobs to check the manipulations of this experimental study. Subjects were instructed to engage in a task that is not related by the fMRI scanner but it was required to complete the required set of experimental session. After scanning, subjects completed a questionnaire about the study and data were gathered by asking the interviewee a series of questions. Such as "did you feel anxiety in fMRI machine"?

Another benefit of this behavioral study is to identify that participants had behavioral responses within and outside the fMRI scanner and they replicated the same procedures after the fMRI session. This behavioral study allow comparison between the data collected during the fMRI study and data collected outside the lab with the same set of subjects. Another benefit is to ensure the validity of the experiment; otherwise a concern could be raised that fMRI machine may have altered the participant's responses [114] and behaviors and behavioral responses and are not biased by the scanning environment. According to [114] "researchers should seek convergent validity by linking fMRI data to other behavioral measures." In this study, similar findings were acquired across the inside and outside the scanning environment and implying that fMRI setting did not bias the participant's behavioral response. Analysis of intra-scanner responses revealed that 98% of responses for each of our 12 subjects could be satisfactorily coded. For the lie, truth, and control trials collectively, no participant made more than 2 mistakes across the two imaging runs. In post-scan debriefing, participants denied noticing anxiety about the lie trials, but few (3 of 12) reported that they felt some "performance anxiety" when thinking about whether their response would be detected by changes in their brain activity. The purpose was to find that subjects had behavioral responses within and outside the fMRI scanner. Finally, participants were offered answers to their questions and given their incentive to participate in this study, thanked, and dismissed.

CHAPTER 5

Results and Evaluations

In both groups, contrasts were derived for brain activity related to the following comparisons: lie>truth, lie>control, truth>lie and truth>control in freedom fighters group and truth>control in freedom activist group as this group was instructed not to lie in any task. These contrast images were then entered into a two-sample t-test across the 12 subjects (six in each group) in a second-level analysis to allow for inferences. This generated statistical parametric maps of the t statistic at each voxel, which were then converted to the Z distribution. From voxel-wise comparisons, activation were considered significant in regions in which we had an a priori hypothesis and whose activation exceeded a height threshold of $P > 0.001$ uncorrected with a range of at least 20 contiguous voxels. This thresholds is frequently applied in the prior lie detection studies, proposed to strike a balance between rates of type I and type II error. Reported activations outside our priori areas had to extend a threshold of $P > 0.001$. The activations in the regions of a priori hypothesis were also examined by extracting the raw time courses of BOLD signals for truth and lie trials from functionally derived local maxima for each participant.

5.1 Contrast 1: Lie>Truth & Lie>Control

Lying is the combination of cognitive processes that subserve deceptive responding and Lie minus True is the subtraction that best isolates the act of lying by controlling for the most confounds. In order to successfully avoid detection in violent questions, the freedom fighters had to calculate the odds of being detected and choose the appropriate strategy prior to making a response that relied heavily on working memory involvement in Lie minus True task. Our data show that on lying task, participants exhibited consistent behavioral and functional anatomical responses. The time-course extraction of the BOLD signal showed a greater activity during lie vs. truth trials (averaged across 6 subjects) and while lying their response times was significantly increased and there was reliable activation within specific regions of prefrontal cortex. We generated group image maps for our freedom fighters to test our hypotheses regarding the functional neuro anatomy and regions involved in the predictive capacity of imaging to detect deception. To investigate the regions that were linked with deception, contrasts between the "lie>truth" and "lie>control" conditions were performed. This study found significant activation ($P < 0.001$, FWE corrected) in the comparison of brain region activity between the freedom fighters group with violent

Cluster	Region	BA	Maximum z	MNI Coordinate x y z	Cluster Size
VLPFC	R	47	4.80	60 14 -5	364
MPFC	L	8	5.63	21 36 202	424
DLPFC	R	9	5.02	40 61 345	429
IFG	R	45	4.87	53 9 2	352
OFG	L	11	3.95	-5 30 30	299
MFG	L/R	9	2.77	32 23 41	211
SFG	L/R	6	2.65	2 46 2	186
Amygdala	L	47	2.48	-17 0 9	73
STG	L/R	39	2.60	39 -53 -1	143
MTG	L/R	21	2.11	-42 21 38	109

Table 5.1: Group analysis of 6 subjects (freedom fighters) combined into a common brain looking at the difference in brain activation when lying about violent activities compared to when they were telling the truth. (Threshold $p < 0.001$ - group analysis of lie minus true)

Cluster	Region	BA	Maximum z	MNI Coordinate x y z	Cluster Size
VLPFC	R	47	5.44	-51 -63 0	388
MPFC	L	8	5.21	-12 6 -1	411
DLPFC	R	9	4.83	22 55 -27	400
IFG	R	44	4.25	23 23 -6	302
OFG	L	11	3.77	23 42 -41	340
MFG	L/R	10	2.77	-21 0 12	211
SFG	L/R	6	2.65	2 46 2	186
Amygdala	L	47	3.21	14 53 -10	127

Table 5.2: Group analysis of 6 subjects (freedom fighters) combined into a common brain looking at the difference in brain activation when lying about violent activities compared to control questions. (Threshold $p < 0.001$ - group analysis of lie minus control)

questions that showed increased signal intensity in more areas in lie minus truth and lie minus control than the truth minus control and truth minus lie. The lie>truth (see Table 5.1) and lie>control (see Table 5.2) contrast yielded nearly identical results include: Ventrolateral Prefrontal Cortex (VLPFC), Dorsolateral Prefrontal Cortex (DLPFC), Medial Prefrontal Cortex (MPFC), Inferior Frontal gyrus (IFG), Orbitofrontal gyrus (OFG), Middle Frontalgyrus (MFG), Superior Frontalgyrus (SFG), Superior Temporalgyrus (STG), Middle Temporalgyrus (MTG) and Amygdala. Average brain function areas of the freedom fighters group in lie>truth are presented in Figure 5.1, main brain regions activated are presented in Figure 5.2 and 3D signal changes are depicted by Figure 5.3.

In keeping with our first a priori hypothesis, these results clearly reveals our hypothesized areas in lie minus truth contrast (FDR corrected, $p < 0.001$, extent threshold>20): (A) Ventrolateral Prefrontal Cortex (VLPFC) (BA47) (B) dorsolateral prefrontal cortex DLPFC (BA8), (C) Inferior Frontal gyrus IFG (BA45) and (D) Medial Prefrontal Cortex

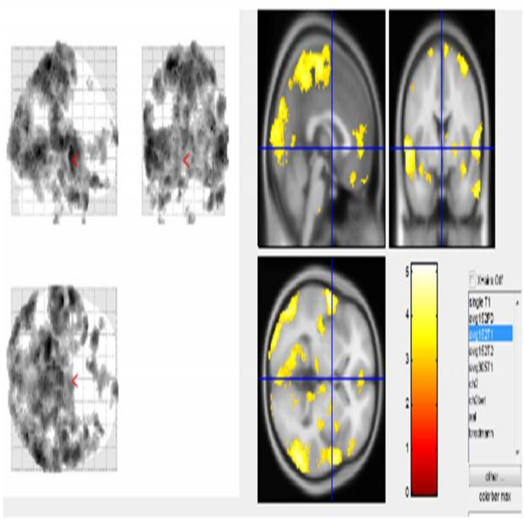


Figure 5.1: The freedom fighters group analysis of lie minus true (lie>true) revealed significant activation displayed on a brain template from xjview. The transvere slices of the briain start dorsal and move ventrally. During analysis, events of truth telling were deducted from events of lying. Statistical Parametric Mapping 8 (Welcome Department of Imaging Neuroscience) were used to determine statistical maps and were superimposed onto a structural template of the brain with MRIcro. Significant activated regions are Dorsolateral Prefrontal Cortex, Ventrolateral Prefrontal Cortex, Medial Prefrontal Cortex, Dorsal Medial Prefrontal Cortex, Inferior Frontal gyrus, Inferior Orbitofrontal and Amygdala shown by yellow.

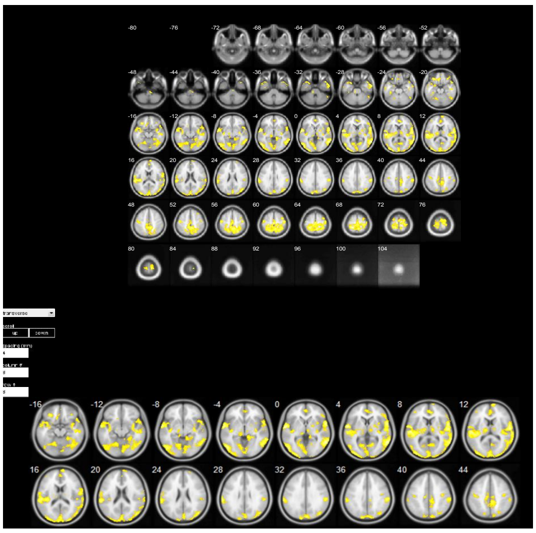


Figure 5.2: Functional image subtraction of control questions from violent questions in freedom fighters group

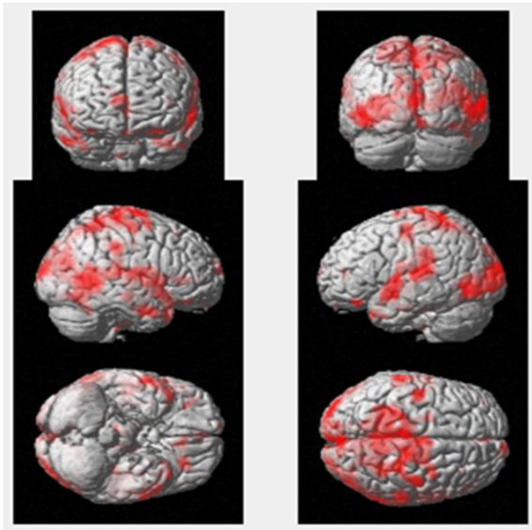


Figure 5.3: 3D structure figure. Brain regions activated by violent questions (lie>truth)

MPFC (BA10) adjacent Brodmann areas with symmetrical local maxima. However, an entirely different set of results observed in in each hypothesized area with distinct patterns of cortical activation in freedom fighter subjects with the processing of different valences of stimuli and emotion. Our hypothesized brain regions activated are presented from Figs 5.4-5.8.

The contribution of DLPFC and VLPFC to deception is most cautiously interpreted as being bilateral in distribution. Our primary focus was not only on the activity of sub regions within the prefrontal cortex but also on activity in the anterior cingulate cortex. However, in contrast to our hypothesis, we did not detect marked activation of anterior cingulate cortex (ACC) in any of the contrast (Lie>Truth and Lie>Control). However, there was a minor focus of less than 20 voxels extent and found small cluster in lie>true comparison. The other non-hypothesized regions such as superior temporal gyrus activated which met statistical significance as they were not hypothesized prior to the study. In the main effect of deceiving the investigator, another essential aspect of human deception the amygdala cortex was found to be active and met statistical significance. The results of this thesis might be related to the previous findings that these regions are associated with emotional processing and fear [45][30][29].

5.1.1 Individual Analysis for Lie Minus True

In this analysis, we generated within-individual statistical maps to test for individual heterogeneity in brain activation among freedom fighter subjects. We then analyzed the fMRI data on a within-individual statistical maps to test for individual heterogeneity in freedom fighters group. Using a statistical threshold of $p < 0.001$ and extent threshold > 20, we examined each individual to determine whether they had significant activation in any of these regions during the deception minus true comparison. Within subject analysis of Lie>Truth and Lie>Control produced large variations in the regions of significant differences in blood flow across this group. An entirely different set of results observed in each individual with

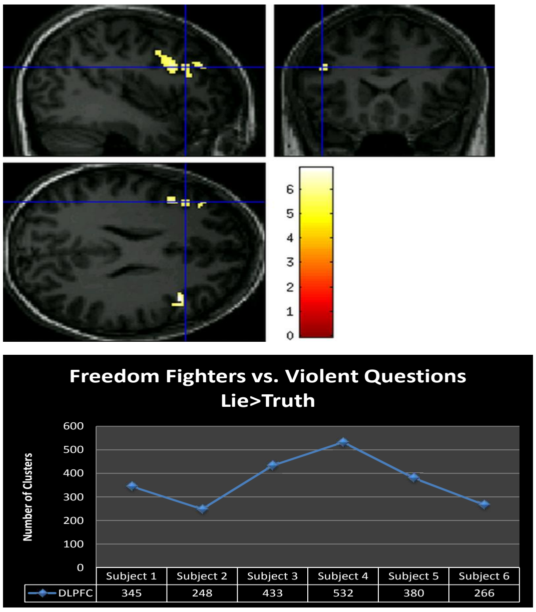


Figure 5.4: The bar graph represents the strength of activation with respect to t-score. The dolsolateral prefrontal cortex (BA9) was activated in freedom fighters against violent questions (lie>truth). In this figure Statistical Parametric Mapping rendered into stereotactic space and superimposed onto sagittal, coronal and transverse Magnetic Resonance Imaging in standard space.

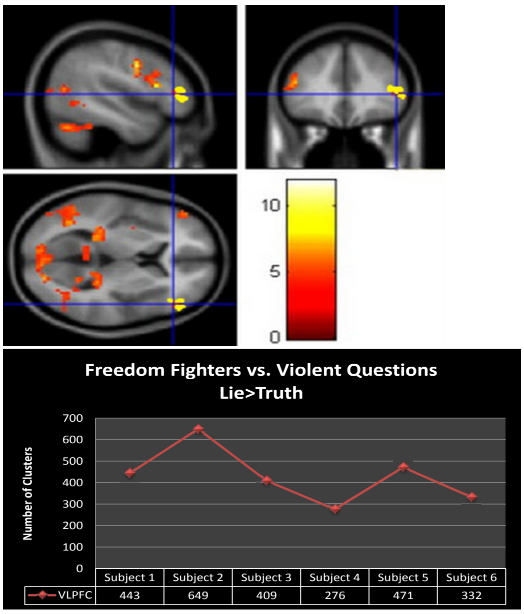


Figure 5.5: The bar graph represents the strength of activation with respect to t-score. The Ventrolateral Prefrontal Cortex (BA47) was activated in freedom fighters against violent questions (lie>truth).In this figure Statistical Parametric Mapping rendered into stereotactic space and superimposed onto sagittal, coronal and transverse Magnetic Resonance Imaging in standard space.

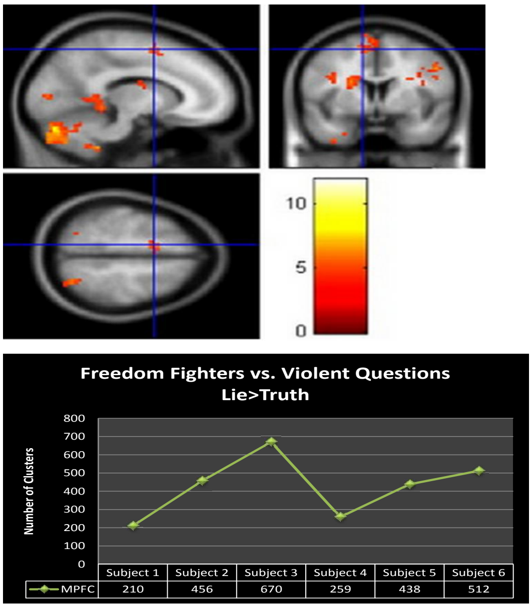


Figure 5.6: The bar graph represents the strength of activation with respect to t-score. The Medial Prefrontal Cortex (BA8) was activated in freedom fighters against violent questions (lie>truth).In this figure Statistical Parametric Mapping rendered into stereotactic space and superimposed onto sagittal, coronal and transverse Magnetic Resonance Imaging in standard space.

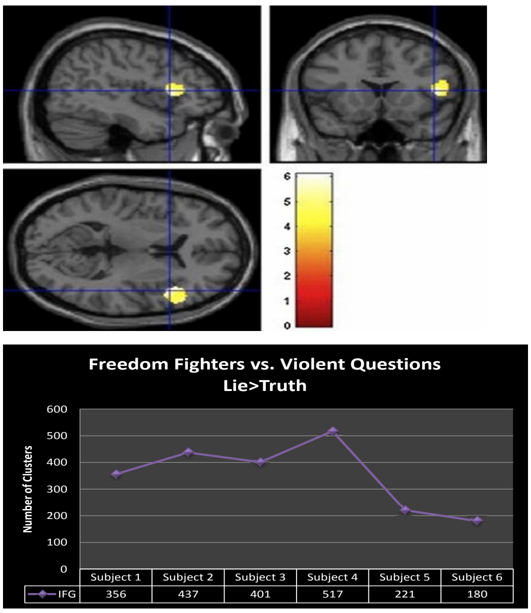


Figure 5.7: The bar graph represents the strength of activation with respect to t-score. The right inferior frontal gyrus (BA44) was activated in freedom fighters against violent questions (lie>truth). In this figure Statistical Parametric Mapping rendered into stereotactic space and superimposed onto sagittal, coronal and transverse Magnetic Resonance Imaging in standard space

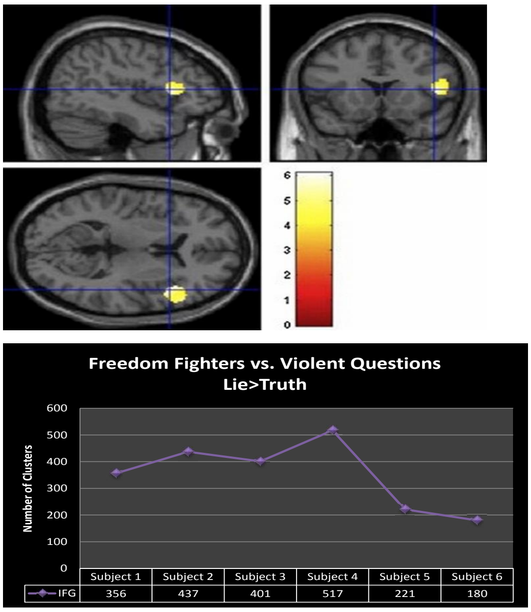


Figure 5.8: The bar graph represents the strength of activation with respect to t-score. Orbitofrontal gyrus (BA11) was activated in freedom fighters against violent questions (lie>truth). In this figure Statistical Parametric Mapping rendered into stereotactic space and superimposed onto sagittal, coronal and transverse Magnetic Resonance Imaging in standard space

different patterns of brain activation (See Figure 5.9 and Figure 5.10). depending on the individual with different types of processing involved in the different types of emotional responses and how intricate the situation and lie is. Our findings appear to be in line with these observations that both shared as well as distinct neural systems are involved in processing different emotions.

In the 6 healthy freedom fighter subjects studied inside the scanner, response times were significantly longer when lying (Figure 5.11). This applied to both the violent sentences and violent images protocol in Lie>Truth which suggests that the recognition, suppressing of truth and feeling of knowing is produced from summary cognitive processes that contribute to efficient recall in a complex search of memory storage. No errors were committed by any of the subjects in the two experimental conditions. Mean accuracy across all trials was .95% correct (i.e. truth or lie according to task specification).

5.1.2 Comparison of brain region activity in Freedom Fighters vs. Violent Questions (Images + Sentences) Lie>True

When the analysis of violent questions was restricted to either stimulus type (violent images and violent sentences), the resulting maps yielded seemingly slightly different patterns of neural activity in the brain network of freedom fighters group (Table 5.3). For instance, performing the violent images, freedom fighters exhibited greater activity in the following areas during deception (relative to telling the truth): Ventrolateral Prefrontal Cortex Dorsal Medial Prefrontal Cortex Inferior Frontal gyrus Medial Prefrontal Cortex Inferior Orbitofrontal and Amygdala (Figure 5.12).

