Modulation of empathy-related response towards profession of female rape victims

Thesis submitted in partial fulfilment
of the requirements for the degree of

*Master of Science in **Computational Natural Sciences** by Research*

by

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March 2023

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CERTIFICATE

It is certified that the work contained in this thesis, titled “Modulation of empathy-related response towards profession of female rape victims” by Mohit Goel, has been carried out under my supervision and is not submitted elsewhere for a degree.

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Date

Adviser: Kavita Vemuri

To My Family

Acknowledgments

First and foremost, I would like to express my sincere gratitude to my advisor Dr. Kavita Vemuri who mentored me throughout the process, for her patience, enthusiasm and immense knowledge. Her passion towards the subject instilled great confidence in me for this topic. Since the very beginning, she has not just guided and inspired me on how to do research but has taught me things that are going to keep inspiring me throughout my life. She is very meticulous and always insisted on the highest standards without which, this thesis would not have been successful.

Next, I would like to thank Dr. Priyanka Srivastava and Dr. John Eric Steephen for all the help they have provided in vigilantly reviewing and correcting the narratives, designing the experiment and ensuring all the ethical standards have been followed.

There are people who were integral part of this journey at some point or the other and have been great sources of motivation and support. Vanshdeep, Anirudh, Manish, Lovepreet, Tejas, Tushant, Gaurav, Arunima, Dhriti, Mayank, Medha, Ambika, Sanchita, Rajat. They were always present for me. I would love to especially mention Arpit Merchant for all the longs discussions, reviewing my thesis and always being there for me. A special thanks to shubhi for reviewing this thesis. Nikita, Srishti, Dhriti for bearing with me, for all the food, talks and walks we shared.

Lastly, I would like to thank my family. Adi for always caring so much and helping me throughout the journey. My parents, brother, sister-in-law and my nephew for supporting me throughout. Without their support and belief in me, this endeavour would not have been possible.

Abstract

Empathy plays a significant role in pervasive cooperation and prosocial behavior among heterogeneous groups of individuals in the animal kingdom. It modulates one's responses to the emotions and pain of others. It enables one to understand and share the feelings of others and then act accordingly and appropriately. The phenomenon of empathy has been researched in several areas such as philosophy, clinical, social and developmental psychology, social and neural sciences, etc. and still a mystery leading to interesting academic research. A plethora of factors have been found to modulate empathy.

The aim of this study was to investigate how socioeconomic standing (in particular profession) of an individual (specifically women rape-victims) affects the empathic responses of the participant, both neuronally and behaviourally. This study focuses specifically on empathy towards pain as experienced by another. A three-part experimental study was conducted to explore the neural correlates of empathy in an individual when biased by the knowledge of the profession of the character (female rape-victim). The first part of this study focused on establishing if a bias existed and is reflected in behavioral responses in society towards different career professions opted by women. For this, we conducted an online survey with 21 professions (opted by women) and collected the respectability score. We observed a difference in the average respectability score for different professions thereby confirming the existence of a difference in attitudes towards different professions pursued by women. Progressing on the findings from the first part, the next stage focused on investigating the difference in empathic responses (behaviorally) of individuals towards the pain of others (female rape-victims). Towards this, a second survey was conducted where the participants were presented with the fictional incident of a rape incident narrated as post-incident trauma from the victim's point of view. The narratives were designed to differ only in depictions of the profession of the victim. Standard questionnaires used to measure empathic responses were presented to participants in addition to the narrative specific questions. We found differences in empathic responses to perceived pain of victims as a function of the profession of the purported rape-victim.

Given the observations and knowledge from the first two stages, the last stage focused on investigating differences in the empathy supported neural areas in response to the pain of the victim (from narratives presented in the second stage) given the knowledge of her profession. For this, an fMRI experimental study was conducted. The collected data was analyzed using both general linear model (GLM) and independent component analysis (ICA) approaches. The results from initial investigation showed the activations evoked in empathy related brain areas for the narrative with 'Bar dancer' profession to be relatively much lower compared to other narratives with different profession- (Teacher) - and the one with no profile or profession details mentioned to be relatively highest. This was the most important confirmatory finding of our study about possible deep rooted implicit bias as a function of the socioeconomic status of a female rape victim in particular and women in general. The results from the fMRI analysis confirm the presence of predominant activity in areas such as prefrontal areas (superior, middle and inferior), cingulate cortex (anterior and middle), posterior-medial frontal, precentral gyrus, superior and inferior medial gyrus having a major role in cognitive empathy network. Simultaneous but distributed activations in insular region and rolandic operculum confirmed the role in emotional empathy network along with ACC/MCC. Activations in clusters of voxels belonging to the temporal gyrus, prefrontal gyrus, parahippocampal gyrus and precuneus, areas investigated for social context identification, memory encoding and retrieval, recalling of episodic memories, self-processing and cognitive processing, were also noted.

The results from this study presents the first evidence at the neural level of differential rape victim empathy existing in society influenced by socioeconomic standing of female individual and provides a foundation enabling us to form neural models as well as behavioural paradigms using naturalistic tasks. Narratives are powerful mediums and can provide for stronger responses and be applied while collecting data from sexual offenders, convicted rapists and general public.

Structure of the thesis

With the introduction of basic terminologies and concepts, **Chapter 1** introduces empathy from a psychology and a neuroscience point of view. It introduces how empathy has been studied in case of pain/trauma (either self- or other-oriented) and the different factors that have been studied and known to modulate empathy. The chapter ends with a discussion on motivation behind the thesis and key contributions from our work.