However, in violent sentences protocol, lying (relative to truth) was associated with greater

Cluster	Region	BA	Maximum z	MNI Coordinate x y z	Cluster Size
ACTIVATIONS WITH VIOLENT SENTENCES					
VLPFC	R	47	4.80	60 14 -5	364
MPFC	L	8	5.63	21 36 202	424
DLPFC	R	9	5.02	40 61 345	429
IFG	R	45	4.87	53 9 2	352
OFG	L	11	3.95	-5 30 30	299
MFG	L/R	9	2.77	32 23 41	211
SFG	L/R	6	2.65	2 46 2	186
Amygdala	L	47	2.48	-17 0 9	73
STG	L/R	39	2.60	39 -53 -1	143
MTG	L/R	21	2.11	-42 21 38	109
ACTIVATIONS WITH VIOLENT SENTENCES					
VLPFC	R	47	4.80	60 14 -5	364
MPFC	L	8	5.63	21 36 202	424
DLPFC	R	9	5.02	40 61 345	429
IFG	R	45	4.87	53 9 2	352
OFG	L	11	3.95	-5 30 30	299
STG	L/R	39	2.60	39 -53 -1	143
SFG	L/R	6	2.65	2 46 2	186

Table 5.3: Group analysis of 6 subjects combined into a common brain looking at the difference in brain activation when lying about violent activities (Violent Images + Violent Sentences) compared to when they were telling the truth. (Threshold $p < 0.001$ - group analysis of lie minus true)

activity in the Ventrolateral Prefrontal Cortex (VLPFC) Dorsal Medial Prefrontal Cortex Inferior Frontal gyrus, and Medial Prefrontal Cortex activated during violent sentences (relative to telling the truth). Other regions such as Inferior Orbitofrontal and Amygdala exhibited weaker effects that failed to survive statistical correction (Figure 5.13). When data from each (violent images and violent sentences) of the lying protocols were combined, lying (relative to truthful responding) was associated with greater activity in: Ventrolateral Prefrontal Cortex (VLPFC), Dorsal Medial Prefrontal Cortex, Dorsolateral Prefrontal Cortex, Inferior Frontal gyrus, Medial Prefrontal Cortex and Inferior Orbitofrontal (Figure 5.14).

5.2 Contrast 2: Truth>Lie & Truth>Control

During analysis we did not observe activation in the opposite comparison such as freedom fighters vs. peaceful questions (truth>lie & truth>control) suggesting that there is a rise in the amount of conflict and higher cognitive control required when falsifying the responses compared to replying honestly. In keeping with our other a priori hypothesis 2, we did not find any area where truth telling was associated with greater activity than lying. Average brain function areas of the freedom fighters group in truth>lie and truth>control are presented in Figure 5.15. Main brain regions activated are presented in Figure 5.16 and 3D signal changes are depicted by Figure 5.17. Many studies have also failed to find brain circuits that exhibit greater activation during truth-telling (compared with lying), reported that 'truthfulness' contains a relative baseline in communication and human cognition and; the truth resembling a pre-potent response, which must be suppressed [106]. The main effect of dishonesty or lying is possibly the most sensitive comparison for recognizing activation associated with deception and identifies increased activity in a network of different brain regions such as prefrontal cortex [106][70][1]. The longer reaction times during lying also support this interpretation as terrorist subjects took longer response which suggests that the activation in prefrontal cortex suggest the cognitive processes that contribute to efficient recall in a complex search of memory storage.

5.3 Freedom activists vs. Peaceful Questions (Truth>Control)

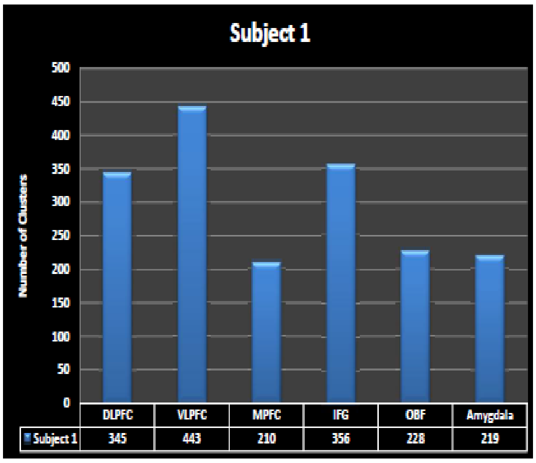
Our analysis of freedom activists vs. peaceful questions in truth>control revealed no activation in freedom activists group (Figure 5.18) with the opposite comparison in true>control in violent questions suggesting that, compared to visualizing peaceful images, violent images increases the greater levels of required cognitive control and the amount of conflict. These findings confirmed the replication of different neuroimaging studies that brain regions do not produce activations during truth telling in neutral images [106][35][70][107][1][68].

5.4 Freedom activists vs. Violent Questions (Truth>Control)

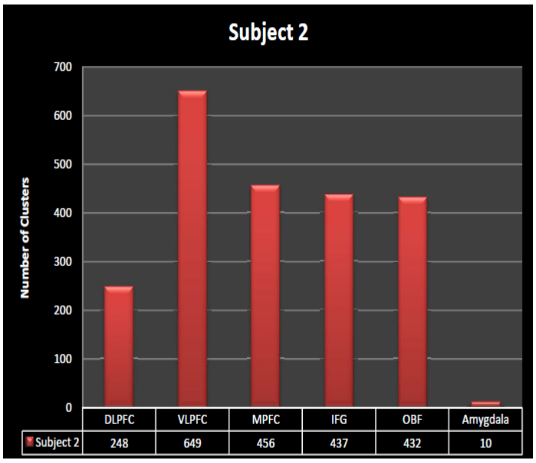
However, the analysis of freedom activists vs. violent questions in truth>control images yielded seemingly slightly different patterns of neural activity in the brain network of freedom activists to either stimulus type (violent images and violent sentences). Consider the conceptual differences in recognizing sentences compared to recognizing images. This thesis did not find any activation in freedom activists during violent sentences suggest that images and words are two qualitatively different tasks and it is not surprising that their activation involve additional, distinct regions of the brain. Average brain function areas of the freedom activists group in truth>control are presented in Table 5.4 and Figure 5.19. Main brain regions activated are presented in Figure 5.20 and 3D signal changes are depicted by Figure 5.21. During truth>control contrasts, our data revealed interesting results and showed increased activity in freedom fighters group in the network of Amygdala (BA47) (FDR corrected, $p < 0.001$, extent threshold > 20) given our a priori hypothesis predictions. However, in contrast to our hypothesis, we found activations in the areas of prefrontal cortex such as left Inferior frontal gyrus (BA45) which is believed to specialized in recognizing images [98][19]. Likewise, the fusiform face area, located in the right hemisphere, is associated specifically to the recognition of faces [53]. These significant areas also overlap with the activated areas in freedom activists group during lie>true (Figure 5.22). Other activated areas were Precuneus (BA7) (Figure 5.23), Hippocampus (BA28) (Figure 5.24), Insula (BA13) (Figure 5.26) and inferior parietal lobule (BA40) (Figure **??**) while answering truth to violent images. Activation in left inferior frontal gyrus also revealed that all of the prefrontal activations pertaining to memories and indicate that these regions are commonly associated with emotional valance of memory content [8][44][34][5]. These results support our a priori hypothesis that the pattern of prefrontal activity would differ depending on the emotional valence of stimuli. We also found that activation pertaining to the memory of emotional pictures related to terrorist activities such as explosions, images of violence activated regions of Amygdala and Insula (Figure 5.27). The horrible images also created a powerful dominant theme with the images of explosion and the sight of human loses with the descriptions of falling buildings of 9/11 were associated with increased activity in the Amygdala and prefrontal cortex such as inferior frontal gyrus. Another possible explanation for these results is that the stimuli used in the present study gave rise to emotions strong enough to activate prefrontal activity even in freedom activists. Additional studies are required in this area to explore whether the present results can be replicated using stimuli that cause more intense emotions. More sophisticated experimental paradigms would better characterize the role of these regions. This study demonstrated that the prefrontal cortex plays a crucial role in the executive processes of deception.

Cluster	**Region**	**BA**	**Maximum z**	**MNI Coordinate**			**Cluster Size**
				x	y	z	
IFG	L	47	4.49	-27	16	-9	189
Amygdala	L/R	46/47	2.85	-2	34	63	159
Insula	L	13	2.83	-38	10	21	80
Hippocampus	R	28/27	3.11	0	-62	33	55
Precuneus	R	7	3.25	-11	23	52	96
IPL	L	40	2.01	7	20	-29	33
MFG	L	9	2.33	-42	21	38	29
SFG	L	9	2.21	-22	45	9	27
MTG	L	21	2.90	-48	-18	-13	26
STG	L	39	2.00	-53	-61	21	25

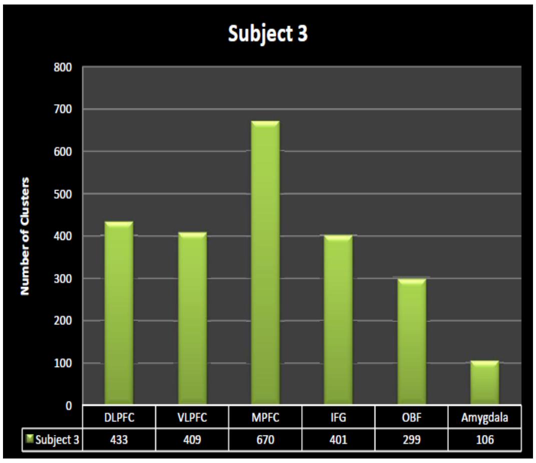
Table 5.4: Group analysis of 6 subjects combined into a common brain looking at the difference in brain activation when telling truth about violent activities compared to with control questions (Threshold $p < 0.001$ - group analysis of truth minus control



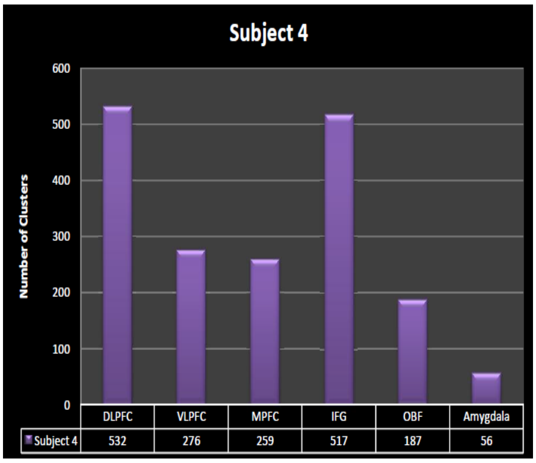
(a) Subject 1



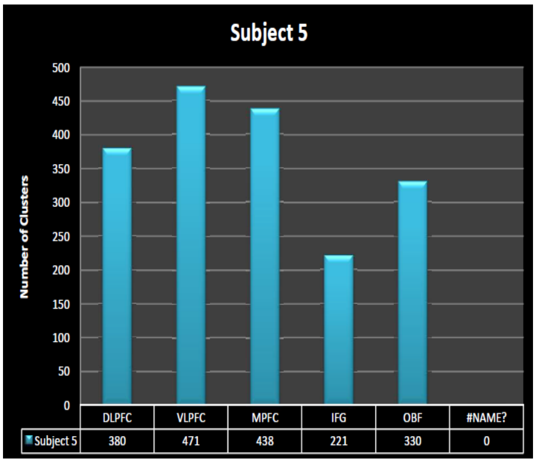
(b) Subject 2



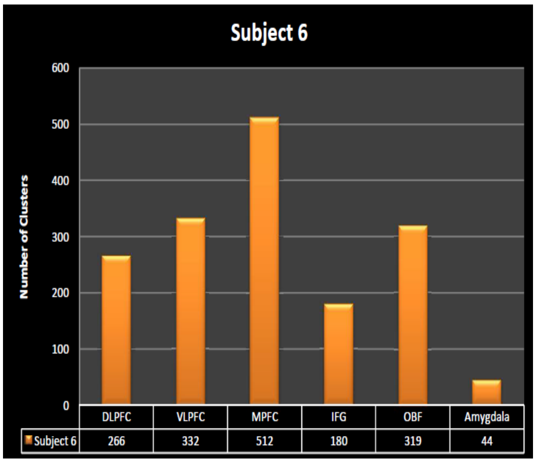
(c) Subject 3



(d) Subject 4

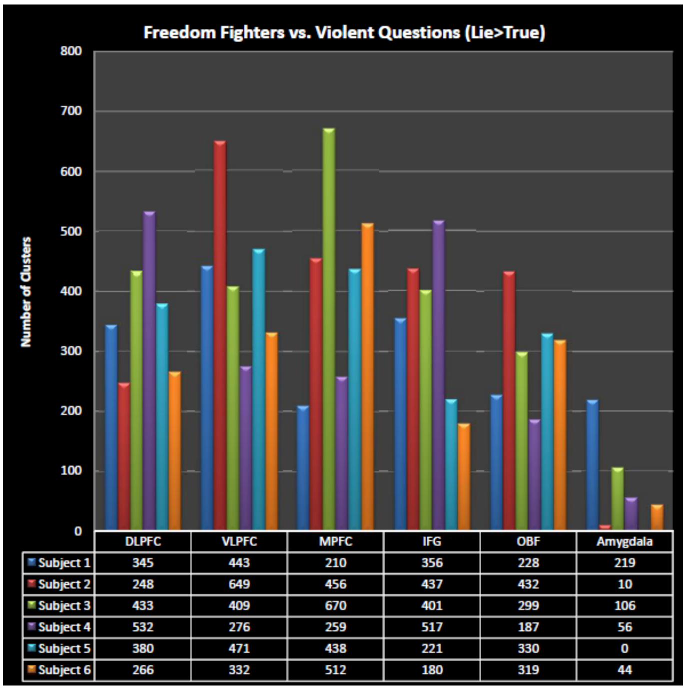


(e) Subject 5



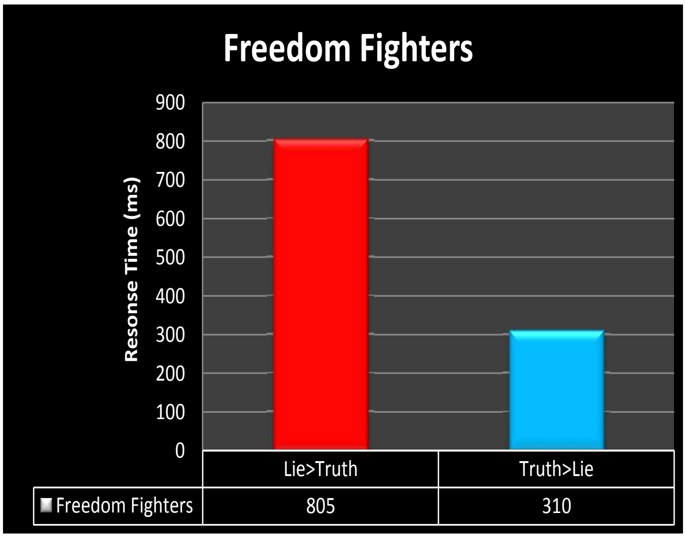
(f) Subject 6

Figure 5.9: Freedom fighters vs. Violent Questions (Lie>Truth)



	DLPFC	VLPFC	MPFC	IFG	OBF	Amygdala
Subject 1	345	443	210	356	228	219
Subject 2	248	649	456	437	432	10
Subject 3	433	409	670	401	299	106
Subject 4	532	276	259	517	187	56
Subject 5	380	471	438	221	330	0
Subject 6	266	332	512	180	319	44

Figure 5.10: Group comparison of Freedom Fighters vs. Violent Questions



	Lie>Truth	Truth>Lie
Freedom Fighters	805	310

Figure 5.11: Difference in response times across groups (Freedom Fighters vs. lie>truth & truth>lie)

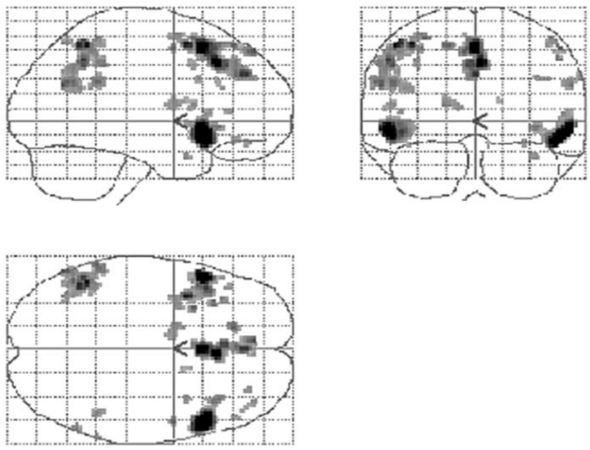


Figure 5.12: Freedom Fighters vs. Violent Images (Lie>Truth)

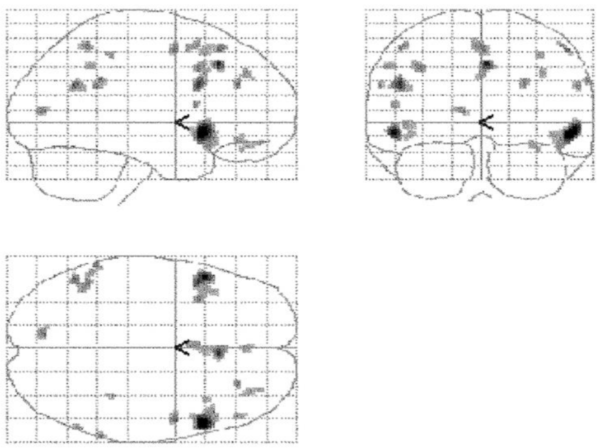


Figure 5.13: Freedom Fighters vs. Violent Images (Lie>Truth)

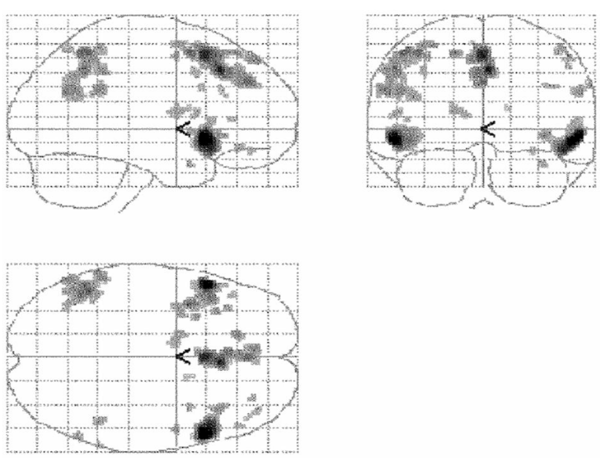


Figure 5.14: Freedom Fighters vs. Violent Images + Violent Sentences (Lie>Truth)

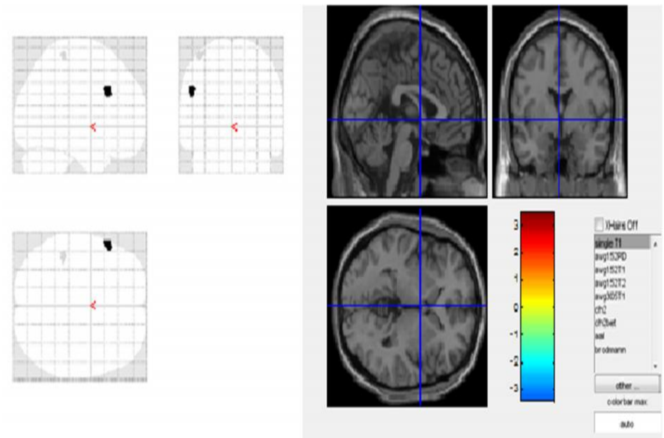


Figure 5.15: The Freedom Fighters vs. Peaceful Questions (Truth>Lie & Truth>Control) group analysis revealed no activation on a brain template from xjview

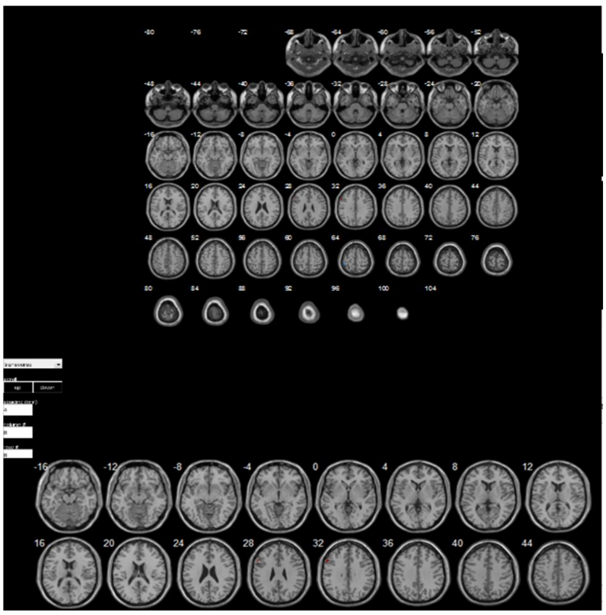


Figure 5.16: Functional image subtraction of truth questions from violent questions in freedom fighters group

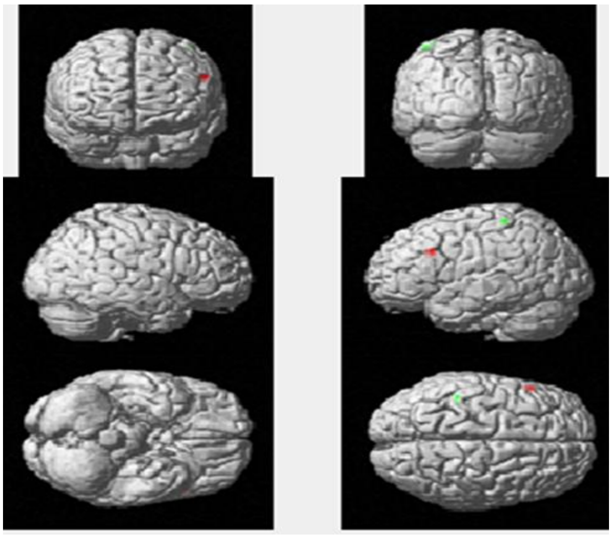


Figure 5.17: 3D structure figure (Brain regions activated by peaceful questions (truth>lie & truth>control)

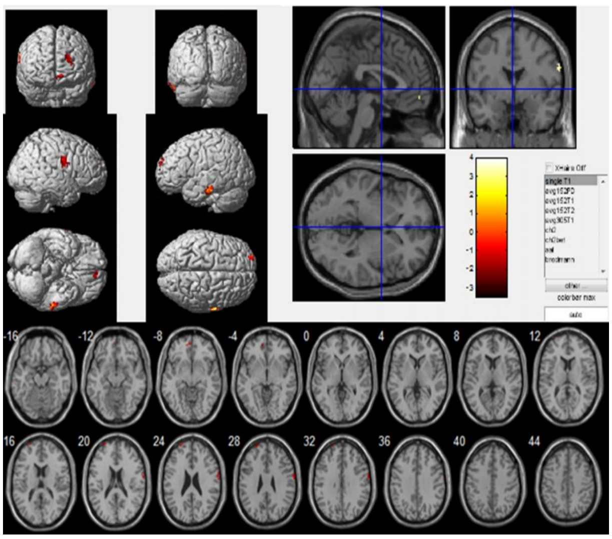


Figure 5.18: Freedom Activists vs. Peaceful Questions (Truth>Control)

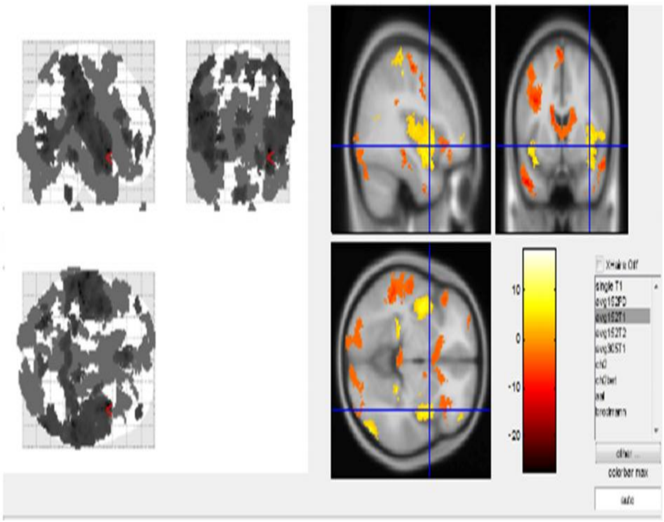


Figure 5.19: The freedom activists group analysis of truth minus control (truth>control) revealed significant activation displayed on a brain template from xjview. The transvere slices of the briain start dorsal and move ventrally. During analysis, events of control questions were deducted from events of truth questions. Statistical Parametric Mapping 8 (Welcome Department of Imaging Neuroscience) were used to determine statistical maps and were superimposed onto a structural template of the brain with MRIcro. Significant activated regions are IFG, Amygdala, Insula, Hoppocampus and Precuneus shown by yellow.

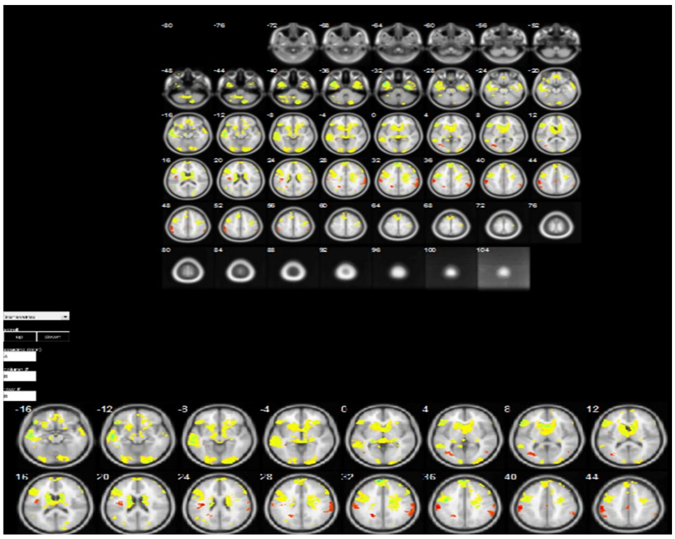


Figure 5.20: Functional image subtraction of control questions from violent questions in freedom activists group (truth>control)

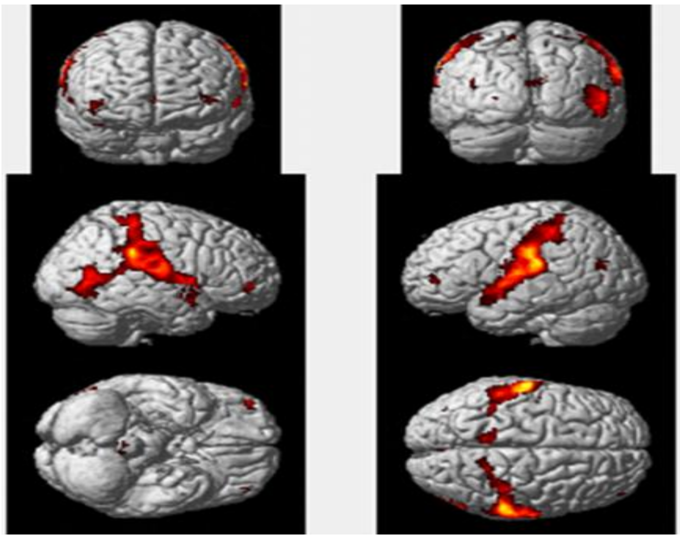


Figure 5.21: 3D structure figure (Brain regions activated by freedom activists vs. violent questions (truth>control)

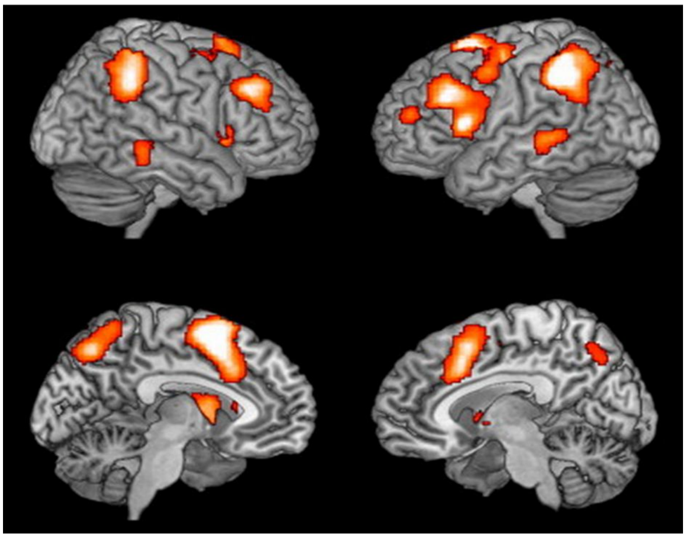


Figure 5.22: Overlapping areas between Freedom Fighters vs. Violent Questions (Lie>Truth) compare with Freedom Activists vs. Violent Questions (Truth>Control)

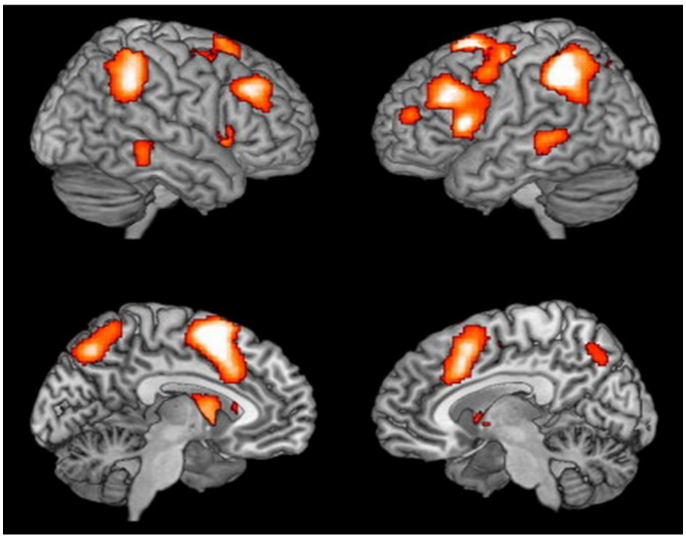


Figure 5.23: Activation of Precuneus in Freedom Activist vs. Violent Questions (Truth>Control)

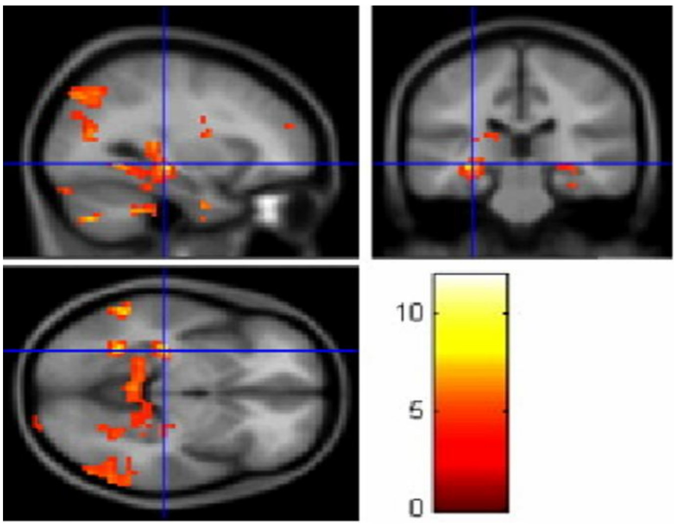


Figure 5.24: Activation of Hipocampus in Freedom Activists vs. Violent Questions (Truth>Control)

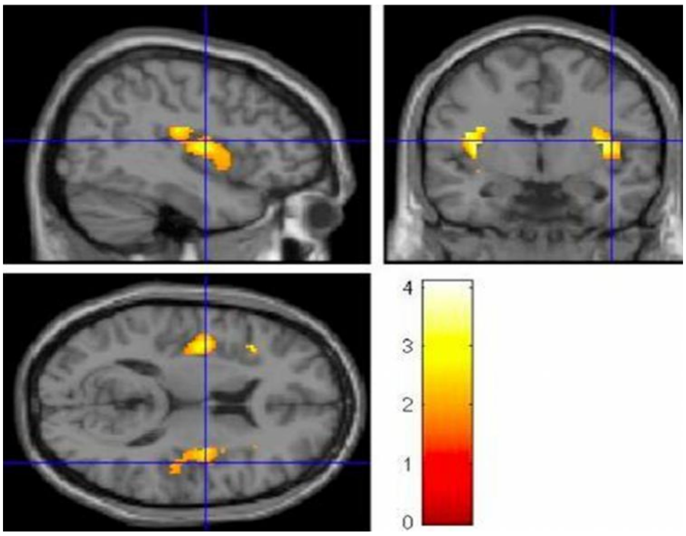


Figure 5.25: Activation of Insula in Freedom Activists vs. Violent Questions (Truth>Control)

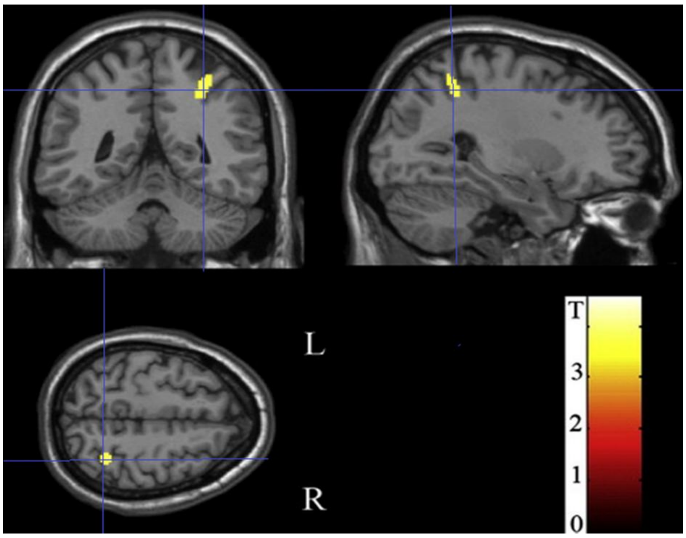


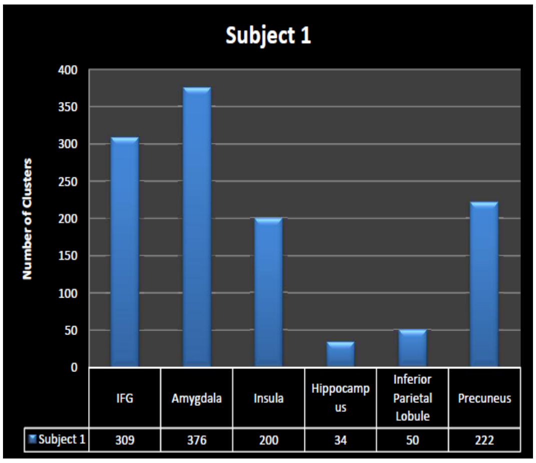
Figure 5.26: Activation of inferior parietal lobule in Freedom Activists vs. Violent Questions (Truth minus Control)

Figure 5.27: Activation of Amygdala and Insula in freedom Activists vs. Violent Images (Truth>Control)

5.4.1 Individual Analysis for Truth Minus Control

In this analysis we generated within-individual statistical maps to test for individual heterogeneity in brain activation among freedom activists to test for individual heterogeneity. Using a statistical threshold of $p < 0.001$ and extent threshold > 20, we examined each individual to determine whether they had significant activation in any of these regions during the truth minus control comparison. This contrast produced large variations in the regions of significant differences in blood flow across this group. An entirely different set of results observed in each individual with different patterns of brain activation (See Figure

5.28). For instance, one participant had no activation in insula, one in precuneus, one in IFG, while 2 subjects had no activation in Amygdala. We assume that activation is depended on the individual with different types of processing involved in the different types of emotional responses and how intricate the situation is.



(a) Subject 1

(b) Subject 2

Figure 5.28: Freedom Activists vs. Violent Questions (Truth>Control)

5.5 Discussion: Contrast 1 & 2

The purpose of the research was to detect the neural signature for deception when freedom fighters groups actively conceal the identity of the terrorist plan and activities and intentionally mislead the investigator. The group analysis (lie>truth & lie>control) performed involved the subtraction of violent questions stimuli - compared to the subtraction of a fixation such as peaceful questions or other baseline measure such as control questions (FDR corrected, $p < 0.001$, extent threshold > 20). However, the neural pattern for peaceful questions did not survive subtraction analysis. We found that in deception pertaining to the memory of violent questions with violent images associated with main effect of deception that showed increased activity in a network of brain areas. Relative to both truth and control trials, lie trials were associated with increased activity in the DLPFC, VLPFC, Inferior frontal gyrus, insula and Amygdala in group and individual analysis in all 6 of the study subjects. It is possibly the most sensitive comparison for identifying activation associated with deception in terrorist group. We also found that deception pertaining to the memory of violent questions with violent sentences was associated with increased activity in the DLPFC, VLPFC, and Inferior frontal gyrus. These results suggest that activation in common prefrontal network in violent question is related with the executive aspects of deception with the emotional valence of stimuli. Our results are consistent with prior observations that the activation of a prefrontal cortex network is specific neural correlates of the act of deception in freedom fighters when tested with terrorist plan. This, therefore, confirms the a priori hypothesis of our studies. The pattern of brain activity in the prefrontal cortex associated with lying that was observed in this study with freedom fighters group is largely consistent with the findings of previous fMRI deception studies, that have indicated a robust contribution of executive function to deception [56][101][10][35][10][8][44][34][5][60][70][83][80] [107][1][79][23][68][69].

As such, it is possible that activation seen in the circuits of prefrontal cortex in a current study is a result of response inhibition, sustained attention, complex interplay of working memory, and mental calculations necessary for the group members of freedom fighters to make deceptive responses. Our study has replicated the results of a large number of studies that have examined the neural activities associated with deception, that deception (compared with truthfulness) is associated with greater activation of the prefrontal cortices, whereas truthfulness is not usually related with greater activity of any cerebral region [10][1][55][51][17][54][32]. In other words, areas of the prefrontal cortex are more active when a subject engages in deception than when responding truthfully. Consistent with our hypothesis, this thesis found that the lie condition (relative to the truth condition) was linked with increased BOLD responses in many areas of prefrontal cortex. In support of this previous work, our present findings strengthen the concept that deception is an inhibition of truth and creation of a lie facilitated by the Prefrontal cortex with the aid of working memory. These results are replication of the finding by [60][68][69][63][105] using different deception paradigms that have reported deception associated BOLD responses in DLPFC, VLPFC and inferior frontal gyrus. These findings have been shown that deception involves executive prefrontal networks in order to attain the production of a 'lie' at the same time as withholding the truth. Most have demonstrated increased activation of prefrontal regions during lying, although the foci implicated have varied between ventrolateral prefrontal [70][1][68][84][59][62], dorsolateral prefrontal cortices [35][1][87] and VLPFC [106][107]

[105] is involved in response suppression and with holding the (pre-potent) truthful response in the context of lie. Our finding replicate these previous findings that neural network for deception involves both attention and memory and it seems that intentional deception involves the monitoring of responses (working memory and error monitoring), suppression of truth (response selection), and attention. Earlier studies have suggested that the areas of prefrontal cortex areas involved in attending to and perceiving precise information are also involved in remembering that knowledge [35]. As such, it is possible that activation seen in the circuits of prefrontal cortex in a current study is a result of response inhibition, sustained attention, complex interplay of working memory, and mental calculations necessary for the group members of freedom fighters to make deceptive responses.