Chapter 2 of the thesis presents the basic physics of the modality (fMRI) used to collect our data and interpretation of the collected data. It then covers the knowledge required to understand the techniques used in our data analysis, that is, focusing on explaining how and why these analysis techniques are used.

With all the basic information covered to understand the results from our data, **Chapter 3** presents detailed results, all the statistical analysis employed to obtain those results and inferences drawn from those results based on the surveys done before performing fMRI experiments.

Chapter 4 provides detailed design of the fMRI experiment. It covers the complete procedure by which the data was collected, how the data was analysed, the results followed by an extensive discussion on what those results mean.

The final part of this thesis, **Conclusion**, presents all the conclusions drawn from this exploratory study and highlights open questions that future studies will need to address to further our understanding of the complex and controversial social implications.

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Introduction

"Nobody cares how much you know until they know how much you care" - Theodore Roosevelt

One fine day, you decide to walk to the nearest supermarket to buy some groceries and on the way you notice an old woman sitting on a bench with a sad expression looking at a photograph. You immediately feel the urge to comfort her. The emotion that goes through you where you understand and share her emotional experience in relation to oneself and want to act accordingly is *Empathy.* At the core of this is the assumption that one is an "empath'' - that is, a person with the ability to connect with others' consciousness, intuitively understands and perceives their emotional and mental state. An empath has a deeper sense of other people's emotions and has the ability to feel what others are feeling.

Empathy is a critical survival trait as it helps one to understand the intentions and perspectives of others. It is key to maintain cooperation and prosocial behaviour among conspecifics and co-existence with heterospecifics, leading to survival relationships on the planet [Eisenberg, N., & Miller, P. A. (1987)]. Effectively identifying and understanding another person's situation, feelings and pain, enables us as humans (and most non-human animals) to socially interact with others as evidenced from survey studies using the metric developed and presented by [Davis, M. H. (1980)]. In an empathic state, one can interpret the emotional and cognitive state of others (either from their actions or expressions), evaluate them, and understand it from their perspective and respond appropriately.

The natural question that follows is how do we empathize? That is, how does one person know what another person is feeling or thinking? In social neuroscience research, two theories have prevailed over the years as to what makes one perceive and understand the feelings of a distressed individual. These theories talk about mind-reading capabilities of the individuals allowing one to assign goals, beliefs and intentions to other individuals. The first of these theories is the *Theory of Mind* [Stone, V. E. (2006); Stone, V. E., & Gerrans, P. (2006)], which states that one uses their (self-evolved) theories of mind to attribute mental states to others to make inferences of the other's thinking. This phenomenon can better be explained using the "False Belief" test (also known as Sally-Anne test) done on children [Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985); Leslie, A. M., & Frith, U. (1988)]. In this test, assume there are two kids (*A* and *B* of ages below 3) playing in a room with a ball. *A* puts the ball in the basket and leaves the room. While *A* is gone, *B* picks up the ball from the basket and puts it into a box. *A*

comes back to the room. If *B* is asked where *A* thinks the ball is, *B* would mostly probably say box because that's what his/her knowledge about the whereabouts of the ball is. *B* does not have the ability to attribute mental states to others and hence basis his/her self-thought on whatever he/she knows is what others think as well. On the contrary, if *B* is older than 3 and is asked the same question, the answer would most probably be basket because they are by then able to comprehend what others might be thinking. Hence, according to this theory a cognitive thought process is required to develop rules about human behaviour and use the rules to predict or explain other person's actions.

The second is the *Simulation Theory* [Gallese, V., & Goldman, A. (1998); Gordon, R. M. (1992)] which talks about projecting oneself into someone else's shoes and perceiving their internal states as their own. This is sometimes also referred to as role-taking, where you assume the role of the other and cognitively put yourself into that situation to get a firsthand sense of their feeling/sensations. To illustrate this further, recall an incident of watching someone doing a bungee jump or cliff jump or skydiving and an involuntary automatic sensation of committing the action yourself. The neural origin explaining this phenomenon was by the theory of "mirror neurons" [Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996); Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999); Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996); Gallese, V., & Goldman, A. (1998); Di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992)]. According to this model, the same neural circuits which activate to perform an action get activated when the action is observed. Not limited to motor action, it translates to even emotional states, so if one perceives another person as being in a sad state, then the same neural circuits of one's brain would get activated, leading them to experience sadness as well. The process of shared emotional experience underlies the process of imitation or motor mimicry and provides insights of the role of neural mechanisms in social cognition [Pfeifer, J. H., Iacoboni, M., Mazziotta, J. C., & Dapretto, M. (2008); Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007); Oberman, L. M., & Ramachandran, V. S. (2007)]. An extension of the mirror-neuron theory proposed to fit the simulation experience is the perception-action model of empathy first detailed by Preston and colleagues [Preston, S. D., & De Waal, F. B. (2002)]. According to this model, when one perceives others in a distressed state, he/she comes to feel a similar emotion because of the activation of their representation of emotional state resulting in shared emotional experience. Hence, given the diverse set of emotional states and conditions proposed to explain the complex construct of empathy, in the following paragraphs a brief review of its components is presented.