5.5.1 Activation of Anterior Cingulate Cortex

Contrary to our expectation and a priori hypothesis, activation of the ACC was not found in the main effect of falsifying the truthful responses. This region has been reported in some earlier neuroimaging studies [35][79][63][105][59]. However, other lie detection studies did not report this region during deception [23][63][105][87]. The absence of this area in our finding suggest either a failure of replication with previous studies or the possibility that earlier reports of anterior cingulate cortex might have been linked to certain procedural aspects of those previous protocols, and not deception per se. one other possibility is that spontaneous or rehearsed lies are more likely to activate ACC [35]. Whereas this kind of lie was not applied in this study context as this paradigm more emphasis upon on real life events. However, thus, anxiety, fear and fatigue in scanner machine may have impacted the results. Nevertheless, given our a priori predictions, the experimental of this study designed in a way which necessarily gave participants a degree of choice to choose either of group (terrorist or peaceful protestor) for their responses might have served to limit ACC's role in response generation. We think it is striking that regions of prefrontal cortex network emerged as prominently activated during the telling of lies. Failure to activate these areas by some of our participants might activate alternative circuits involved in lying in order to different beliefs in the task at hand or because of different types of lies [35].

An important question is whether the significant activation of ACC in previous studies is unique to deception or this region is activated for monetary rewards. A study done by Langleben and colleagues [63] observed in dorsal ACC in addition to the DMPFC during voluntary lying: However; participants in this study were told that they would win a prize \$20 if they are successfully cheated the interrogators but forfeit this prize if they were unable to conceal the identity of their card from fMRI. Thus offering subjects a monetary incentive to lie accurately under scrutiny is such a task that involves motivation for reward and which have been shown to consistently activate the anterior cingulate gyrus. Therefore, it is possible that the lie detection task used in current experiment might not activate this region since it lacked any motivation for tangible reward. Moreover our small sample size and lie trials may have influenced the detection of activation of the anterior cingulate gyrus during lying in freedom fighters. Future studies are needed to clarify the involvement of the ACC in deception. Further work should investigate this pathway in subjects who did not activate this pathway to determine what impact if any they have on functional Magnetic Resonance Imaging detection of deception.

5.5.2 Activation of Amygdala In Freedom Fighters

Interestingly activation of amygdala in freedom fighters suggests that this thesis may have identified some extremely significant preliminary markers in terrorist group. Consistent with the results of previous studies showing evidence of significant contributions of the Amygdala [1][79][66] claiming that the production of deceptive and the inhibition of true responses are requisites for deception, the intention of deceiving others is likely to be accompanied by emotional regulation. This study might also support this interpretation that activation of Amygdala in FF (during violent question in telling lie) would be expected in relation to the intention of deceiving the interrogator. Our finding also suggesting that the process of deceiving the investigator might make more cognitive demands than that of obeying the investigator. In the main effect of deceiving the investigator, another essential aspect of human deception, the ventromedial prefrontal and the left amygdala were found to be active. This result might be related to the previous findings that both the ventromedial prefrontal cortex and amygdala are associated with emotional processing [45][4][46]. Activation of Amygdala in freedom fighters during deception was because of emotional processing in violent images. This showed that we achieved our aim of making the task situation in counter-terrorism scenario close to real life.

5.5.3 Dorsolateral prefrontal cortex (DLPFC - BA 8/9)

Among the sub-regions within the prefrontal cortex, the involvement of the left DLPFC in lying has been documented in neuroimaging studies [3]. Studies have proposed that this region may be responsible for the executive aspects of deception. Various stimulus types such as deception for autobiographical or nonautobiographical knowledge [84] deception for experienced or non-experienced events [3], spontaneous or memorized lies [35], deception of everyday acts [32], deception about the possession of a specific card [64]. However, Dorsolateral Prefrontal Cortex in deception is not always consistent across studies as some researcher did not find this region associated with deception [105]. Our conjunction analysis revealed that the left DLPFC and right DLPFC were commonly associated with deception and provide strong evidence that these areas plays a critical role in the processes of generating dishonest responses and inhibiting honest responses, regardless of whether the contents of memory are emotional. The question is how the network region of DLPFC associated with deception modulates and modulated by other regional activity. Thus assuming that, the processes of falsifying truthful responses and deceiving others are differentially associated with the activities of these regions. [54] defined this process as the inhibition of the prefrontal cortex by transcranial direct current stimulation that helps deceptive behavior as measured by decrease in the sympathetic skin conductance response, faster reaction times, an increased behavioral pattern of skillful lying and a decrease in feelings of guilt. The transcranial direct current stimulation released the moral conflict associated with deception that is represented in the prefrontal cortex such as DLPFC and VLPFC and thus facilitated the deceptive behavior. Our results strongly support the view that the DLPFC plays a critical and an important role in the executive aspects of deception as well as in viewing emotional images. This region is also activated in our study due to emotional valence of memory content such as source memory.

5.5.4 Ventrolateral prefrontal cortex (VLPFC -BA 47)

In recent studies, activity in VLPFC in the left and right regions has consistently been identified during deception compared with telling the truth in fMRI studies [106][35][70][107][1][68][69][51][54][63][105][3][64]. This region has been involved in the selection of retrieval strategies in the process of deception [92]. It is associated in cognitive control [58], attentional retrieval for anticipation of performance for maintenance of rules prior to task execution [71] and with working memory, particularly for sustained mnemonic response during spatial memory tasks [71]. It supports our hypothesis that deception involves the major areas of prefrontal executive. Our findings may relate specifically to an inhibitory function, the withholding of the truth that is central to our current study design. The right ventrolateral prefrontal cortex is also associated with the inhibition of true answers. Deceptive responses place greater than normal demands on the cognitive processes of the VLPFC executive control functions specifically, inhibition and response alternation [3]. It plays a significant role in conditional learning, self-monitoring of erroneous performance and competing goal-irrelevant motor responses [105]. This region has also been identified [7] in the suppression of automatically cued motor responses in paradigms holding rule conflict. Given the role of VLPFC in freedom fighters can be viewed as two possible explanations for our current findings, that is unable to differentiate using the current data. Activations of these homologous regions may be due to an inhibitory function, the withholding of the truth (in response to specific stimuli) that is accompanied by the production of a lie response and central to our current experimental design. Other reason may be is response reversal (alternation learning). Hence, further investigation is required to differentiate response from alternation response inhibition [97].

5.5.5 Inferior Frontal Gyrus (IFG - BA45)

In the contrast of lie>truth we also observed activation in IFG (Table 5.1, Figure 5.8) that presents how left and right inferior frontal gyrus activated in freedom fighters during deception in order to switch to and maintain a given response set. During the lie condition, the inferior frontal gyrus may have been activated in the present study, in order to switch to the deceitful set. Neuroimaging studies have also provided evidence for the involvement of the joint activation of the Inferior frontal gyrus regions and the different areas of prefrontal cortex (PFC) in working memory, task switching, response selection, complex mental calculations and seems to be part of decision-making processes [42][112][31]. More appropriately, this joint activation has been associated and correlated with deception the mediation of conflict, and reward and motivation [85]. These functional roles of the prefrontal cortex may be essential to deception.

5.5.6 Medial prefrontal cortex (MPFC - BA 10)

The activation of the Medial prefrontal cortex (BA 10) region was entirely expected because all freedom fighters reported in post scan that they had made calculated responses to calculate the proportion of right and wrong answers. However, Medial prefrontal cortex is a large cortical area with many associated functions and it is also believed that this area is activated only when individuals had a mental framework into which they placed incoming information [80]. It is well known from earlier studies that activated regions in this network are significant during the control of executive functions, programming strategies, information integration, manipulation and manifestation of the process of holding in place primary goals while still processing secondary goals simultaneously [92][16]. These observations are in excellent agreement with the findings in our experiment as all subjects had already established a mental framework for deception well before they entered the experimental conditions and underwent scanning process with fMRI. Activation of the MPFC on the other hand, represents intentional retrieval, anticipation of performance, the selection of retrieval strategies, cognitive control and a unique working memory representation in the process of deception [80]. These prefrontal regions were activated during the recall tasks used in our study, which is steady with the results of bilateral prefrontal activation with memory processing that has been reported earlier. These two regions were activated in performing memory tasks with a different functional basis. While right-sided prefrontal activation was typically documented during retrieval [87] and left-sided prefrontal was observed during memory encoding [5].

Previous studies [56][101][10] reveal that the activation of inferior frontal gyrus is not limited to deception but these areas are widely activated in an extensive variety of tasks related with different aspects of "executive functions". The recognition of prefrontal cortical activation in various studies show the involvement of response inhibition and cognitive control in task switching are independent of their role in lie detection [71][39]. Over lapping areas such as inferior frontal gyrus and amygdala (Fig. 22) in both groups also reveals that it remains to be understood which of these brain regions are essentially and necessarily involved in the generation of lies. It remains to be seen that neurocognitive operations in a cortical network can be recognized that is specifically involved in deception.

When the analysis of this study was restricted to violent pictures stimulus type in both groups during violent questions, the resulting maps revealed different patterns of neural activity in the prefrontal cortex (Table 5.3). Such as a significant effect were observed in the left DLPFC and left VLPFC between deception when comparing non-violent images. This study also did not observe any activation in freedom activist group in violent sentences compared to violent images. However, further analysis exposed that all of the prefrontal cortex activations observed in each comparison of deception as well as in viewing violent images by freedom activists during violent questions, indicating that these areas are commonly related with deception as well as emotional valance of memory content. Thus these results support our a priori hypothesis that the pattern of prefrontal activity may be activated would differ depending on the emotional valence of stimuli. The present results suggest that a common prefrontal network is associated with the executive aspects of deception with the emotional valence of stimuli, at least in the experimental paradigm used in this study. Another possible explanation for our null results in ACC is that the stimuli used in the present study did not offered any reward for deception to make a difference in prefrontal activity between the two kinds of deception. Additional studies are needed to show whether the present results can be replicated using stimuli that cause more intense emotions.

CHAPTER 6 Discussion

This thesis explores lie detection with two different kinds of experimental studies. When reviewing result of these two studies, we found inconsistency within each group of task paradigms. After interrogating autobiographical questions in our first study, we successfully managed to replicate a study done by [59] and found similar results to get deceptive answer minus a truthful answer (lie minus true) and the reverse (true minus lie):

Lie scans - Truth scans = Areas of activity associated with lying.

True scan - Lie scans = Areas of activity associated with truth.

We correctly identified deception during the Ring-Watch testing in 3 of 4 participants. The lie minus true group analysis revealed significant activation in 4 regions. These results are consistent with a previous study [59] with no significant activation for true minus lie This paradigm enabled us to reduce possible confounding variables. However, the study was clearly at variance with the real-life ecology of lying as subjects were not attempting to lie in high-stake situations. We assume that there was no activation in true minus lie as there was no real motivation in participants and this paradigm did not resemble with real world scenario. Individuals in our experiment were fully compliant with the paradigm as observed by their response accuracy but they and were not asked emotive questions. Due to these limitations we were surprised not to find any more significant activations (such as Amygdala, and prefrontal cortex) in innocent groups and emerged as only a weak effect on the visual form of the task. It is also possible that first study did not place sufficient demands upon participants generating their own response. However, our second study was designed in a way to address the limitations of our first study.

To accurately detect the participant's truth and deception, we designed a paradigm resembled to real-world situation. The great strength was to provide freedom to the participants to choose the behavior (freedom fighters or freedom activists) with respect to their nature. They could choose to commit peaceful protest or violent action against an oppressive regime. The major purpose of this paradigm is to compare instructed lie (previous laboratory studies) - with close to real lie to identify whether deceptive and honest responses can be differentiated in real life situation. We assumed that it is possible to get different activation in both groups in real life scenario. The results in this thesis successfully reveal that there was no activation in both groups while interrogating about peaceful activities. Our study is also highly consistent with other neuroimaging studies with a higher level of brain activation comparing in lie situation comparing with truth. We observed great activation in several brain areas such as prefrontal cortex when freedom fighters denied their terrorist mission plans and no activation were witnessed when they denied about peaceful activities as they were not involved any of the peaceful activity. Similarly, no areas showed any activation when freedom activists admitted about their peaceful activates. Nevertheless, certain congruencies have emerged as this thesis observed large similarity in the degree of activation for each individual in FA group when they were interrogated about terrorist activities (they were not even aware with any of the terrorist plans). A set of regions also significantly activated in freedom activists like freedom fighters. Results reveal that almost same areas (prefrontal cortex and Amygdala) were activated in FA group compared to FF group while scanning with violent questions and especially in violent images. We assume that data retrieved can lead to parallel activation of regions dealing with and might invoke other physiological consequences and may be countered that those regions activated are merely activated due to anxiety, fear, recognition, retrieval and response reversal. Interestingly activation of prefrontal cortex and amygdala in freedom activists suggests that this thesis may have identified some extremely significant preliminary markers in innocent group that have developed a sensitive and valid method for law enforcement agencies in interrogation scenarios.

6.1 Why Freedom Fighters Activated Prefrontal Cortex?

Previous studies reveal that activity of prefrontal cortex is not unique to deception and not been an only marker of deception [63]. For instance, some executive processes and the working memory are subserved by the prefrontal-cingulate-parietal regions that can also be employed for behavioral purposes other than lying [63]. This activation is may be an automatic process of recognition of familiar images that was readily measured using fMRI in our study. It replicates the result of earlier studies [40] that reveal that some activation may also be present because of incidental recall of knowledge and the perception of familiar images that is closely related with activity in the areas of prefrontal cortex. Other studies explain that neural correlate of this variance is may be because truthful memories are present in a larger network of areas than instructed or rehearsed lies [54]. We identified that truthful knowledge is acquired via extensive interactions with the real world. Thus, truthful memories have many more retrieval cues and are more redundant than instructed lies. This set of processes shows that this response is unique and is entirely determined by the already present knowledge in FA group prior to the scanning session. Activation of IFG in FA group is consistent with the notion that this region is involved in recognition and memories retrieval.

Literature also reveals that there are two parts to successful memory in certain circumstance that determines that the particular image or face has indeed been seen before called item memory and remembering the context of that prior experience called source memory [68]. In contrast to item memory, which discusses to recall or recognition of previously presented information or knowledge, source memory refers to memory for the state of previously presented information. Memory for source is undoubtedly at the core of episodic memory retrieval [33]. It concerns information such as circumstances of the experience, the time and place, image, face, associated sensory features or in short, everything that can add up to make the prior experience a unique episode in individual's life. Source memory is critical in interrogation research with criminals and terrorists to specify the unique characteristics that differentiate source memory and item memory [33]. In the context of fMRI few studies [102][38] have been conducted to date provided evidence the source memory and item memory are linked with left and right prefrontal cortex respectively. These studies have provided evidence that due to item memory and source memory encoding the activation of prefrontal cortex were identical in both groups for different reasons. For instance, in this study we used an image of a gun as a law enforcement interrogator to probe the memories of both groups (freedom fighters and freedom activists) to answer a critical question - Have you seen a kalashnikov or a pistol in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime? Our results reveal that this particular image activated significant activation in both groups in prefrontal cortex areas. This area was activated in freedom fighters groups because of deception as a task memory and same area activated in freedom activist subject due to recognition and familiarity of this gun as a source memory. It is largely consistent with the findings of previous fMRI lie detection studies that have specified a robust contribution of this region executive function to deception and also for recognition determining that particular image or face has indeed been seen before and remembering the context of that prior experience [102][38]. Further analysis indicated that the strength of the neural activity for perceiving familiar images of guns and location of cities in Vienna and Graz was much greater in regions underlying perceptual processes as well as with executive processes (i.e., IFG). At this point, we can claim that our approach may become the standard to examine brain areas responding differentially to certain mental states and cognitive differences and may prove useful in detecting deception. We attained unique evidence during post study questionnaire and a brief verbal exchange with participants and most of the subjects agreed that they were familiar with some of the weapons and places as mentioned in our terrorist mission. Activation of Hippocampus and precuneus in freedom activists also suggested that current research is a result of the retrieval strategies when subject's attempt to recollect those items or faces they have already seen or heard before [38]. The information may then be maintained by working memory, which is reflected by activation of IFG. Activation of prefrontal cortex in both groups shows that the regions that have frequently been identified as associated with deception are also activated during detecting the image familiarity. This variability in results may also be due to critical design characteristics.

Literature is not yet clear what specific areas of the prefrontal lobes are related with familiarity versus recollection [38]. As recognition memory is not a stand-alone concept; however, it is a highly interconnected and integrated sub-system of memory. In reality, however, the location of brain activation involved in recognition or familiarity is highly dependent on the nature of the stimulus itself. Though, there is evidence in previous studies that the right inferior frontal gyrus is involved more in familiarity whereas the left inferior frontal gyrus is correlated more strongly with recollection [38]. However activation in left inferior frontal gyrus involved in recollection was hypothesized in many studies to result from semantic processing of words. Subsequent studies used nonverbal stimuli such as images to produce the same finding [33][38]. These studies recommending that prefrontal activation in the left hemisphere are consequences from any kind of detailed remembering [38]. This thesis also raised the limitations inherent in previous scientific literature that they rest on the assumption that there is only one type of lie. Taken together, this suggests that our work may have identified some extremely significant preliminary markers in both groups that have the promise to enhance the development of valid and sensitive methods for the lie detection in real life scenario. The activation in the prefrontal cortex region, which houses the brain's calculation center, was the result of the freedom activist group's recall of an existing memory as opposed to the formulation of the lie. Thus, examination of lying and its detection using functional imaging paradigms will provide further theoretical refinement in differentiating deceptive and honest responses from suspected terrorists.

6.2 Why Freedom Activated Amagdala?

Our results are consistent with prior studies that investigated the neural correlates of the regulation of negative emotions also activates Amygdala and Insula due to fear when subject view the negative emotional pictures [15]. Negative emotional stimuli may evoke more autonomic and peripheral physiological responses than do positive emotional or neutral stimuli. Three of the seven studies reported major activation foci in the amygdala [15]. Secondly, the amygdala is an area of the brain associated with emotions such as fear and anxiety. However, activation of Amygdala in freedom activists groups viewing violent images during truth telling process reveals that anxiety is not only presumably associated with deception but terror, fear and nervousness may also activate the limbic system in Amygdala during truth telling [15]. As one can recall and speak truthfully of an event that involves anxiety. Our study show that memory and fear can also activate the similar regions during truth telling and lie telling and it is difficult to distinguish in both groups that who is innocent and who is guilty.

On the other side, activation of Amygdala in freedom fighters reveals that Amygdala is also activated in prior lie detection studies due to activation of the representative of inhibition or deception [15]. In many studies the main effect of deceiving the interrogator showed activations of the VLPFC as well as amygdala [2]. This activation adding new evidence that the brain areas assumed to be responsible for social interaction or emotional processing are active during deceptive behavior similar to that in real-life Scenario. Further analysis revealed that activity of the prefrontal cortex and Amygdala showed this region has a pivotal role in telling lies. Our results provide clear evidence of functionally dissociable roles of the amygdala and the prefrontal sub-regions for human deception.

In post-scan debriefing, freedom activists noticed anxiety about the violent images such as weapons and bomb blast and people are dying, but most (4 of 6) freedom fighters reported performance anxiety as that they felt some anxiety when realizing about whether their response would be detected by changes in their brain activity. This phenomenon suggesting that our study successfully achieved its goal. In the post-scan questionnaires, 8 of the 12 subjects reported having greater difficulty regulating negative emotions relative to positive emotions. Thus, the regulatory process might engage more cognitive control and employ the Amygdala is more strongly activated for negative than positive emotion. Furthermore, it is important to note that previous studies have suggested that the cortical areas involved for attending to and perceiving specific information are also involved in remembering that information [2]. It was hard to determine who is innocent when both groups have activation in similar cortices areas while interrogating with violent activities questions.