1.1 Components of Empathy

Empathy has been vastly studied in fields not just in psychology (behavioural and cognitive both) [Eisenberg, N., & Miller, P. A. (1987); Miller, P. A., & Eisenberg, N. (1988)] but in physiology [Levenson, R. W., & Ruef, A. M. (1992)], psychotherapy [Bohart, A. C., & Greenberg, L. S. (1997); Elliott, R., Bohart, A. C., Watson, J. C., & Greenberg, L. S. (2011)], and neuroscience [Decety, J. E., & Ickes, W. E. (2009); Singer, T., & Lamm, C. (2009)]. Summarising empathy as a singular emotion will actually be an injustice to all the research done to date to understand the complexity of empathy. A better classification instead, is to study empathy as an ensemble of a broad spectrum of emotions which interact with each other. We describe the primary components as have been studied in literature:

1. One of the very basic constituents of this ensemble is *perspective taking*. In this, the observer projects oneself into another's situation and tries to imagine what would happen if the former was in place of the latter (similar to simulation theory of role-taking). That is, the observer attempts to take the perspective of another person's internal state including another's feelings and thoughts to identify and understand what the other person is going through [Decety, J. E., & Ickes, W. E. (2009)].
2. Another important component that precedes empathy is unconscious *mimicking* or *imitation* of another person's actions, movements, postures or expressions. This component was probably always there as part of human interaction. You talk to a sad person and you might end up with a sad look on your face post the interaction [Decety, J. E., & Ickes, W. E. (2009)].
3. The third component of empathy, the sharing of similar emotions, is generally referred to in literature as *emotional contagion* [Decety, J. E., & Ickes, W. E. (2009)]. When humans interact with each other, they perceive another person's state in a given situation leading to shared emotional experience with the observer.

All of these emotional experiences combined with other emotions like *sympathy* and *compassion* for others give rise to a feeling of concern for the welfare of others in a distressed state [Decety, J. E., & Ickes, W. E. (2009)]. This holistic act of feeling concern for others and acting accordingly and appropriately is termed as *Empathy.* The above components of empathy, have been further categorised by field of study, a few are discussed below.

1.2 Types of Empathy

In social psychology, empathy is defined as a multidimensional construct which can be broadly categorized into two main components : Cognitive empathy and Emotional/Affective empathy [Deutsch, F., & Madle, R. A. (1975); Nummenmaa, L., Hirvonen, J., Parkkola, R., & Hietanen, J. K. (2008); Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009); Cox, C. L., Uddin,

L. Q., Di Martino, A., Castellanos, F. X., Milham, M. P., & Kelly, C. (2011); Schnell, K., Bluschke, S., Konradt, B., & Walter, H. (2011)].

Cognitive Empathy: It is the ability to cognitively understand from another's perspective. Comprehending other's affect and circumstances and acting accordingly is Cognitive Empathy. This is subdivided into further categories a) Perspective taking; b) Fantasy [Davis, M. H. (1980)].

- Perspective taking : It is the tendency to cognitively perceive others' emotional and mental state and trying to imagine what others might be feeling. It is the capability to imaginatively put yourself into others' shoes.
- Fantasy : It is the tendency to identify strongly with fictional/imaginary characters for example from movies or narratives.

Emotional Empathy: It is the ability to share the emotional state of the observed individual. A more visceral response to the observed experiences of others. This is further subdivided into sub-categories a) Empathic Concern; b) Personal Distress [Davis, M. H. (1983); Rogers, K., Dziobek, I., Hassenstab, J., Wolf, O. T., & Convit, A. (2007)]

- Empathic concern: Imagining oneself into others' situation gives a perspective of what others might be thinking or feeling but the intensity of ones' empathic response to the observed suffering depends on how much one cares for the other. A concern for others strengthens the connection between individuals and increases the feeling of compassion and sympathy for others. These are other-oriented feelings where one feels the emotion derived from the suffering of others.
- Personal distress: This is more of a self-oriented feeling where one feels distressed (not the same feelings as the other) over the sufferings of others. This feeling can be seen in infants of age 2 years or younger who respond to others' discomfort by themselves getting anxious. This feeling may or may not reflect the exact observed emotion. Eg. Someone might feel sad on seeing someone familiar in depression [Hodges, S. D., & Myers, M. W. (2007)].

Both of these components are independent and dissociable, yet together contribute to human empathy [Jones, A. P., Happé, F. G., Gilbert, F., Burnett, S., & Viding, E. (2010); Harari, H., Shamay-Tsoory, S. G., Ravid, M., & Levkovitz, Y. (2010); Ritter, K., Dziobek, I., Preißler, S., Rüter, A., Vater, A., Fydrich, T., ... & Roepke, S. (2011)].

Current research attempts to understand whether the dissociation is also reflected at the neural level. Preliminary models to study the strength of functional connectivity in brain network responsible for the moderation of affective component of empathy has shown the

ventral anterior insula, orbitofrontal cortex, amygdala, perigenual anterior cingulate while for the cognitive component it is brainstem, prefrontal cortex, superior temporal sulcus, ventral anterior insula [Nummenmaa et al. (2008); Cox et al. (2011)]. In the next section, the brain areas supporting empathy response as reported by most functional magnetic resonance imaging methods will be discussed.

1.3 The Neuroscience of Empathy

For a long time, neuroscientists have been curious to find out neurobiological roots to empathic concern. Whether an individual is an empath by birth (nature) or do emotional encounters and experiences modulate something biologically to make one an empath (nurture)?

Influence of nature (genes) and nurture (environment) over human cognition has been the topic of research many times in the fields of cognitive neuroscience, psychology, sociology, etc. The interaction between environmental factors and genetics is crucial in untangling the mechanisms underlying human behaviour, social dynamics, cognition and also ability to empathize with the pain of others. Researches by [Decety, 2010; Warrier et al., 2018] put forward that variations in genes associated with neural processing, social cognition and emotional regulation influence empathic responses. In another study, put forward by [Zaki, J., Weber, J., Bolger, N., & Ochsner, K. (2009)], they discussed how genetic mutations affect the neural mechanisms underlying the empathy for pain and influence how one perceives the pain of others. However, it has also been noted that genetics alone do not shape pain empathy. Individual experiences, cultural practices and surrounding significantly condition empathic responses [Decety, J., & Yoder, K. J. (2016)]. Influences of educational background, societal beliefs and biases have been observed to play roles in modulation of empathic responses towards pain of others.

Genetics do provide foundation for individual differences in pain empathy but socialization, environment and personal experiences play a great part too in altering the attitude towards others and perception of others' pain.

An attempt to further discuss some of the answers to these questions has been made in this study by first understanding the neural basis for empathy and then understanding what factors affect this structural (white matter, grey matter, etc.) and functional (network or area wise deficiency) network.

1.3.1 Brain regions involved in Empathy

The research found its roots in the discovery of “mirror neurons” originally in area F5 of the monkey premotor cortex which got activated both when the monkey performed an action or observed an action performed by another [Di Pellegrino et al. (1992); Rizzolatti et al. (1996)]. The functional role of these mirror neurons was hypothesized to act as mediator to imitation and action understanding [Jeannerod, M. (1994); Rizzolatti, G., Fogassi, L., & Gallese, V. (2001)]. This was followed by brain-imaging studies on humans which noted the presence of neurons exhibiting mirroring properties in the motor cortex. Cochin, S., Barthelemy, C., Roux, S., & Martineau, J. (1999) used quantified electroencephalography (qEEG) to show the activation in both motor cortex and frontal cortex during visual observation and execution of human motion. Hari et al. (1998) performed a magnetoencephalographic (MEG) experiment where participants had to perform and also observe a motor task. They found similar enhanced activity in the precentral motor cortex in both the cases. In a theoretical review [Rizzolatti, G., Fadiga, L., Fogassi, L., & Gallese, V. (1999)] of separation of action understanding and actual imitation by observation of action performed by another individual, found increased neuronal activity in prefrontal lobe in case of action imitation while no activation during action recognition was reported. They summed up their review with another important observation of involvement of Broca’s area in case of observation of meaningful tasks (picking up a glass or hitting somebody) compared to random hand movements.

Once the mirroring properties of motor cortex neurons were established, scientists wanted to explore further whether mirror neurons also play a role in other complex situations like recognizing and perceiving facial expressions and emotional experiences. Recognition of facial expressions is an extremely important skill that connects us to our social and physical environment. We make a judgement on what the individual might be feeling or thinking on the basis of our ability to read/analyse facial expressions. Phillips et al. (1997) performed fMRI experiment to find the neural substrates involved in perception of expression of disgust. They presented the participants with visual stimuli showing mild disgust, strong disgust or fear and contrasted the results with that for neutral expressions. They found amplification in activity in anterior insular cortex, a region also implicated in response to distasteful stimuli [Kinomura et al. (1994)]. Wicker et al. (2003), for their fMRI experiment hypothesised that the areas involved in the experience of feeling disgust also showed enhanced activity in the case of watching the same emotion in others. In the experiment, participants were asked to inhale odorants producing the feeling of disgust as well as watch the video showing others inhaling a substance and expressing their emotions via facial expressions. The area that was reported to show increase in activity in both the cases was anterior insular cortex confirming their hypothesis.

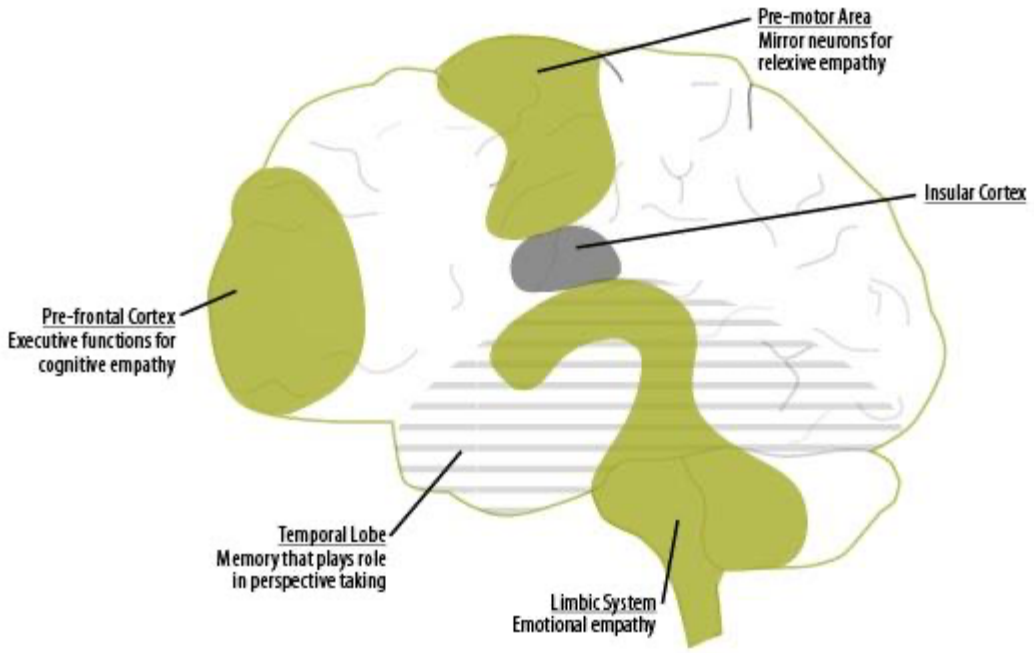


Figure 1.1: The architecture of the human brain depicting different areas in the brain that are part of the empathy network. [Image source: Nebraska Children. (2014, January 15)]