We note that areas like cortical regions area can be involved with more than one cognitive function. Secondly, its activation during a dishonest act does not verify that it is directly related in deception processing. Thirdly, these evidences are consistent with the finding of the areas like IFG are also commonly activated in other published studies of executive processing when no deception is involved [2]. Thus the greatest limitation we found in our research of neuroimaging approaches is that they may not actually be revealing about deception selectively. Extent of these activations can vary from case to case both by the content of questions and the situation in which they are presented and also based on inter-individual differences in personality traits. Nevertheless, certain congruencies have emerged in previous lie detection studies [2]. Some have reported no activation of prefrontal cortex during truth telling than lying, others have testified that areas of prefrontal cortex exhibit greater activation during the lie response than telling the truth [15][2]. All these previous studies are consistent with one central hypothesis, that lying requires the contribution of higher centers and works like an executive task and processing time is significantly longer during lying than truth. Over lapping areas such as inferior frontal gyrus and amygdala in both groups also reveals that it remains to be understood which of these brain regions are essentially and necessarily involved in the generation of lies. It remains to be seen that neurocognitive operations in a cortical network can be recognized that is specifically involved in deception. This study also did not observe any activation in freedom activist group in violent sentences compared to violent images. However, further analysis exposed that all of the prefrontal cortex activations observed in each comparison of deception as well as in viewing violent images by freedom activists during violent questions, indicating that these areas are commonly related with deception as well as emotional valance of memory content. Thus these results support our a priori hypothesis that the pattern of prefrontal activity may be activated would differ depending on the emotional valence of stimuli. The present results suggest that a common prefrontal network is associated with the executive aspects of deception with the emotional valence of stimuli, at least in the experimental paradigm used in this study.

6.3 Results in Countermeasures

Another major contribution of this study is to examine the effects of methods and countermeasures used by individual to defeat fMRI to make the results unusable or misleading. An important question we addressed in this direction is to investigate whether brain-based measures of deception can also be deliberately manipulated by a trained suspect to appear credible. Techniques used to achieve this are called countermeasures. The scanner is detecting patterns of blood flow associated with brain activity. Subject had to add additional brain activity and these countermeasures could make fMRI-based lie detection ineffective against trained liars. One can disrupt almost any kind of scanning procedure, whether done for functional or structural purposes. Blatant movements to disrupt the scan would be apparent, both from watching the participant in the scanner and from seeing the data, leading to a possible negative inference that the unwilling subject was trying to ruin the results. Nonetheless, that functional scan itself would be useless.

This study was also examined with same paradigm and subjects were trained to use countermeasures to fill this research gap. This study found that there was a large difference in activation in single participants with countermeasures. These findings show that fMRI based deception detection can be vulnerable as entirely different areas activated in FF group with respect to lie-minus-truth questions. The deception detection accuracy was accurate (100%) with activation in medial prefrontal cortices and ventrolateral cortices but fell to 20% with countermeasures such as moving toes, blinking eyes and moving tongue with some of the relevant mission dates and places and reciting to himself the multiplication tables. Our results shows that hemodynamic signals from medial and lateral prefrontal cortices could be activated in deceptive responses but that such differential activation and subject classi?cation accuracy is substantially reduced in this controlled laboratory situation when subjects use a covert countermeasure. An entirely different set of results observed in each image, making the "terrorists" appear "innocent". Furthermore, we also attempted to find a lie detection test with fMRI to determine whether a suspect was having the subjective feeling of pain might be fooled by the remembering their past experiences of pain. These results are innovative because this is the ?rst fMRI study to apply countermeasures during a lie detection task in real world scenario. This suggest that whole procedure may be limited if subject is not cooperative and are able to completely defeat the entire test and render the test results. Currently such factors cannot be prevented for deliberate distortion of results. These results suggest that this lie detection tool can be vulnerable to countermeasures, calling for caution before applying this technique to applying this technology to the high-stakes world of the courtroom. An accurate lie detection system will likely have to account for these dimensions and exploit the variations that arise from the different types of cognitive processing involved in the different types of emotional responses. However, it is unlikely that participants in this study had particular training for these countermeasures before the investigation session and tried to use it systematically, which would be the case for these students seriously trying to cheat the machine.

6.4 Functional FMRI and Our Results: Cost and Benefits

In a counter-terrorism scenario, interrogation results are routinely offered as evidence and are potentially damning to suspects. This thesis is an interesting finding and this investigation might have practical implications for lie detection and in interrogation. Although future studies have to work on our interesting findings to read a suspect's entire mind to distinguish innocent from terrorists. However, our findings reveals that this technology has ability to assess whether a suspect has personal knowledge of faces or places would nonetheless be useful in intelligence interrogation. Accordingly, while the ability of this neuroimaging technology to detect whether an individual had personally seen a terrorist for instance Osama Bin Laden or a particular critical infrastructural building in a city would be of obvious value, so too would its potential ability to interrogate suspect's personal knowledge of, for example, terrorist training camps or other mid- to low-level known terrorists. Likewise, the method employed in this study could be utilized during intake screening to be focused on suspects who show recognition of key places or people and facilitating the release of those innocent who do not. This study improved the lie detection paradigm by devising more accurate experiments by considering the importance of the individual's emotional state while engaging in deception, and that examined changes in functional connectivities. The results of this work may be helpful to distinguish between a finite set of alternative thoughts such as different degrees of recognition, different levels of feelings of familiarity and different motional states that could improve fMRI based lie detection. The acquisition of results from this research made a bridge the analytical gap between the experimental and the true life situation.

Violent images used in our paradigm gave rise to memory recognition involved in different cognitive processes for particular places and weapons known as the source monitoring framework create memory illusions that can contribute to false evidences in which interrogators believe they are guilty on the basis of recognition to support those beliefs. With our fMRI results we found that not all evidences are truthful and suspects may be coerced into falsely self-incriminating confessing to terrorist act that they did not commit. With these indistinguishable results the interrogators may come to genuinely believe that suspect committed the terrorist activity on the basis of their vivid 'memories', recognition, and feeling of knowing. While analyzing the functional Magnetic Resonance Imaging data on a within-individual basis in freedom fighters group, we observed large variations in the regions of significant differences in blood flow across group. These data and prior studies suggest that fMRI within individual is neither sensitive nor specific for detecting deception [63]. Further work is needed to determine in the fMRI paradigm, can realize this goal within individual detection of deception.

This thesis uniquely identified the gap between the instructed lie and the real lie is also a significant problem of construct validity and reliability of the experimental paradigm such as instructed falsehood. Thus it cast significant doubts on the research conclusions to draw an inference from the accuracy of fMRI based lie detection in experimental settings to the potential accuracy of those paradigms in detecting real-world liars. There is a significant possibility that it would render the precision and accuracy of its images and its results may be totally useless only if there were no correlation at all between the mental activity involved in the instructed lie and that involved in the real lie. Thus, it may well be misleading to conclude that activation of such a relatively broad region of the brain indicates deception by a larger number of participants or, in a group study. This thesis further suggests that the whole procedure may be limited if participants are not cooperative or if different kinds of lies are associated with different patterns of brain activation.

The aim and results of the current study might be understood by some scientists as advocating a view that different learning styles and working memory have real consequences for the brain regions and that education should be adapted accordingly. It is significant to distinguish between learning styles and cognitive styles. Cognitive styles are supposed to be an individual's way to process information; however learning styles are concerned with the learning environment. It can be said that different cognitive and mental are involved with cognitive and motivational process and can be argued that areas like prefrontal cortex and Amygdala are not only involved in deception but a range of different physiological consequences. This thesis suggest that this activation in FA shows truthful memories or may be because subjects attempted to recollect those items or faces as they have already seen these weapons or heard about it before. This thesis points out the methodological flaws of previous experimental studies. Results show there are no specific areas of brain function that may be used to dissociate the processes of deception and truth telling as found overlapping in freedom fighters and freedom activist groups and similar areas of involvement underlying these processes. On the basis of these results this thesis argue that this much work have to be done in this domain to determine how the suspect became familiar with the image of gun or a face or item pictured, such as whether the suspects had first-hand knowledge of the stimulus or whether they had merely become familiar with the stimulus from a violent image. However it may soon be possible to use fMRI to determine suspect's feelings about any terrorist camp or activity, rather than just whether they recognize them. Some neuroscientists claim that within 50 years they "will have a way to essentially read minds [63]." It is important to understand that interrogation in counter-terrorism scenario is not about uncovering all that there is to know from "one key evil genius". Rather, it is about uncovering "tiny bits of the truth" from a large number of suspects [76]. Besides, strategies for emotion regulation may have a cross-cultural bias, i.e. Strategies that Asian or Arabic employed might be quite different from that employed by Austrians or other ethnic groups. The bias may then be translated into different patterns of brain activation. We note that the results cannot be generalized to female subjects because this study recruited only male samples. Investigating gender differences in the neural correlates of emotion regulation might be a promising avenue for further studies.

For the first time, this thesis is advancing forensic interrogation techniques that may be potentially reliable in a criminal justice system to identify brain patterns associated with deception in a real life scenario within an individual. Furthermore, our novel experimental paradigm that is unique, identifiable brain regions might be used to detect deception with a high degree of accuracy if work on weak points. However, the current state-of-the-art for fMRI lie detection is too premature to be used as an interrogation tool admitted into the courtroom as evidence. These results suggest that, although fMRI may permit investigation of the neural correlates of truth, however, we need to understand the complex nature of brain and other different personality traits to fully understand the phenomenon of lie detection. The complex nature of various types of deception raise a question that whether a unified set of brain regions can be identified that serve as a reliable indicator of deception per se, instead of the wider class of processes involved in 'executive functioning'.

6.5 Complex Nature of Brain and Deception

The comprehensive cognitive models of lying have remained illusive up till now. Acts of deception or lie detection can be very distinct from one another. For instance, criminal's knowledge of target's know-how and intention may enable him to deceive interrogator more convincingly. [35] argue that it appears a simplification to even think of lying as a unified class of cognitive process that can be exposed with a single measurement. The ToM (theory of mind) plays a major role in the interaction between target and deceiver [105]. More complications arise with second-order theory of mind when another person thinks it is a lie - like telling the truth. Criminals and terrorists will have a stronger motivation to lie in high-risk circumstances (e.g., terrorist interrogations), which has significant inferences for deception-detection techniques [76]. Accordingly, different studies show that a range of motivational and cognitive processes are involved in deception, including strategic decisions [68], memory processes [84], response generation and inhibition [105] and reward expectations [84]. Surprisingly, scientific researchers have shown a large variability in the brain areas reported to be involved in deception. For instance, studies done by [68][105] do not report activation of dorsolateral prefrontal cortex (DLPFC). [35] don't found Ventrolateral prefrontal cortex (VLPFC) and ACC was not detected in [87] study when subjects make a deceptive response. Due to the complexity of different types of deception, it has to be questioned whether a unique set of brain regions can be identified that serve as a reliable indicator of deception per se, rather than the broader class of processes included in 'executive functioning'. Finally, fMRI studies on lie detection typically describe young and healthy adults. However, BOLD activity is known to be altered with age, in patients with cardiovascular diseases and with drug use [76][105][87]. These results calling fMRI's validity into question as it does not provide reliability for detecting lies with which a deceptive response can be identified. The results published in peer-reviewed journals reveals that these cognitive areas are generally activated in studies of executive processing when no deception is involved and activation in these regions during lying also does not verify that it is directly involved in deception processing [87]. The second is the possibility that in the context of these published studies in which subjects have been instructed and rehearsed to lie about their mission or stealing, what the functional MRI may be detecting is not the mental process of lying but instead reflects the participant's recognition of the image or text to which they has been instructed to respond by lying. On the other side, the gap between the instructed lie and the real lie is a significant problem of validity, as following an instruction to lie tells us nothing about the kinds of brain activity involved in actual lying. This practice would render the scanning results totally useless - only if there were no correlation at all between the brain activity involved in the instructed lie and that involved in the real lie. It does not prove that specific region is directly involved in deception processing.

Another complex view of lie detection with fMRI is explained by [76]. They found in this study [76] that experienced liars may produce less activation in fMRI scanning as frequent lying makes lying easier as BOLD contrast decreases with increasing capacity for lying. However, severe liars displayed relatively low brain contrast activity when they lied. Authors found in the study that participants who were not skilled at lying showed greater brain contrast activity when they were lying, They further observed that habitual lying may mark the lie response more dominant and makes lying easier and observed that BOLD activities under the influence of lying were negatively correlated with the capacity to deception. Authors also found that subjects with Anti-Social Psychological Disorder who are skilled at deception, lack moral sense and often train themselves in lie-telling. Furthermore, they have necessary mental calculations, response inhibition and working memory to gain proficiency in deception, which may help their lie-telling that eventually integrate these elements into their lifestyle. This and other studies [54] concluded that skillful liars more successfully inhibited prefrontal cortex to improve lying compared with less skillful liars. When these subjects lie, they execute deceit as if they were telling the truth, and exhibit deficient psychosomatic and physiological reactions. [84] Noted that fearlessness and cold-heartedness are negatively associated with activation patterns in the brain networks (prefrontal cortex and anterior cingulate cortices) correlated with deception. This is an interesting finding and this investigation might have practical implications for lie detection. Thus, it is necessary that greater attention should be given to the detection of lies in individuals who are skilled at lying.

6.6 Limitations of Our Study

Perhaps this study considered the emotional components of deception; however, telling lies in the current experiment was not an authentic representation of deception in real-life situations. To some extent, engaging in a deceptive act comprises the decision to risk discovery. This risky choice may increase the motivation to avoid detection. One limitation of our second study is that simulated deception in laboratory experiments cannot be compared as equivalent to real-life deception. Thus replication of our results in a more natural situation is therefore warranted. This study did not examine the role of risk-taking in interpersonal deception. Similar to the previous lie detection studies the current study also cannot offer punishment or penalties associated with being ”caught" in a lie. For instance, payment for their loss or to incur penalties commensurate with what would be incurred in the real life scenario for any individual if they were unsuccessful at lying. However, the current experiment was not limited to interrogate deception in a laboratory setting as the activation patterns in amygdala and Insula could be due to the fact that our paradigm was motivational and involve high-stakes. Additionally, the perceived punishment for not successfully deceiving the examiners was relatively minimal. The difference in consequence and how consequence impacts fMRI results will need to be explored before a valid method of accurately detecting deception in high stakes settings can be established. There are some other limitations to our current protocol. For instance, the relatively controlled choice for motor response when lying as participants had only one possible lie response to choose which they did not devise themselves and they were not devising new lies in our this study. Henceforth, investigators may have identified those brain circuits specifically activated by suppressing the truth (a pre-potent response) and producing its opposite - the lie. It is also possible that these activated regions are only activated by the responding yes where no would be truthful (response reversal).

6.7 Future Directions and Conclusion

The ever-widening international scope of neuroimaging research is unsurprising. India was the first country to convict a criminal defendant (Aditi Sharma) of murder in June 2008 [12]. On the grounds of a brain scan indicating that she had memory or "experiential knowledge," of the murder. The test-an EEG results convinced the judges that Sharma possesses a specific knowledge of murdering her fiancé and allegedly proving her culpability as brain lighting up in various colors and indicating specific knowledge of her fiancé's murder. Within 6 months of her conviction, another court in India used the same procedure to find 2 more criminal defendant based on decisive results of experiential knowledge. On the other side, the US legal system has yet to admit neuroimaging evidences in either criminal or civil proceedings jury [18]. However, to assess truth-telling capacity of criminal defendant and experiential knowledge of an event is not far from occurring. Michael Gazzinga, an American neuroscientist predicts that neuroimaging technology will eventually dominate the entire legal system [103]. Various countries have shown interest in interrogational neuroimaging on the possible use of neuro-scientific evidences. An Italian court of appeals was the first court in Europe to use brain-imaging scans and genetic information in 2009 May to reduce a defendant's murder sentence found that the evidence showed an unavoidable propensity toward violence [18]. The prospect of using neuroscience to investigate the terrorist mind, including the motivations of terrorists, has obvious allure. Researchers are examining to anatomical features (phrenology), inheritance (genetics), history of unresolved psychic conflict or emotional trauma (psychoanalysis) to explain why some commit crime/terrorism and others do not [18]. However, supports for this technology still believe that greater understanding of neuro-scientific evidence with a sound regulatory scheme would prove beneficial to the legal arena.

This study provides scientific evidence that additional research in lie detection with fMRI is needed and various countermeasures should be assessed thoroughly and documented explicitly before they can be used in applied settings such as courts, where an innocents accused of terrorism act may want to proof their innocence. The possible uses of countermeasures in fMRI-based lie detection have yet to be extensively explored, but at this point they cast additional doubt on the reliability of this tool in terrorist interrogation and employee screening or in litigation. Potentially significant applications of our findings for future investigations include research aiming at distinguishing different types of liars and different types of lying. A study done by [111] uncovers the gender-related effect that needs to be considered in neuroimaging studies. For instance, the presentation of fearsome images leads to stronger and persisting amygdala activation, while amygdala activation in men decreases rapidly [111]. Despite above problems, and challenges, this study suggests that using BOLD fMRI to investigate brain changes associated with lying is both possible and potentially of value. Future research using similar paradigms with reliable scanning parameters may enable better understanding and detection of deception. Findings and an in-depth understanding of the neural correlates of deception with emotional valence of memory content may provide us with a solid foundation for further scientific investigations of deception and its detection in counterterrorism interrogation. In future research, we will further study those individual who were more skilled at lying. For instance, people with ASPD that may have interesting finding and this investigation might have practical implications for lie detection. Thus, it is necessary that greater attention should be given to the detection of lies in individuals who are talented at lie-telling and possess a greater capacity for deception and constant lie-telling may even become a part of their lifestyle. For instance, individuals such as prisoners or people with ASPD who has already admitted their crimes.

In sum up, studies done in this thesis discusses that deployment of fMRI as an interrogation tool to assess whether this neuroimaging technology may or may not be a significant tool in the war against terrorism. Another main contribution is to propose recommendation, best practices and guidelines in the final chapter of this thesis that can address scientific, social, ethical, privacy and general public concerns that can be applied in real world that could revolutionize police work and likely to provide significant benefits to society. Finally, I conclude that the use of fMRI in counterterrorism scenarios may play a vital role if social, cultural, and linguistic differences across participants in the understanding of questions and the meaning and appropriateness of deception may contribute to differences in regional activation patterns observed during lying versus truth-telling. In the absence of an invariant neural signature for lying, successful detection of deception using fMRI may require a better appreciation of possible sociocultural effects. This way this technology can be effective in distinguishing truth tellers from liars and to determine hidden conscious states of an individual, with accuracy greater than chance.

Our results and above discussion literature reveals that this technique may emerge as more promising technology that aims to directly reveal if a suspect's brain displays particular responses. Thus fMRI can be used as a tool warranted in interrogation techniques in this era of terrorism that is creating an all-pervasive fear and can be considered as a magic bullet in the war on terror. This scientific technique may provide intelligence operatives to focus their investigations on the suspects who actually commit terrorism and to determine if he or she has been to any specific place before. If a person was in any terrorist training camp, you can actually determine that. On the other side, an information absent will provide support for the claims of innocence that individual is not guilty of committing any crime and has no knowledge specific to any particular group. The imaging results can be used against the suspect at trial and to prevent future tragedies. Similarly, the primary goal of the current research is also to develop a novel experimental paradigm with fMRI based interrogation techniques in a counter-terrorism scenario that will be discussed in the final chapter. The ultimate goal of our innovative methodology, recommendation and guidelines is the implementation of fMRI in real life situations and in human security perspective that will enable intelligence operatives to detect suspicious behavior indicators to provide real-time decision support.