After the discovery of involvement of mirror neurons in mimicry of actions and expressions, the question came down to how the processes of action recognition and action imitation contribute to the actual experience of emotion? How are these related?. Towards answering this, [Carr, L., Iacoboni, M., Dubeau, M. C., Mazziotta, J. C., & Lenzi, G. L. (2003)] in their experimental review summarized the information flow from visual stimulus to emotion generation. Since mimicking is established to play an important role in emotion regulation, they hypothesized that areas such as superior temporal gyrus, posterior parietal cortex, inferior frontal cortex, which are important for action representation, must be connected to limbic areas responsible for emotion processing. The reported activations were higher for areas like inferior frontal cortex, superior temporal gyrus, insula and amygdala in case of imitation compared to the case of mere observation of expressions. This study provides evidence of the critical role of the insula, which connects the action representation areas anatomically to emotion processing areas. Further proof to this mechanism of shared representation modulating the emotion processing areas was provided by [Decety, J., & Chaminade, T. (2003)]. In a positron emission tomography (PET) experiment they presented video narratives as stimuli by actors with their facial expressions in agreement, neutral or incongruent to the emotion of the story. The reported enhanced activity in emotion processing areas in coordination to the action representation network confirms the postulates of above mechanism.

1.3.2 Pain and Empathy

One of the vastly studied empathy responses is that for pain. When we watch someone familiar or a blood relative getting cut or falling down, we feel anxiety and distress. Basically, when we see someone suffering it is not only the visual areas of the brain that get activated but also the regions involved in processing and sensing self-inflicted pain gets activated as well. This network of empathy was coined as *Pain Empathy*. One of the prime examples of our very initial exposure to pain empathy would be to watch someone getting a shot of medicine via injection. As soon as the doctor injects the needle, we immediately perceive pain through facial expressions, crying or screaming and recognize pain by probable previous experience the other person is going through and though subjective, one also feels a similar pain.

The whole experience of empathy for pain is postulated to be modulated by a network of neurons constituting the emotional-affective dimension of pain, also known as the neuromatrix of pain [Melzack, R. (1989)], which is activated in response to sensory stimulation by the nociceptive system constituting the sensory dimension of pain [Melzack, R. (1968)]. Since the identification of a network of brain regions mediating the experience of pain was postulated, experimenters have applied various noxious stimuli to the body of volunteers to study their neural responses. One such study by [Davis, K. D. (2000)] was an attempt to examine the thalamic and cortical neural activity due to acute pain by electrically stimulating the right median nerve at different levels of pain and also exposing the volunteer to noxious hot- and cold- stimuli and looking at the activation by fMRI technique. The magnitude of pain evoked was observed to be modulating the activity in cortical regions. Activity in thalamus was reported for all the stimuli and anterior insula was observed to be active for acute pain whereas posterior insula was active for mild pain. While the secondary somatosensory cortex (S2) showed enhanced activity for aggressive thermal stimulation, primary somatosensory cortex (S2) was reported to be active in case of electrical stimulation. Other studies [Rainville, P., Duncan, G. H., Price, D. D., Carrier, B., & Bushnell, M. C. (1997); Coghill, R. C., Sang, C. N., Maisog, J. M., & Iadarola, M. J. (1999); Tölle et al. (1999); Isnard, J., Guénot, M., Ostrowsky, K., Sindou, M., & Mauguière, F. (2000); Hofbauer, R. K., Rainville, P., Duncan, G. H., & Bushnell, M. C. (2001); Ostrowsky et al. (2002); Bingel et al. (2003); Lloyd, D., Di Pellegrino, G., & Roberts, N. (2004); Singer et al. (2004); Iannetti, G. D., Zambreanu, L., Cruccu, G., & Tracey, I. (2005); Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005); Singer, T., & Lamm, C. (2009); Fuchs, P. N., Peng, Y. B., Boyette-Davis, J. A., & Uhelski, M. L. (2014)] have also been major contributors in the establishment and verification of neurosignature of pain in the brain. [Apkarian, A. V., Bushnell, M. C., Treede, R. D., & Zubieta, J. K. (2005)] provide an extensive review for a wide array of studies, including neuroimaging studies with fMRI, PET, EEG, MEG conducted to investigate the brain regions implicated in pain processing. The studies have reported a common network of the brain regions responding to nociceptive stimulation which include primary (S1) and secondary (S2) somatosensory cortex,

anterior cingulate cortex (ACC), insular region and with less reliability, the thalamus [Derbyshire, S. W. (2000); Peyron, R., Laurent, B., & Garcia-Larrea, L. (2000); Iannetti, G. D., & Mouraux, A. (2010)]. This network of regions mediating the experience of pain is referred to as *Pain Matrix*.