CHAPTER 7

Functional MRI: Applying the Concept to Law Enforcement

The current chapter introduces a first step towards developing a novel experimental interrogation paradigm, recommendations and guidelines that aims to apply a number of reliable and practical applications of fMRI within a rule of law and human rights framework. This development will led to speculations about the development of this neuro-imaging technology that could directly examine the terrorists memories, intentions and its mind. Interrogators will be able to confidently say that the fMRI told us this detainee lied about X or that he recognizes terrorist Y or fMRI picked him out as a terrorist. However, this confidence that intelligence operatives will have in this neuroscience technique will be based on aura of infallibility, scientific validity and objectivity [52]. Secondly, there will be no similar chilling effect like polygraph - when fMRI will be used in high-pressure environments as a part of counterterrorism operations [52]. For instance, the mistreatment of detainees in Abu Ghraib and Guantanamo Bay is arguably the result of worst excesses confidence in the reliability of devices like polygraph. This work proposes a methodology in interrogation framework and applies the scientific procedure of fMRI analysis to determine objectively whether or not the person is aware with the information contained in the probes.

7.1 Methodology

One of the most important aspects of security agencies is the prevention of terrorist attacks with a prior knowledge of terrorist practices and mindsets regarding preparation and implementation of attacks - so called Pre-Incident Phase. Secondly, to establish accurate and reliable connections between features of the terrorist attacks the one hand and features of the perpetrator or witnesses related to the terrorist activity on the other - Post-Incident Phase [48]. Our research is also focusing on the dynamics of the pre-Incident and post incident phase of terrorist attacks. Examples of the knowledge of these phases include weapons details, information regarding specific locations, time, key personnel, source of funding, recognition of false identities for group members, acquisition of supplies, the deployment of assets and other related information. This methodology proposes three paradigm of using fMRI in interrogation process. These phases are: Examination, Interviewing and Scanning.

7.1.1 Examination

This process is research-intensive as it consists of the designee that will determine the significant features of terrorist activity. The interrogator must be careful to select stimuli in such a manner that a subject who is innocent would find them as equally plausible as the irrelevant chosen. Thus, no physiological response is expected on fMRI. However, this information must be present in the brain of suspected terrorist. The probes selected in terrorist related activities must be included the landscape that the terrorist ran through while planning or committing the act. Interrogator must formulate the actual event of terrorist related activity with the features and background information in two ways. Firstly, about known terrorists whose suspicious activities or relation with terrorist organization is reasonably certain because of the evidence available. Secondly, the suspects whose guilt is doubtful or uncertain because of lack of essential evidences or because of weaknesses in the available facts. It is important to note that some suspects cannot be placed precisely in either of these two groups.

The accuracy of interrogator's efforts to classify a suspect depends upon their experience, ability, availability and accuracy of the information. For instance, the questioning must be designed to develop a detailed account of the suspect's activities before, during, and after the action was committed [48]. Information that is certainly known to interrogator and if suggest the suspect's activities, then these details should be used in formulating questions to determine her/his reactions and to test whether the suspect is inclined to lie. An inaccurate classification may lead to an unsuccessful interrogation or innocent person can be punished [48]. Specially, if the questioning technique based on the original classification is not skillfully modified or changed during the examination.

7.1.2 Interviewing

Once this information has been collected and probes are prepared, interrogation officer must interview the suspect prior to the fMRI scanning process. This procedure is necessary to determine exactly what the person knows, why he/she has knowledge of certain information relevant to the examination. This phase is also useful to find out about subject's innocence and non-suspicious explanation [48]. Moreover, questioner also observes the verbal and non-verbal behavioral symptoms of deception in the subject [48]. When evidence is weak, interviewer must proceed cautiously by different questions or pictures. The purpose is to place the suspect in a position where he/she will be forced to alter facts that are definitely known to him. It will lead the potential terrorist to believe that answers are already known to the police officer. However, when evidences are strong and when suspect whose relation with the radical organization is reasonably certain, interviewer should assume an air of confidence. He should stress the evidence to analyze the relation of the suspect with terrorists and strive with WHY the suspect committed a terrorist activity rather than IF the suspect committed the terrorism. This process would also help interrogators to remove those stimuli that are significant, not related and independent of the suspicious activity at issue. This process may serve as baseline for security officials. It will ensure that person informed about the targets that will be shown to him in fMRI machine will render a scientific conclusion regarding guilt or innocence.

7.1.3 Scanning

After the interviewing, the investigator must select stimuli that is collected through interview process (known to the suspect) to apply the scientific procedure of fMRI. This phase is a scale moving from overt conscious evaluation of stimuli accompanied by response selection of the subject, to unconscious perception constructing meaningful and measurable brain activity [49]. Test administrator must also select irrelevant targets and placed a subject in MRI scanner to analyze scanning parameters by showing a series of words and picture to detect recognition. For example, for the deception task, different types of questions can be visually displayed to the subject with control questions because of the different imaging site. The button-press paradigm will be used to investigate brain activity associated with deception. This task would be designed in a way that the subject would consciously evaluate the stimuli presented and decide whether to press "yes" or "no (i.e. "Yes, I know him" or "No, I do not know him").

The subject is told to press one button to confirm a fact and another button to deny the information as each image is shown. The subject will click a pad button to advance to the next stimuli to keep his/her attention on the scanning test itself. Interviewer must present each question in a way that it is easy to identify the category of the stimuli (e.g., one of the following is the knowledge about terrorist weapon) to observe a subject's neural response with. Investigator may also present a suspect with pictures of potential terrorist targets, suspected terrorists, recognition of key people or places and watches movies (e.g. a digital reconstruction of the terrorist scene). These images would generate certain neural responses if the suspect were already familiar or to reveal different information (such as, where a suspect had been or what he/she had seen with another suspect). Thus counterterrorism agencies would be able to distinguish whether the subject was lying based on the BOLD signal change associated with the response to a particular question. The subject's response can be classified by complex mathematical algorithms recently created by various researchers that are able to analyze imaging data of deception [23]. The finding of information present or information absent will recommend a scientific determination of whether the suspect has knowledge of the probe stimuli tested or not. Difference in brain responses among individuals can be used as a baseline for comparison. The results of fMRI analysis will educate law enforcement agencies and judiciary in rendering their verdict about the subject [23].

7.2 Functional MRI: Strengthening the Criminal Justice System Against Terrorism

Researchers are skeptical of claims that an fMRI have potential to identify innocent subject from abuse at the hands of intelligence operatives. However, those who doubt the deployment of this machine in scenarios for good or ill should judge the statement from a United States intelligence officer. Who explained how he and his team "once put a suspects hand on the Xerox machine, turned it on, and told him it was a truth detector and would administer a massive shock if he lied" [77]. Interestingly, the result was positive and the subject "was bluffed into a good confession" [77]. Similarly, such kind of output is also more likely to achieve successfully by functional MRI and we can expect that this tool will successfully be applied in interrogation context with a high degree of confidence.

This technology is of course expensive requires extensive support facilities and highly trained staff. However, this mechanism may therefore be most useful in national security scenarios due to the security clearance and complexity of this equipment. This machine is hard to cheat unlike polygraph. It is very easy to deceive polygraphs with a simple internet search that can reveal many ways how to mislead the interviewer. One former polygrapher charges 59.95 dollars for his manual plus DVD offering information on beating this device [43].

7.3 Neurotechnology and National Security Concerns: Removing Obstacles to Investigating Terrorism

Although this research and various other studies have reported reliability and reasonably high accuracy rates for fMRI studies, there are still significant concerns must be addressed prior to moving this technology to real-world application. In addition to the scientific challenges, advances in fMRI identify numerous social, legal and general public concerns to the process of and the science behind it [27]. Some state that this tool isn't reliable enough to be used outside of a laboratory setting [99]. Thus, these challenges require further investigations to assess its relevance capabilities to national security.

According to some critics, variation in experimental design, situational variables, subject characteristics and the preliminary nature of the existing data are the key scientific challenges in fMRI studies [78]. Large numbers of replicate scans under extremely controlled conditions are needed to accommodate for inter-scan and inter-subject variability [78]. However proponents counter that certain methods and techniques have been developed to overcome for the inbuilt physical limits of fMRI machine [65]. Though, the only feasible technique of increasing the subject's signal is by repeating the scanning several times in order to reaches a level where the signal can be heard over the noise and to get the meaningful data. Secondly, critics explore that so far fMRI studies have been conducted in artificial laboratory environments with small numbers of normal (drug free, non-criminal) volunteers to maximize positive results. The criminals and experienced liars were not included and their effects on interrogation are unknown as none of the protocol studies applied to the actual criminal investigations [100].

Other common line of criticism deals with the mental capacity of subjects to record information either during the alleged commission of the terrorism or prior to the fMRI scanning itself. For instance, what if suspect is under extreme emotional distress, under the influence of narcotics or intoxicated or so forth? [65]. According to William Iacono "we don't know enough of how memories are formed during crimes." However, such a criticism is unfounded, as the human brain is always recording information regarding of whether we realize it [89].

Next, various opponents criticize that suspect could attempt to be deliberately deceptive and it is possible for well-prepared terrorist to cheat the fMRI [65]. However, supporters of this technology suggest that fMRI scanning is different from other lie detection tests and it is hard to beat this neuroscience technology [108]. The responses are evaluated by the neural activity and the presence of certain information in their brain suspect not merely for their truth or falsity. Self-deception will have no effect on fMRI testing [65]. A terrorist or a criminal who has convinced himself that he is not guilty; he/she still has recorded information and knows the salient feature of the crime [89]. Thus, our suggested method can measure a brain response at the moment of recognition or if suspect lie. It is equally effective if this test is given to hardened terrorist or pathological liar. A number of opponents claim that fMRI scanning is based on bias [100]. Interrogator could potentially impact the analysis result through the decision process in choosing the specific stimulus. However, [77] has responded that bias is impossible to insert in fMRI scanning process because its responses associated with neuronal activation. The determination of information present or absent is directly revealed by suspect's brain displays made by the fMRI machine and not by the interrogator.

Furthermore, critics of fMRI points out that this technique is not reliable enough to be used as a lie detector in interrogation course of action. It could lead to further abuse of prisoners and human rights violations in the form of torture. It may also allow interrogators to believe more justified in using whatever painful method they use in investigations to extract the information they are looking for [28]. However, advocates strongly recommend that fMRI has potential to minimize the torture dilemma by monitoring involuntary responses and indicating when such fabrications occur. [108] also counter this argument and saying that, pain would appear to be a necessary condition for any kind of physical torture in interrogation but functional MRI is not painful and uncomfortable. It certainly not represents any physical or mental torture and no foreseeable direct health risks associated with its use. The only possible pain that this scan could inflict is to keep the individual motionless. The subject's head is immobilized with foam pillows while inside this machine as suspect's movement could compromise the quality of the scan result. These restraints would almost certainly not inflict to even uncooperative subject and anything near the level of pain that would rise to torture. This practice is contradictory to so-called stress positions that international tribunals have considered to be a torture (for instance, subject being hung by the legs or arms). In fMRI machine, the individual is required only to remain lying down for an extended period that has no relation to the extreme stress positions [23].

It can be concluded that the suspect's body is not physically compromised by this piece of equipment as fMRI is passive, in the sense that it does not enter the body. Now the concern is only with the mental, rather than physical intrusion. Various critics have highlighted that this technology erode the right of fundamental liberty interest[1] in private thoughts. However, [52] is rejecting this assessment and says that this tool does not provide any precise conclusion about a person's thought or what a person is thinking. It can only show a difference across time, across location and across tasks. An fMRI is very good at discovering when brain tissues are active during different cognitive tasks. Thus, regardless of the technological particulars of this tool, it is strongly suggested that fMRI does not violate the right to internal mental privacy [52]. It must be regarded as intruding upon the fundamental liberty interest in private thoughts. Though it can be argued that, a claustrophobic subject might undergo mental suffering in the scanner. However, this distress must have been the result of the use of mind-altering substances or procedures. This psychological condition inherent in the subject is probably not sufficiently severe to rise to the level of torture such as threatened dismemberment or castration. It is also important to note that this scanning cannot be operated on an unconscious person - unlike

[1] Chavez v. Martinez, 538 U.S. 775, 760 (2003) (citing Washington v. Glucksberg, 521 U.S. 702, 721 (1997)).

blood tests, so some form of considerable restraint will be required to ensure that an unwilling suspect remains virtually motionless.

Despite the subject's mental condition, he/she would almost certainly not suffer prolonged mental harm because of fMRI, and certainly not constitute torture under any International Human Rights Law. One other objection to the fMRI as a lie detection raises worrying questions regarding civil liberties [28]. However, we argue that it would be a human rights violation to deny access to fMRI scanning as it serves the cause of human rights and provide scientific means to prove subject's innocence. The potential forensic uses of fMRI also reflect the fact that outrage attending the news about Abu Ghraib and Guantanamo Bay would have been different if prisoners had been examined by fMRI instead of hooded, naked, sexually posed by hostile interrogation. The images featured provoked shock and anger in the society and turned into emblems of degradation and humiliation [20]. Being lying in the fMRI scanner is neither the moral equivalent of being deprived of sleep for 36 hours in a cold torture cell nor legal equivalent of being forced to strip naked and simulate sex with another prisoner.

Opponents also argue that use of this novel method as reliable lie detection will raise different unanswered legal questions [65]. These controversies can be elevated under legal regimes and the international law about privacy and government power. However, science always moves forward, not backward. Hank Greely, Professor of Law at Stanford Law School support this theme and saying that fMRI evidence is certain to be accepted by the courts in future [12]. "The easier, the cheaper, the more pleasant a technique is, the more likely it is to be used in the legal system [12]." [86] also states that, "courts usually seem willing to consider brain imaging evidence under the same standards that they apply to other scientific evidence".

Putting aside all the arguments, but more to the point, how much precision could be increased for fMRI? How accurate should it be to be widely accepted in legal and security settings? Scientists are unable to accurately predict how much the error rate might be reduced? It is also unclear that whether this technology needs to reduce the error rate from 10 percent to something comparable with the billions-to-one accuracy (such as DNA) - will be useful or not? However, given the mechanics of the scientific research involved, it is difficult to conceive of this claim as the legal system has also issues concerning unreliability and repeatability in many procedures. For example, fingerprints experts have sometime claimed perfect accuracy, but a number of pragmatic studies have revealed misidentification rates of about [77].

Critics have also argued against the effort and length of time that would be requisite to acquire an adequate number of probes in interrogation and also in judicial process. However, this problem can be solved by putting more logistic support and by offering more trained staff to the interrogation process to run the fMRI scan and analyze the results effectively. Finally, one of the most common concerns of fMRI scanning may involve the portability of this tool (weighing 20,000 lbs or so). For example, what if intelligence community wants to carry out fMRI scanning on a large number of people or if subjects live in tribal areas such as Afghanistan? However, we argue that Mobile MRI[2] is the counter strategy that can be used to rebut this objection. Mobile MRI is housed in a highly specialized trailer and a great way to have access to this equipment. It is useful to have access to this facility

[2] For example: `http://www.mobileleasing.com/mobiles/mobile-mri`

if a hospital's or imaging center's MRI is not currently functional or not available. This unit adheres to the same strict procedures a fixed MRI unit at imaging center must meet. There is no cause for concern by the subjects if this unit is used for MRI imaging.

Advantages of mobile MRI systems are shorter installation times, lower initial investment and rapid response. Similarly, mobile fMRI will be particularly useful if government has to scan a number of people in remote areas. This service may allow law enforcement agencies to carry out identity checks on suspects in large public occasions and sporting events that could be targeted by the terrorist attacks. It is also useful to access crucial data in challenging environments such as national border control areas military and nuclear power plant zones. However, security officials must make absolutely certain that they are scanning only when they suspect an individual of an offence and can't establish his identity. This action will reduce the number of errors and will rapidly improve security reaction times. Furthermore, fMRI mobile scanning could help police performance with decrease the number of arrest significantly and hasten the speed of criminal investigations.

The potential of fMRI in attempt to transfer this technology outside the research context poses several challenges in the context of national security. However, apart from many challenges, critiques have to bear in mind that functional MRI is just two decades old. Scientists reviewing the ability of photography 20 years before could not visualize the idea that one day this device would be able to determine images of planets orbiting other planets and resolve images less than a fraction of a second long at micrometer scales - which has now been done. According to Vanderbilt's Frank Tong, "If brain scans were admissible in court, and became popular enough, then even if they were not mandatory they would become in a sense obligatory. Because if you didn't voluntarily undergo it, then there would be the question, 'Why didn't you take the test?[3]'.

Secondly, for decades, polygraph has been widely used in interrogation by law enforcement agencies and has long been rife in the courtroom despite their flaws. Even supporters of this device confess a 10 percent failure rate. Brandon L. Garrett, the law professor of the University of Virginia analyzed 200 cases in his published study in which innocent people were wrongly convicted by the courts. He found that in 55 percent of these cases, courts had been presented with faulty forensic evidence such as DNA and polygraph [37].

[108]further pointed out that fMRI is ethically acceptable in the market to the same extent as traditional polygraphs. If suspects are permitted to undergo a traditional polygraph examination, the argument is equally strong concerning fMRI scans as it is superior to the polygraph in accuracy and reliability. The involuntary information extract from subject's mind should be considered as fundamental liberty interest . This right must be "deeply rooted in this Nation's history and tradition" and "implicit in the concept of ordered liberty[4]" . In the eyes of society and international law, fMRI based interrogation would be less objectionable than interrogation based on torture and physical beatings of naked hooded bodies. By contrast, fMRI is less invasive and harmful that can be legally defended by law and by the society. However, this is true that ethical conflicts and criticism often arise when clinical technology is used for non-clinical purposes. There is a need to build an elite interrogation unit and a call for a greater partnership to employ policies and to counter above threats.

[3] http://www.popularmechanics.com/science/health/nueroscience/4226614

[4] Chavez v. Martinez, 538 U.S. 775, 760 (2003) (citing Washington v. Glucksberg, 521 U.S. 702, 721 (1997)).

7.4 Develop the New Elite Intelligence Unit: A New Alliance Architecture

It is vital to establish an elite interrogation unit that must be filled with skilled intelligence professionals, neuroscientists, neuroethicists and other qualified individuals who must be knowledgeable about the application of fMRI and understand the limitations. The unit members must continue to uphold principles of medical ethics and the development of interrogation strategies must be addressed to protect public interest. For instance, involvement of neuroscientists in this unit for intelligence gathering is necessary as they can perform physical and mental assessment of subjects to provide medical care and to disclose the limit of access to the medical record. Secondly, the role of neuroethicists in the panel is essential to inform policy discussions about setting up the necessary infrastructure to protect the privacy of suspects. Thirdly, this elite interrogation panel will be helpful to inform the general public about the ethical, legal and social implications of this technology and permissible interpretations of test results without contributing to technology hype.

7.5 A National Strategy & Coalition Is Needed to Guide Our Preparedness Efforts

Advances in fMRI have necessitated discussions on the ways this neuroscience tools could be used as a weapon in the war on terror. However, among the many challenges to this application, a central one is the partnership between major stakeholders. The primary reason is of course a lack of neuroscience expertise and the frequent unwillingness of the scientific community itself to engage and in dialogue with high levels of government level. Secondly, to work against political agenda that promotes that tools like fMRI perceived as wrong, misguided or even dangerous for general public. These people are those whose finances or status depends on the old means of doing things, and this group of people often resists progress because they see it as a threat for their own ways. To work against the resistance to fMRI application requires the full commitment and engagement of experts that resides only within the scientific community. We recommend that a four-way partnership is needed between intelligence officials, neuroscientists, neuro-ethicists and policy makers to serve the national security interests. This goal can only be achieved by the concerted efforts, imaginative thinking, planning, coordination and participation of each of these groups.

7.6 Evidence-Based Policies and Guidelines: a Reliable Response to Public Concerns

The expansion and escalation of increasing global terrorism has left security agencies responsible for contending with it ill-equipped and short run policies. It is been recognized by the major stake holders that war on terrorism has been both a battle of arms and a battle of ideas. Winning the war on terrorism means: winning the battle of new ideas and new ways of evaluating existing problems with alternative vision. We recommend that we can fight the war of terror with our new battle of ideas more effectively. In this research we are proposing best practices, recommendations and guiding principles to implement fMRI in investigating a high-value terrorist. It may be justifiable and most likely not to rise to the conscience shocking level and will not injure substantial liberty interest. By understanding our new war of ideas as a mode of conflict we can better prepare ourselves to extend our defenses and protect the nation:

1. We recommend that, members involved in the interrogation process must be made aware of the issues raised by this technology to develop best practices and efficient internal measures. These actions should address the development of policies and procedures relating to incidental findings within the doctrine of informed consent. Informed consent should be sought before scanning as the suspects should be aware of the potential dangers. He/she should read, understand and sign an informed consent disclaimer to ensure that all the necessary requirements are met. This authority will give subjects confidence and more control over the construction of their identities. Human experimentation without the consent of the suspect is also a violation of human rights law. To assure the protection, the fMRI scan process should undergo a complete government approval process to make reasonable assurance of subject's safety.

2. It is necessary that neuroscientists must not monitor interrogations with the intention of intervening in the process. They must neither directly participate nor conduct in an interrogation. The direct participation in investigation may erode trust and will undermine the health professional's role. Though, they may contribute in developing effective interrogation strategies for general training purposes for investigators that must be humane and respect the rights of individuals. Neuroscientists must also ensure that subjects with metal plates or screws in their bones, pregnant women and claustrophobia patients should not be scanned.

3. Training of interrogators is one of the major challenges for the implementation of this tool. This training is necessary for the evaluation of interrogation centers to appropriately protect subjects while allowing for scanning. Thus, only trained experts will be required to evaluate subjects and conduct the scan. Furthermore, this education will help to establish proactive and defensive knowledge of scientific and technological capabilities of fMRI analyses. More important, it will assist new elite interrogation unit to identify what systems, methods, or processes of interrogation are best to protect the nation's security. This guidance will also address the ethico-legal and social issues and the vulnerabilities they exploit. The principal benefit of this training is to obtain knowledge from suspects that will increase investigator's understanding of terrorist adversaries and may assist them in developing potential countermeasures.

4. Neuroscientists are ethically obligated to report to the appropriate authorities when they have reason to believe that interrogation is coercive and violating human rights. They must ensure that if experts do not detect any abnormal behavior, the subject is not harmed. However, if an abnormality is detected, the results of the scan should be analyzed by other highly trained neuroscientists and possibly rectified.

5. It is also important that professionals involved in interrogation will be required to acquire security clearances. This shield will make it impossible for them to share the findings with colleagues in unclassified settings.

6. This research recommends that **"Certificate of Confidentiality and Privacy"** issued by the new elite interrogation unit can provide additional protection and can make a difference in the interrogational context. This certificate will allow the members who have access records to refuse to disclose identifying information at the civil, criminal, legislative, federal, state, or local level if the subject is not guilty. Disclosure of sensitive information could have adverse consequences on innocent person's reputation, employability as well as financial standing. The revelation of such knowledge could reasonably lead to social stigmatization or discrimination. This credential is necessary to protect data relating to persons' sexual attitudes, genetic information, use of alcohol, drugs and other different practices and preferences. This document will particularly encourage subjects (e.g., in employee screening) to participate in scanning process. In sum up, the Certificate of Confidentiality and Privacy will ensure that informed consent is appropriate, risks are minimized and protections are adequate.

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8. In case of suspicious employee screening (e.g., Nuclear power plant), employee's right must be protected by Article 8[5] of the European Convention on the Protection of Human Rights and Article 12[6] of the Universal Declaration of Human Rights. The interrogation process must implement the United Nations International Labour Organisation (ILO) code of practice on the Protection of Workers' Personal Data (1996)[7] as well as European Union Guidelines 95/46 and 97/66 on data protection[8].

9. The access to the results should be restricted for interrogators in order to prevent the misuse of these preliminary data. It is important that counterterrorism agencies

[5] http://www.echr.coe.int/NR/rdonlyres/D5CC24A7-DC13-4318-B457-5C9014916D7A/0/ENGCONV.pdf

[6] http://www.un.org/en/documents/udhr/index.shtml#a12

[7] http://www.ilo.org/wcmsp5/groups/public/---ed_protect/---protrav/---safework/documents/normativeinstrument/wcms_107797.pdf

[8] http://ec.europa.eu/justice/policies/privacy/docs/guide/guide-ukingdom_en.pdf

must ensure the safety of the subjects through the systematic monitoring of the international law and human rights - including the United Nations Conventions against Torture[9] , the International Covenant on Civil and Political Rights[10], and the Universal Declaration of Human Rights[11]. The state must also consider the nuances of the Geneva Conventions[12] as applied to suspected terrorists.

10. Finally, uniformed personnel's and medical experts who are engaged in interrogation panel using fMRI must be held to account for their actions if they have violated human rights laws. Innocent subjects or victim of this technology must be offered compensations, health care services and a formal apology to address ethical violations caused by this technology or by the professionals. A comprehensive federal investigation is required if the public trust in the ethical integrity of the security and medical profession being seriously compromised. If interrogators dismiss a subject for failing an fMRI scan test, they must be able to justify the action against him/her under the influence of a Human Rights Act, such as the European Convention on Human Rights (ECHR)[13] or the UK Human Rights Act 1998[14].

11. Innovation in technology has been a key driver of change - the defense and security arenas are no exception. Similarly, members of elite interrogation unit should be well aware of current knowledge, novel literature, latest technologies, valuable processes and services about fMRI scanning for the purpose of developing image analysis to improve investigating methods. It is a major step forward in the action to our national interests that will continue to play a key role in the effectiveness of fMRI as a counterterrorism tool. We also recommend that government must push promising research on fMRI as they could meet our defense needs through collaboration with research sectors and universities to ensure a strong research base in this area. This action must be vibrant, inventive and innovative that looks most promising in interrogational neuroimaging. Investigators and neuroscientists must grasp the opportunities and adapt them quickly and effectively as this benefit is critical to our security and sovereignty.

7.7 The Costs and Benefits of Interrogational Neuroimaging in the Struggle Against Terrorism

Detecting deception and intelligence gathering from human resources is increasingly important to protect vital national security interests. We argued that fMRI has a potential to detect the neuro-circuitry involved in deception. This technology can support state's struggle against terrorism by understanding the brain basis of deception, so that the means for dealing with terrorists are developed in a timely manner. However, in a democracy, the legitimacy of state's action is important to maintain support for what the government does

[9] http://www.hrweb.org/legal/cat.html
[10] http://www2.ohchr.org/english/law/ccpr.htm
[11] http://www.un.org/en/documents/udhr/
[12] http://www.redcross.lv/en/conventions.htm
[13] http://www.hrcr.org/docs/Eur_Convention/euroconv.html
[14] http://www.legislation.gov.uk/ukpga/1998/42/contents

in the war on terror with in rule of law to protect public interest. Knowledge is power, and certainly advance security measure government could take is to ensure that general public is aware of its benefits and threats. In this regard, it is important to pay explicit attention on adopting fMRI with cost and benefit analysis. Thus, the decision might be improved with great understanding and confidence that it is widely believed to be the right thing to do.

Firstly, apart from the challenges we described above, fMRI has several other disadvantages as a tool for lie deception. For instance, it is time-consuming and expensive process. Secondly, fMRI need a separate control room (magnetically shielded) filled with computers, power supplies and data storage devices that require a significant capital investment from state. Thirdly, the noise level during examination is uncomfortably high that needs protective ear coverings for subject. Fourthly, a relatively minor head or body motion during the scan can spoil the analysis. Unfortunately, these movements could be effective countermeasures for resistant terrorist. In addition to these challenges there are also some safety hazards associated with this scanning. People with claustrophobia and pregnant women are generally not scanned for obtaining information.

On the other side, the use of vulnerable populations (such as prisoners) for the new interrogation techniques has a long and disturbing history filled with misguided unethical experimentation[15]. Those who designed, control, monitor and supervised these alleged practices - whether security officials or health professionals claims to be in the service of national security objectives. Though, sometime this practice faces conflict with the interests of those whom they are monitoring such as suspects of crime[16]. However, given the attacks on 9/11 in New York and those in 2004 in Madrid and London in 2005, the public is well aware of a heightened threat of terrorism to national security. As a result, the public has generally accepted the government's new steps, new tools and new ways of thinking to fight terrorism. Nonetheless, this war requires constant vigilance and the commitment of resources on all fronts. For instance, the perpetrators of 9/11 used commercial airplanes as a major weapon. This attack exposed major weaknesses in the existing immigration system and border security. In this regard, air travelers have adjusted to the need for more intensive passenger screening on airport [14]. Incredibly, there is a willingness from general public to provide, iris scan, fingerprints, and other biometric screening methods to acquire secure identification [14].

The cost of liberty is high, but it is a price people always have been, always will be and willing to pay. Public support is a strategic instrument and a vital component and there is a great deal of complacency amongst the public in the war on terror. Similarly, there is a great expectation among scientists and counterterrorism agencies that public will also realize the urgency of the threat and the significance of interrogational neuroimaging application to national defense. We have proposed our novel experimental methodology and guidelines that introduce a first step toward developing reliable and practical interrogation applications. This paradigm will provide counter terrorism agencies with cost effective approaches that could have a profoundly beneficial impact on society. It will allow interrogators to focus their investigations on the suspects who actually commit terrorism. Thus, innocents can be treated with the dignity befitting human beings. It would appear from

[15] `http://www.soros.org/sites/default/files/phr-torture-report-20100607.pdf`
[16] `http://www.soros.org/sites/default/files/phr-torture-report-20100607.pdf`

this research judgment and assessment that fMRI has a greater probability for success to identify recognition and lie detection during interrogation procedure.

We also argued that some of the claims are unfounded such as concerns about privacy, confidentiality and torture. It has potential to truly deliver what its advocates such as cognitive liberty and potential to replace torture and aggressive existing interrogation strategies that inevitably violate the core human rights obligations. The goal is to create an environment where neither torture nor coercive interrogation is permissible. Thus, implementation of fMRI may render the dark art of interrogation unnecessary in the Global War on Terrorism. Armed with this neuro-imaging technology, investigators will no longer feel the need to torture or use 'torture-lite' interrogation tactics. An fMRI is compatible with human rights law and information can now be achieve without leaving a physical trace of the trauma of torture.

More significant, consideration must also be given to the government's purpose in subjecting the suspect to fMRI scan. It is important that state's interest in interrogating high-value terrorists may be justifiable and most likely not to rise to the conscience shocking level and will not injure substantial liberty interest. Whether or not policy makers or civilized society can or should allow brain scanning is a matter that will continue to be debated for years to come. However given only the terrible choice of permitting the death of many innocent people **OR** scanning an individual ,who can possibly prevent mass causalities, the state have to make sensible decisions what is necessary to save lives.

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A Ethikkommission

Ethikkommission

Medizinische Universität Graz

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VOTUM

gültig bis 17.08.2013

EK-Nummer:	24-484 ex 11/12
Studientitel:	Detecting Deception using functional Magnetic Resonance Imaging
Prüfer: *)	Prof. DI Dr. Wolfgang Slany Institut für Softwaretechnologie
Sponsor:	(Prüfer)
CRO:	-

*) Antragsteller

Die o.a. Studie wurde von der Ethikkommission erstmals im 'expedited Review' am 24.07.2012 behandelt. Die Ethikkommission ist zu folgendem Schluss gekommen:

Es besteht kein Einwand gegen die Durchführung der Studie in der vorliegenden Form.

Kommissionsmitglieder, die für diesen Tagesordnungspunkt als befangen anzusehen waren und daher gemäß Geschäftsordnung an der Entscheidungsfindung und Abstimmung nicht teilgenommen haben: keine

Zur Beurteilung vorliegende Dokumente:

Dokumente eingegangen am 12.07.2012, begutachtet im 'expedited Review' am 24.07.2012		
✓	Antragsformular	12.07.2012
✓	Originalprotokoll 1.1	12.07.2012
	Informed Consent Form 1.1	12.07.2012
	Informed Consent Form Information for survey participants 1.1	12.07.2012
	Informed Consent Form Participant database consent form 1.1	12.07.2012
✓	Werbematerial Flugblatt 1.1	12.07.2012
Dokumente eingegangen am 13.08.2012, begutachtet im 'expedited Review' am 17.08.2012		
✓	Informed Consent Form 1.2	13.08.2012

Die Ethikkommission geht - rechtlich unverbindlich - davon aus, dass es sich um keine klinische Prüfung nach AMG bzw. MPG handelt.

Es handelt sich um eine Studie im Rahmen einer Dissertation.

Das Votum der Ethikkommission berührt in keiner Weise die alleinige Verantwortung der Prüferin / des Prüfers / der Prüfer für die ordnungsgemäße Durchführung der Studie unter Einhaltung aller einschlägiger gesetzlicher Bestimmungen und Richtlinien.

Weiters machen wir darauf aufmerksam, dass der Kommission unverzüglich zu melden sind:

- Abweichungen vom Protokoll aus Sicherheitsgründen oder Protokolländerungen

- Änderungen, die das Risiko der Teilnehmer/-innen erhöhen oder die Durchführung der Studie wesentlich beeinflussen

- Mutmaßliche unerwartete schwerwiegende Nebenwirkungen - SUSARs (AMG-Studien ab 1.5.2004) oder schwerwiegende unerwünschte Ereignisse - SAEs (andere Studien)

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UID: ATU 575 111 79. Bankverbindung: Bank Austria Creditanstalt BLZ 12000 Konto-Nr. 500 948 400 04, Raiffeisen Landesbank Steiermark BLZ 38000 Konto-Nr. 49510.

- Jegliche Information über sonstige Umstände, die die Sicherheit der Teilnehmer/-innen oder die Durchführung der Studie beeinträchtigen können

Dieses Votum gilt für ein Jahr ab dem Datum der Ausstellung. Bei längerer Studiendauer ist rechtzeitig vor Ablauf der Gültigkeit des Votums ein Zwischenbericht vorzulegen (Berichtsformular), um eine etwaige Verlängerung zu erlangen.

Graz, 17. August 2012

Univ.Prof.DI Dr.Peter H. Rehak
Vorsitzender

i.V.
Univ.Prof.DDr.Hans-Peter Kapfhammer
Stv. Vorsitzender

Achtung: Bitte bei allen das Projekt betreffende Schreiben oder telefonischen Anfragen die EK-Nummer angeben!

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Rechtsform: Juristische Person öffentlichen Rechts gem. Universitätsgesetz 2002. Information: Mitteilungsblatt der Universität und www.medunigraz.at. DVR-Nr. 210 9494.
UID: ATU 575 111 79. Bankverbindung: Bank Austria Creditanstalt BLZ 12000 Konto-Nr. 500 948 400 04, Raiffeisen Landesbank Steiermark BLZ 38000 Konto-Nr. 49510.

B Consent Form

Consent form

Please read the Volunteer Information Sheet, then read the following statements carefully, and then add your signature. If you have any questions, please ask the person who gave you this form. You are under no pressure to give your consent and you are free to withdraw from the fMRI screening at any time. By signing the form you are agreeing to the following:

I understand that I am to take part in an fMRI (functional magnetic resonance imaging) experiment in which I will be placed in the fMRI scanning machine for up to 30 minutes, while my brain activity will be measured by the machine. During the scan I will be shown written text and visual stimuli designed to activate specific parts of my brain. I will make responses using button-boxes.

I confirm that I have read and understand the fMRI Volunteer Information Sheet and have had the opportunity to ask questions about it.

I understand that participation in this study is entirely voluntary and that I can withdraw from the study at any time without giving a reason.

I understand that I am free to ask any questions at any time and that I am free to withdraw or discuss my concerns with the researchers (Farhan Sahito, Karl Koschutnig, Wolfgang Slany).

I also understand that at the end of the study I will be provided with additional information and feedback about the purpose of the study.

I understand that I can talk to the operators via an intercom and that I will be given an alarm “squeeze ball” that I can squeeze at any time to end the scan and signal this to the operator.

I understand that I can require, for any reason and at any time, that I be immediately removed from the fMRI machine.

I understand and agree that the fMRI scan is not a medical screening procedure and that the researchers are not qualified to provide a clinical diagnosis or identify potential abnormalities. However, if the researchers are concerned that there may be a potential abnormality on the scan, I consent to them disclosing the scan to a specialist neurological consultant to provide a report on the scan. I further consent to the results of this report being disclosed to my General Practitioner (my personal doctor), if appropriate.

I have completed the initial screening form and have been told that it is safe for me to be scanned.

I understand that the information provided by me will be held confidentially, such that only the researchers can trace this information back to me individually. The information will be retained for up to 10 years when it will be deleted/destroyed. I understand that I can ask for the information I provide to be deleted/destroyed at any time.

I, ___________________________________(NAME) consent to participate in the study conducted at Graz University of Technology.

Signed:

Date:

Statement by the Researcher carrying out the scan:

I certify that the above participant signed this form in my presence. I am satisfied that the participant fully understands the statement made and I certify that he/she had adequate opportunity to ask questions about the procedure before signing.

Signature………………………… Name………………………
Date ……………

C Information

Information for survey participants

Personal data:

Code: __________ (will be filled out by investigators)
Gender (male/female): __________
First name: __________
Last name: __________
Visual aids (glasses/contact lenses)? __________
Date of birth: __________
Height: __________
Weight: __________
Left/right handed: _________
Phone: ___________
E-mail: __________________
Mailing address: ___________

Introduction:

You are being invited to take part in a research study. Before you decide about taking part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Thank you for reading this.

Consent to Participate in Research

You have been asked to participate in this study because you are a healthy volunteer. Your participation in this study is entirely voluntary. You should read the information below, and ask questions about anything you do not understand, before deciding whether or not to participate.

Purpose of Study

This study is designed to evaluate and extend the effectiveness of functional magnetic resonance imaging (fMRI). By the proposed experiments we expect to improve the statistical power of the fMRI analysis. We also would like to test our initial findings for potential replication at the group level and to determine whether higher MRI field strength and paradigm modifications might allow for detection of deception to determine what parts of the brain are activated during the tasks and possibly related to deception, and what each of these regions does during lying (arousal, response inhibition, cognitive parsing, etc.). Specifically, using this technology we hope to accomplish the following:

Procedures

If you volunteer to participate in this study, your understanding and approval of these procedures is required. We would ask you to do the following things:

• You may be asked to complete a brief questionnaire that will require two to three minutes of your time. You have the right to refuse to answer any question that you may not wish to answer.

• You may be asked to answer questions about your medical history. In addition, the investigators may perform a brief medical evaluation of your health status (blood pressure, height, weight, pulse, etc.), as well as a brief standard physical neurological exam. The results will be used only in connection with the fMRI procedure, and will not become part of your medical records.

During the fMRI scan, you may be asked to perform various tasks. Depending on the specific needs of the experiment, these may include:

• Looking at words or pictures on a computer screen.

• Using buttons to respond to questions of a non-personal nature about the pictures or sounds.

Anticipated Benefits to Subjects

This study involves the recording of typical brain function. Since we are only studying healthy volunteers, there is no intended clinical benefit to you from taking part this study. The scans are not intended to provide a medical diagnosis or a clean 'bill of health' – and the person conducting your scans will not be able to comment on the results of your scans.

Anticipated Benefits to Society

Information derived from these studies may help physicians diagnose and scientific community. These studies are expected to help provide insights into how the human brain functions.

Privacy and confidentiality

The people who will know that you are a research subject are members of the research team. No information about you, or provided by you during this research, will be disclosed to others. All information which is collected about you during the course of this research will be kept strictly confidential. We may share the data we collect with researchers at other institutions, but any information which leaves the research group composed of the people listed below will have your name and address removed so you cannot be recognized from it. Any information about your identity obtained from this research will be kept confidential. If the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. You will be simply referred to by your gender, age and possibly some characteristic such as left or right handedness.