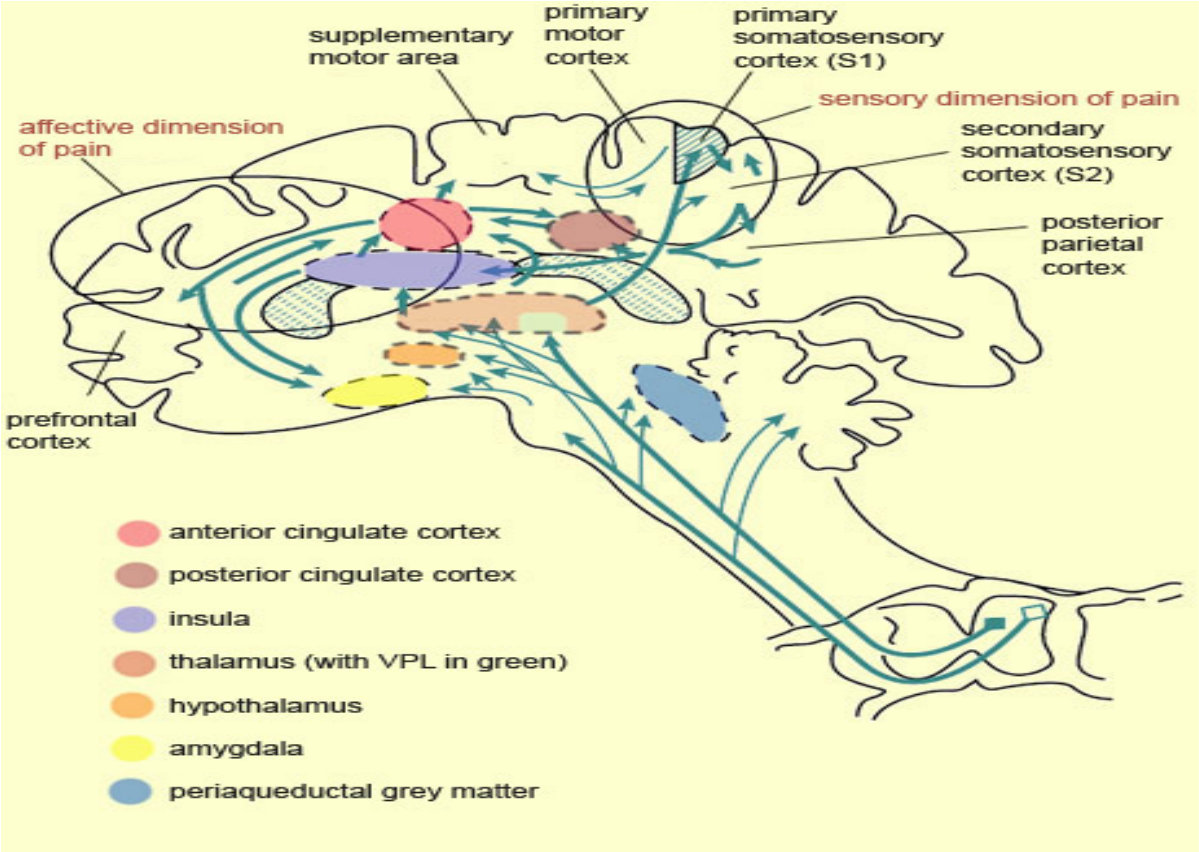


Figure 1.2: Schematic of different areas of the brain that form the neurosignature known as 'Pain Matrix'. [Image source: Neuroskeptic. (2016, January 9)]

Importantly, empathizing for pain needs to make a very important distinction between "self" and "other". Knowledge of the neural processes involved in the perception, understanding and feeling of pain in others with a conscious mind, i.e. keeping distinction between self and other, brings us closer to decoding empathy as shared representation of others' emotions is the first and most important step to empathy. To investigate this neurosignature, [Jackson et al. (2005)] designed an fMRI experiment where participants were shown photographs of limbs in possible or predictable painful situations like hands getting cut by a blade or feet getting stuck under the door. In the absence of specific noxious stimulus to participants, and consistent with the shared representation model, the study reported significantly enhanced activity in the anterior cingulate region, the anterior insula, cerebellum and the thalamus which were previously reported to be the constituents of the *Pain Matrix*.

In another fMRI experiment, the components of pain matrix involved in interpersonal sharing of affect were explored by [Singer et al. (2004)]. They prepared a paradigm where the participants were either exposed to painful stimulus or they observed a signal indicating that their partner present in the same room is getting the painful stimulus of indicative measure. By doing this, they removed the effect of visual information of actually watching someone getting hurt and would indicate the neural pathways specifically involved in perception of pain in others. In depth analysis of the results revealed enhanced activity in bilateral anterior insula (AI), rostral anterior cingulate cortex (ACC), brainstem and cerebellum in case of both self experience of pain and empathic response to perception of pain in partner. On the contrary, posterior insula/secondary somatosensory cortex, sensorimotor cortex and caudal ACC showed activity specifically in case of receiving pain on self. From this study, they concluded that although AI and rostral ACC got activated for both, the "self" and "other" conditions, they do not form the whole pain matrix and are just part of the motivational-affective dimension of nociception. Lamm, C., Decety, J., & Singer, T. (2011) conducted a meta-analysis of 41 neuroimaging studies on pain empathy and reviewed the neural circuits involved in processing sensory information to development of empathic response. The summarised results indicated bilateral anterior insular cortex (AIC) and medial/anterior cingulate cortex (MCC/ACC) to play an intricate role in empathizing for pain. The picture-based stimuli were reported to modulate activity in inferior parietal/ventral premotor cortices, areas involved in action understanding. The reported activations were higher in ventral medial prefrontal cortex, precuneus, temporo-parietal junction and superior temporal cortex, areas identified in distinction of self from the other pain.

1.4 Modulation of Empathy

The past few decades have witnessed significant enhancement in our knowledge of empathy and its modulating factors, though most have focused on the pain empathy networks. A set of research experiments have explored the variations in empathic responses to different stimuli (not restricted to pain depicting stimuli) in order to study the neural responses to painful stimuli and an observed cue indicating similar pain to loved one. Lloyd et al. (2004) also witnessed the presence of shared neural representations in the brain for felt as well as directly observed pain to others in the absence of abstract cues. Is empathy only elicited in the case of observed pain? To find the answer to this question [Jackson et al. (2005)] did an experiment to explore if just the perception of pain is enough and found the similarities in the brain activity in case of experienced pain and perceived pain to others. The variations in empathic responses to facial expressions depicting different emotions like happiness, sadness, disgust, anger, afraid and surprise [Carr et al. (2003); Decety, J., & Chaminade, T. (2003)] was also explored.

Extending the findings from pain empathy studies I focused on how empathy understanding is modulated by social relationships or familiarity between individuals, which is relevant to the selected research problem statement. It has been observed that individual differences and social cues are postulated to play an important role in regulation of empathic feelings towards others [Preston, S. D., & De Waal, F. B. (2002); Lamm, C., Meltzoff, A. N., & Decety, J. (2010)]. While race of a person and the corresponding racial bias, intercultural and social differences is a big indicator of perceived (dis)similarity between individuals, with findings by [Avenanti, A., Sirigu, A., & Aglioti, S. M. (2010); Forgiarini, M., Gallucci, M., & Maravita, A. (2011)] which indicated that the neuronal activity for empathic response to the pain of others is dependent on the race of the witness and that of the recipient. They observed a decline in empathic reactivity in people with implicit racial bias to the pain of outgroup members compared to ingroup members. The act of altruism for perceived group membership is also referred to as *parochial altruism* [Choi, J. K., & Bowles, S. (2007)]. Aligned with the results reported in studies referenced above and methodologies applied, [Hein, G., Silani, G., Preuschoff, K., Batson, C. D., & Singer, T. (2010)] took their study a step further and reported that prosocial decisions are best predicted by both the combined effect of perceived group membership and empathic concern, which further is modulated by the observer's degree of negative evaluation, for the receiver. With the fundamentals as derived from the studies investigating the neural correlates for pain and those derived from studies examining the social perceptions and conditions that modulate empathy, our study extends the social perceptions that bias empathy to pain/trauma experienced by a purported rape victim. To the best of our knowledge, this is the first of its kind study to examine complex empathy responses to heinous crime against female rape victim.

1.5 The problem statement

As mentioned in the detailed discussion above, different components of empathy, be it perspective taking or empathic concern or personal distress, have been studied using stimuli like static images showing infliction of pain on others or cue-based stimuli where signals indicate whether the other person is feeling the pain or not. The neural correlates for self- as well as other-oriented pain have been explored using different modalities like fMRI. Detailed research has focused on the existence of social, intercultural and racial biases in empathic responses to perceiving pain in others. But, to the best of our knowledge, no study has looked at neurological differences in individuals with distinct empathic responses towards the pain and trauma of female rape victims modulated by known social bias on professions engaged by the victim. To answer this question, we need to follow a two step-process. First, there is a need to gather better information on whether the knowledge of the profession of victims affects empathy in individuals. If yes, then the next question is what are the neurological differences

observed in individuals with distinct empathic responses, given the knowledge of the profession of victim?

To understand social interactions, the naturalistic stimuli presenting exchange of contextual information is best conveyed by audio, video or written narrative paradigms. The immersive nature of these formats make them the ideal choice for the purpose of this study. However, the audio and video formats have some unnecessary biases attached to them which can confound the empathetic response. E.g., how the character in the story looks [Sharma N. Goel M, Vemuri K (2019) (Ref: Section – 5.3 of this thesis)], or how the character is dressed [Cogoni, C., Carnaghi, A., & Silani, G. (2018)]. Because the written narrative is a controlled form of stimuli wherein a sequence of events can be coherently presented with a possible tight regulation of extent of response is our expectation. Without external visual or auditory stimuli which might add to biases due to facial skin tone, attire or tone emotions, a text narrative can insert a description or a role or a character like the profession of the victim in different scenarios, which allows one to make their visual imagination, and hence it presents itself as the best-form stimulus to be used in our study.

1.6 Our contributions

The complicated nature of the study led us to break the problem into non-trivial subproblems and work on them in sequential order.

1. The first important task for this thesis was to establish if social biases modulate empathic response towards different career professions opted by women. For this purpose, we designed an online survey asking participants to rate on a linear scale, from 1 (minimum) to 5 (maximum) on respectability score from the listed professions as being considered by a close known female as a career option. Our important insight from this survey, after observation of difference in overall respectability score for different professions, was confirmation of the existence of biases in society towards different professions opted by women as a career.
2. The next stage in this thesis was to confirm the existence of differences in empathic scores of the individuals towards the trauma/pain of a rape victim given the knowledge of profession of victim. Another survey was conducted where the participants were presented with fictional (but based on actual rape incidents reported by media) narrative recitation of rape incident and post-incident trauma from victim's point of view. The narrative recitations were controlled to vary only in depiction of professions of victims. Using standard questionnaires used in comparable experiments in related literature, we found differences exist in

empathic responses to perceived pain of a rape victim, given the knowledge of profession of the victim.

3. The last stage in this thesis was exploration of neural correlates of empathy in individuals given the knowledge of profession of the rape victim. For this purpose, we designed and conducted a fMRI experiment again using fictional narrative recitations of rape incident to tease out neural correlates involved in empathising. We analyzed the data using state-of-the-art techniques used in comparable experiments in the literature and found differences in activity of brain regions involved with empathy in case of different narratives.

Chapter- 2

Introduction

Neuroimaging applies techniques to image the structural and functional nature of the human nervous system. That is, it helps in providing insights into the anatomical structures and working of the neuronal networks. Over the years, various techniques have been developed for imaging like Positron emission tomography (PET), Magnetoencephalography (MEG) [Hämäläinen, M., Hari, R., Ilmoniemi, R. J., Knuutila, J., & Lounasmaa, O. V. (1993)], Electroencephalography (EEG) [Niedermeyer, E., & da Silva, F. L. (Eds.). (2005)], Magnetic resonance imaging (MRI), etc.