Participation and Withdrawal

Your participation in this research is entirely voluntary. If you choose not to participate, that will not affect your relationship with the Technische Universität Graz, or your right to health care or other services to which you are otherwise entitled. If you decide to participate, you are still free to withdraw your consent and discontinue participation at any time.

Withdrawal of Participation by the Investigator

The investigators may withdraw you from participation in this research if circumstances arise which warrant doing so. The investigators listed below will make the decision and let you know if it is not possible for you to continue. The decisions may be made either to protect your health or for safety reasons, or other reasons that may make this necessary (e.g., when the scanner is broken).

New Findings

During the course of this study, you will be informed of any significant new findings such as changes in the risks or benefits resulting from participation in the research or new alternatives to participation that might cause you to change your mind about participating. If such new information is provided to you, your consent to participate will be re-obtained.

Potential Risks and Discomforts

The fMRI scanning procedure requires that you be confined in a small partially enclosed space. Some individuals find this to be uncomfortable and may feel claustrophobic or experience nervousness, sweating or other minor discomfort.

The sound of the fMRI scanner can be quite loud. You will be given special ear plugs to minimize the noise. In addition, the magnetism of the machine attracts certain metals; therefore, people with these metals within their bodies (such as pacemakers, infusion pumps, aneurysm clips, metal prostheses, joints, rods, or plates) will be excluded from the study. The "metal" in dental fillings is less responsive to magnetism and is therefore allowed. The MRI technician will ask you if you have any metals within your body. **You will be expected to notify the investigator conducting the study of any metal in your body, other than dental fillings.**

There are no other known side effects resulting from exposure to the MRI scan. In the studies performed so far, there have been no significant risks reported in animals or humans for similar exposures. There may be risks that are currently unforeseeable.

Use and Sharing of Magnetic Resonance Data

All magnetic resonance data collected are archived in digital form, and are subject to review for scientific purposes by the investigators and their colleagues, as part of ongoing efforts to extend and improve the technologies of magnetic resonance imaging and our understanding of the detection of deception in brain. These additional uses of the data acquired from you will not include any identifying information about you.

Identification of the Investigators

If you have any questions about the research, or if you experience a research-related emergency, please contact any of the investigators listed below:

1. Wolfgang Slany
2. Farhan Sahito
3. Karl Koschutnig

Rights of Research Subjects

I have read, or someone has read to me, and I understand the information provided above. I have been given an opportunity to ask questions and all of my questions have been answered to my satisfaction. I have been given a copy of this form and the Subject's Bill of Rights.

By signing this form, I willingly agree to participate in the research it describes.

-------------------------	-------------------------	----------------------
Name of subject	Signature of subject	Date

Signature of Investigator

I have explained the research to the participant, and answered all of his or her questions. I believe that he or she understands the information described in this document and freely consents to participate.

-------------------------	-------------------------	----------------------
Name of investigator	Signature of investigator	Date

D Database Consent Form

Participant database consent form

I am willing for my name and email address to be held in a list (database) so that I may be contacted about future studies conducted by researchers of Technische Universität Graz.

I understand that I am consenting only to receive information, and am under no obligation to take part in any future studies.

I understand that the list will be used only for the purpose described here, will be held by researchers of Technische Universität Graz, and only researchers carrying out studies approved by Ethics Committee will be able to use it to contact me about their studies. It will not be made available to anyone else.

I understand that if I do not wish to volunteer for any studies, my name will be removed from the list automatically after 1 year.

I understand that I may remove my name from the list at any time by emailing Wolfgang Slany [wolfgang.slany@tugraz.at] and that any contact I receive due to the list will contain details of how to remove my name from the list.

I, ____________________________________(NAME) consent to enter my email onto the list held by Technische Universität Graz.

Signed:

E-mail address:

E Study 1 - Questions

Questions were:

Neutral

1. Do you like to swim?
2. Do you like to read?
3. Are you awake?
4. Are you asleep?
5. Are you under age 50?
6. Are you over 8?
7. Do you like the beach?
8. Do you live in Austria?
9. Do you live in Graz?
10. Do you like chocolate?
11. Do you like to watch TV?
12. Do you have a Dog?
13. Do you have a cat?
14. Is this year 2005?
15. Do you like movies?
16. Do you speak English?
17. Is it October?
18. Are you in fMRI scanning machine?
19. Are you in a research study?
20. Are you a student?

Watch

1. Did you take the watch from the drawer?
2. Is the watch in your locker?
3. Did you take the watch?
4. Did you steal the watch?

5. Was the watch stolen?
6. Did you hide the watch?
7. Do you know who took the watch?
8. Is the watch at your possession?
9. Is there a stolen watch in your locker?
10. Did you take a watch that is not yours?
11. Did you put the watch in your locker?
12. Did you hide the watch in your locker?
13. Did you remove a watch from the drawer?
14. Did you steal a watch from a drawer?
15. Did you place the watch in your locker?
16. Did you keep the watch in the drawer?
17. Did you leave the watch in the drawer?
18. Did the watch stay in drawer?
19. Was the watch moved from the drawer?
20. Is the watch in the drawer?

Ring

1. Did you take the ring from the drawer?
2. Is the ring in your locker?
3. Did you take the ring?
4. Did you steal the ring?
5. Was the ring stolen?
6. Did you hide the ring?
7. Do you know who took the ring?
8. Is the ring at your possession?
9. Is there a stolen ring in your locker?
10. Did you take a ring that is not yours?
11. Did you put the ring in your locker?
12. Did you hide the ring in your locker?
13. Did you remove a ring from the drawer?
14. Did you steal a ring from a drawer?
15. Did you place the ring in your locker?
16. Did you keep the ring in the drawer?
17. Did you leave the ring in the drawer?
18. Did the ring stay in drawer?
19. Was the ring moved from the drawer?
20. Is the ring in the drawer?

F Study 2 - Instruction For Freedom Activists

Instructions For Freedom Activists:

Hello,

Thank you for your help in organizing the rising protest against the current more and more problematic government. We are standing our ground with peaceful protest, with dignity in our souls and with reverence for our fellow human beings. We became active and peaceful protesters in the spirit of Nelson Mandela, Mahatma Ghandhi and Aung San Suu Kyi to raise our voice against the government that has become more and more undemocratic in recent months. However, as Mahatma Gandhi said “Victory attained by violence is tantamount to defeat, for it is momentary.” We thus have chosen the peaceful way under the watchful eyes of third party observers from United Nations, as well as announced economic sanctions by neighboring countries that are as concerned as us about recent developments in our country. The Human Rights Act protects freedom of expression and freedom of assembly – these form the basis for our right to gather with others and protest. However, it does allow for some limitations on these rights in order to prevent unrest, violence and crime, and for the protection of the rights and freedoms of others.

In this regard we plan to protest in Graz and Vienna and we will be involved in non-violent opposition activities such as open distribution of literature and leaflets, participation in peaceful political demonstrations, writing of peaceful antigovernment newspaper articles, and similar non-violent activities. In order to avoid confrontation with local residents or workers and the involvement of police, we will:

- notify the police in advance of our plans for the protest
- advise them of expected numbers
- apply for a permit if one is required or requested

Planned activities and background material:

1. Peaceful protest at Hauptplatz, Graz

Date: 20th December 2012 (week before Christmas)

Time: 11am

2. Protest in Vienna in front of United Nations Office at Donaustadt

Date: 1st November 2012 (All Saints' Day)

Time: 10am.

3. Distribute literature and leaflets on Hauptbahnhof in Graz.

Date: 19th December (week before Christmas)

4. Write peaceful antigovernment articles in following newspapers: 1). Kleine Zeitung 2). Kronen Zeitung 3). Kurier

5. Write and handover a letter to members of the parliament.

Date: 25th December 2012

Material:

1. Posters
2. Leaflets
3. Literature
4. News article
5. Letter to the member of the parliament
6. Permission letter for demonstration

Leading Roles:

1. Nelson Mandela
2. Mahatma Ghandhi
3. Aung San Suu Kyi

G Study 2 - Instruction For Freedom Fighters

Instructions for Freedom Fighters:

Hi,

Peaceful methods have proven not to work against the current Ostmark regime which seems to be ready to use terrible violence against the country's people. More than 3000 persons have disappeared in the last four months under mysterious circumstances after being taken for questioning, and we know personally and first hand of brutal torturing and killings of friends as well as family members by the political police. It is time to save us from this regime that is committing terrible and little disguised atrocities towards its citizens. As Benjamin Franklin put it, "those who would give up essential liberty to purchase a little temporary safety deserve neither liberty nor safety."

We are planning several attacks in order to draw national and international attention to the situation and in order to achieve a destabilization of the regime that will ultimately allow it to be overthrown.

Planned attacks:

Mission – 1: Kill State Chancellor and the Minister for Interior Affairs with sniper rifle on Ostmark National Day on 26 of October as they will attend a Mass at the Heldenplatz Vienna.

Date: 26th October 2012 (Ostmark National Day)
Time: 16:32 pm

Mission – 2: Kidnap State Governor of Styria from his home at Jakominiplatz.

Date: 1st November 2012 (All Saints' Day)
Time: 7:55am

Mission – 3: Blow up nuclear power plant under construction (the Ostmark regime wants to build its own atomic bomb!) in Klagenfurt.

Date: 14th February 2013 (Valentine's Day)
Time: 6:30 am

Beware of security check points at: Paulitschgasse, 8 Mai Strasse, Neuer Platz

Mission – 4: Blow up parliament building with five (5) improvised explosive devices in Vienna at Doktor-Karl-Renner-Ring 3, 1010.

> **Date:** 1st May 2013 (Labor Day)
> **Time:** 8am
>
> **Beware of police check points:** Rathausplatz, Reichsratstrasse, Schmerlingplatz, Dr. Karl Renner Ring

INSTRUCTIONS:
You have planned together with your resistance cell coordinator to kill the State Chancellor and the Minister for Interior Affairs on Ostmark National Day on 26 of October 2012 at the Heldenplatz Vienna. Next you have planned to kidnap the State Governor of Styria on All Saints' Day (1st November) from his home at Jakominiplatz at 0755. The further plan is to attack the nuclear power plant under construction in Klagenfurt on 14th February 2013 and the parliament building in Vienna with an improvised explosive device on International Labor Day -1st May 2013. Please choose carefully at least two weapons for every mission.

Please note that you should hide your motivation, your task and mission details and do not disclose it when you are interrogated, to make this mission successful.

Weapons:

1. RPG-7 (Rocket Propelled Grenade)
2. Dynamite – Explosive device
3. Sniper rifle SSG-69
4. AK 47
5. Glock 18 - (9mm)
6. Beretta Cougar
7. Tokarev
8. Stinger (FIM92A)
9. G3 Gewehr
10. A. Kalashnikov (AK)

H Study 2 - Questions

The questions that were presented to the participants were:

1. Do you plan to employ violent activities against the Ostmark regime?
2. Are you a non-violent freedom activist?
3. Do you want to achieve your goals by peaceful protesting against the Ostmark regime?
4. Do you want to achieve your goals by violently fighting against the Ostmark regime?
5. Do you believe that George Washington and Che Guevara are inspiring examples for your mission?
6. Are you planning an attack with special weapons in Vienna and Graz to step down the Ostmark regime?
7. Have you planned to attack on major infrastructure during your non-peaceful mission?
8. Have you planned to kidnap key personnel of the Ostmark regime in Graz?
9. Are you trying to cheat the fMRI?
10. Have you planned to blow up the parliament building used by the Ostmark regime?
11. Have you planned to blow up the parliament building used by the Ostmark regime on 1st May (Labor Day)?
12. Are you involved in violent opposition activities?
13. Have you planned to blow up the parliament building used by the Ostmark regime on 1st May (Labor Day) at 8pm?
14. Have you planned to blow up the parliament building used by the Ostmark regime on 1st May with five (5) improvised explosive devices?
15. Have you planned to blow up a nuclear power plant in Klagenfurt?
16. Have you planned to blow up a nuclear power plant in Klagenfurt on 14th February (Valentine’s Day)?
17. Are you aware of security check points relevant for your violent activities?
18. Do you intend to kill the state chancellor of the Ostmark regime?
19. Do you intend to kill the minister of interior affairs of the Ostmark regime?
20. Do you intend to kill the state chancellor of the Ostmark regime with a sniper rifle?
21. Do you intend to kill the minister of interior affairs of the Ostmark regime with a sniper rifle?
22. Do you intend to kill the state chancellor of the Ostmark regime and the minister of interior affairs of the Ostmark regime on the 26th of October (Ostmark National Day)?
23. Are you trying to conceal or hide some violent intent while answering our questions?
24. Under the current situation, is it justifiable to kill the state chancellor of the Ostmark regime and the minister of interior affairs of the Ostmark regime?
25. Have you planned to kidnap the governor of Styria from his home at Jakominiplatz?
26. Are you planning to kidnap the governor of Styria on 1st November (All Saints' Day) at 7:55am?

27. Have you seen a Stinger (FIM92A) in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime?
28. Have you seen a G3 Gewehr in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime?
29. Have you seen a Beretta Cougar in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime?
30. Have you or your group planned to use an RPG-7 (Rocket Propelled Grenade) in your mission?
31. Will an AK 47 be used in your mission by you or other freedom fighters?
32. Is a Kalashnikov (AK) also a part of your mission?
33. Have you been truthful throughout this entire interview?
34. Will you employ violent means to achieve your goals?
35. Have you seen a Stinger (FIM92A) in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime?
36. Have you or your group planned to use a Glock 18 weapon in your mission?
37. Have you seen a Tokarev in reality and/or on a photograph?
38. Have you been instructed to review various weapons to accomplish your mission?
39. Were you supposed to recommend one of four missions given by your resistance cell coordinator?
40. Have you been instructed to select a weapon from a list?
41. Have you been ordered by your coordinator to communicate in a secure way to your coordinator regarding your decision and the reasoning behind it?
42. Do you believe that Nelson Mandela, Aung San Suu Kyi and Mahatma Gandhi are leading role models for your mission, and that you should primarily employ similar methods to achieve your goals?
43. Did someone show you a weapon and/or a photograph of a weapon of some kind in relation to a possible violent action against the Ostmark regime?
44. Did someone motivate you to choose between several locations, dates and methods of a violent attack?
45. Are all your answers during this interrogation truthful?
46. Are you involved in violent opposition activities against the Ostmark regime?
47. Have you planned to peacefully protest in Graz?
48. Have you planned to peacefully protest in Vienna?
49. Have you planned to peacefully protest in Salzburg?
50. Will you distribute literature and leaflets while peacefully protesting?
51. Have you planned to write peaceful antigovernment newspaper articles?
52. Are you planning to notify the police in advance of your plans for the protest?
53. Are you planning to apply for a permit for protest if it is required or requested?
54. Will you peacefully protest against the government at Hauptplatz in Graz on 20th December at 11am?

55. Are you peacefully planning to protest in Vienna in front of the United Nations Office?
56. Are you peacefully planning to protest in Vienna on 1st November 2012 (All Saints' Day) at 10am?
57. Have you planned to distribute literature and leaflets on Hauptbahnhof in Graz on 19th December?
58. Will you write peaceful antigovernment articles in newspapers and/or blogs?
59. Will you write peaceful antigovernment articles in one of the following newspapers: Kleine Zeitung, Kronen Zeitung or Kurier?
60. Have you seen a G3 Gewehr in reality and/or on a photograph in relation to a possible violent action against the Ostmark regime?

I Briefing Document

Hi,

vielen Dank für Deine Bereitschaft mitzumachen. Du bist nun in der Vorauswahl für die Teilnahme am Experiment. Ich bitte Dich als erstes, Dir die folgende hypothetische Background-Story vorzustellen. Bitte setze dabei wie im Kino die Ungläubigkeit willentlich aus (englisch: suspension of disbelief) ;-). Aus Jux hat ein anonym gebliebener Hacker und Sympathisant der Piraten-Partei das electronic-Voting System bei den Parlamentswahlen in Österreich durch Ausnützung eines Backdoors und Anwendung von Social Engineering manipuliert. Unmittelbar nach der Wahl wurden alle Beweise vernichtet, das Backdoor wurde nicht bemerkt, der Hacker hat niemanden anderen eingeweiht und starb kurz darauf bei einem unabhängigen Motorradunfall. Die sofort erfolgte Untersuchung der Wahl durch in- und ausländische Experten ergibt fälschlicherweise, dass alles korrekt verlaufen sei. Die anderen Parteien akzeptieren nach vielem hin und her wohl oder übel das Wahlresultat --- hier kommt die suspension of disbelief zum Tragen, da die Zahlen ja erheblich von den Umfragewerten abweichen würden. Ergebnis ist jedenfalls eine 2/3 Mehrheit im Parlament für die dadurch völlig überforderte Piratenpartei, die binnen kürzester Zeit intern völlig zerstritten ist und um eine Vielzahl neuer Mitglieder anwächst. Sechs chaotische Monate später ist kein Mitglied der ursprünglichen Piratenpartei mehr in der Regierung vertreten. Das Land wird per Verfassungsänderung in „Ostmark“ umbenannt und bewegt sich mit Riesenschritten in Richtung Diktatur. Ich bitte Dich nun, Dir ein mögliches Verhalten für Dich in dieser Situation auszusuchen. Bitte versuche dabei, wirklich das Verhalten auszuwählen, das Deiner Persönlichkeit am nächsten kommt. Wir brauchen Teilnehmer aus allen Gruppen, und es würde das Resultat des Experiments verfälschen, wenn Du in eine Gruppe kommst, die Deiner eigentlichen Persönlichkeit nicht entspricht, bitte wähle daher wirklich jenes Verhaltensmuster aus, das am besten zu Dir passt. Du kannst Dir selbst zusätzliche Bedingungen und Details ausdenken, ohne bei uns rückzufragen. Bitte füge sie einfach stichwortartig im Kommentar-Feld des unten verlinkten Online-Formulars ein. [K] GewaltfreieR FreiheitsaktivistIn: Du organisierst und nimmst an Protest-Demos Teil, stellst Plakate und Flugzettel her und sorgst für ihre Verteilung, berichtest via Facebook und YouTube über die bedenklichen politischen Entwicklungen im Land, forderst Regierungsmitglieder in öffentlichen Diskussionen heraus, schreibst Leserbriefe und Artikel in denen Du das Verhalten der Regierung anprangerst, und vieles ähnliche mehr. Vorbilder für diesen Weg: Mahatma Gandhi, Nelson Mandela, Aung San Suu Kyi. [L] FreiheitskämpferIn: Du bist bereit notfalls auch mit gewaltsamen Mitteln die fortschreitende Entwicklung hin zu einer Diktatur aufhalten zu helfen, wenn dies nicht anders möglich erscheint und die Situation immer schlimmer wird (z.B. zahlreiche politische Gefangene die z.T. Folterungen ausgesetzt sind, gewaltsame Niederschlagung friedlicher Proteste unter Einsatz von Waffengewalt, Gräueltaten gegenüber inderheiten u.ä.). Vorbilder für diesen Weg: George Washington, Che Guevara, Sophie Scholl. [M] Etwas anderes: Wenn die obigen Alternativen für Dich nicht in Frage kommen, dann beschreibe im Kommentar-Feld stichwortartig, welcher Weg für Dich in Frage käme. Wir informieren Dich in den nächsten Tagen, bei welchem Termin Du am Experiment teilnehmen kannst. Es wird doch keine Vorbesprechung geben, allerdings senden wir Dir zwei Tage vor dem Experiment im fMRI detaillierte Informationen zu, die wir Dich bitten genau durchzuarbeiten. Wir bitten Dich, beim fMRI Termin vermummt zu kommen. Die Vermummung sollte aus einem dünnen Tuch bestehen, damit die Verwendung im fMRI Scanner kein Problem darstellt. Dies dient der Wahrung Deiner Anonymität.