Each imaging technique has its own pros and cons. PET is a non-invasive technique but a radioactive substance is injected in the participant's body and cellular level changes can be recorded. Methods like MRI, EEG, MEG are completely non-invasive in nature, as no dopant is required. CT-scanning technique uses X-rays to probe into physical human body structure while techniques like MRI exploits the magnetic susceptibility property of atoms present in the human body and gives high spatial accuracy. Techniques like EEG have a very high temporal resolution, that is, the data gathered gives information on when the signal change occurs. For brain imaging each of these techniques can be combined to measure different attributes of the brain.

Based on facility availability, financial capability, experimental requirements and compatibility we chose fMRI as the imaging technique for our project. In this chapter, I first introduce the basic principles and prerequisite knowledge required to understand the signal that we get from MRI scanners. Then I have given a detailed description of how the data is preprocessed, analyzed, statistically tested for significance and visualized. In the end, I have given a brief introduction to the toolboxes we have used for our data analysis.

2.1 Magnetic Resonance Imaging (MRI)

2.1.1 Introduction

Magnetic Resonance Imaging, or MRI for short, is an imaging technique which in medical settings is primarily used to image the anatomical structure of the human body. This technique works on the principle of nuclear magnetic resonance (NMR). Bloch, F. (1946); Purcell, E. M., Torrey, H. C., & Pound, R. V. (1946) later [Lauterbur, P. C. (1973); Mansfield, P., & Grannell, P. K. (1973)] were the pioneers to demonstrate the use of NMR to image physical structures. Since the advent of MRI as an imaging technique with the ability to provide high spatial resolution, it has found great clinical utilization.

2.1.2 MRI Physics

A rotating charge has a magnetic moment associated with it. The human body being rich in water content has an abundance of hydrogen nuclei, i.e. protons. In their natural arrangement these moment vectors point in different directions to generate a net zero magnetization [Figure 2.1].

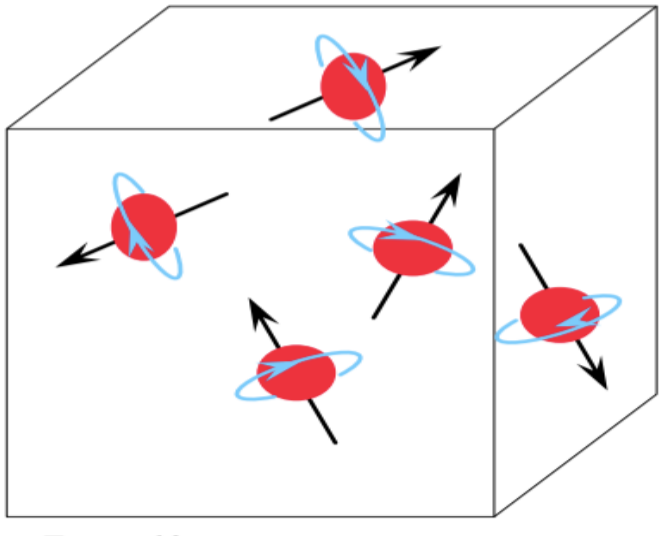
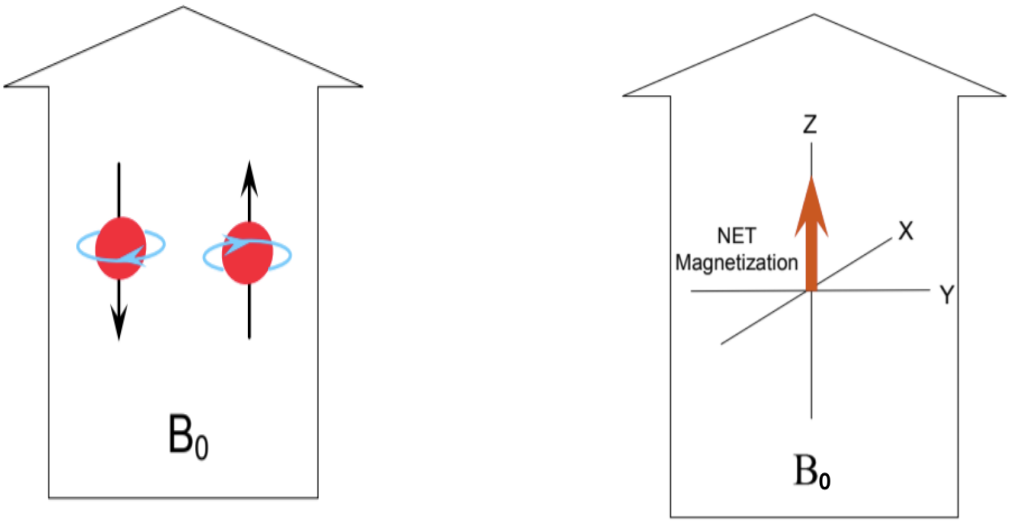


Figure 2.1: Spinning charged hydrogen nuclei having magnetic moments pointed in random directions to attain a net zero magnetization. [Image source: Blink, E. J. (2004)]

But when in a strong external homogeneous magnetic field (say B_0) they try to align themselves parallel or antiparallel to it [Figure 2.2 (a)]. This results in a net non-zero magnetization in the longitudinal direction, i.e. the direction of the external field [Figure 2.2 (b)]. The resultant of this force makes the rotating object to precess along the direction of the applied force.



(a) **(b)**

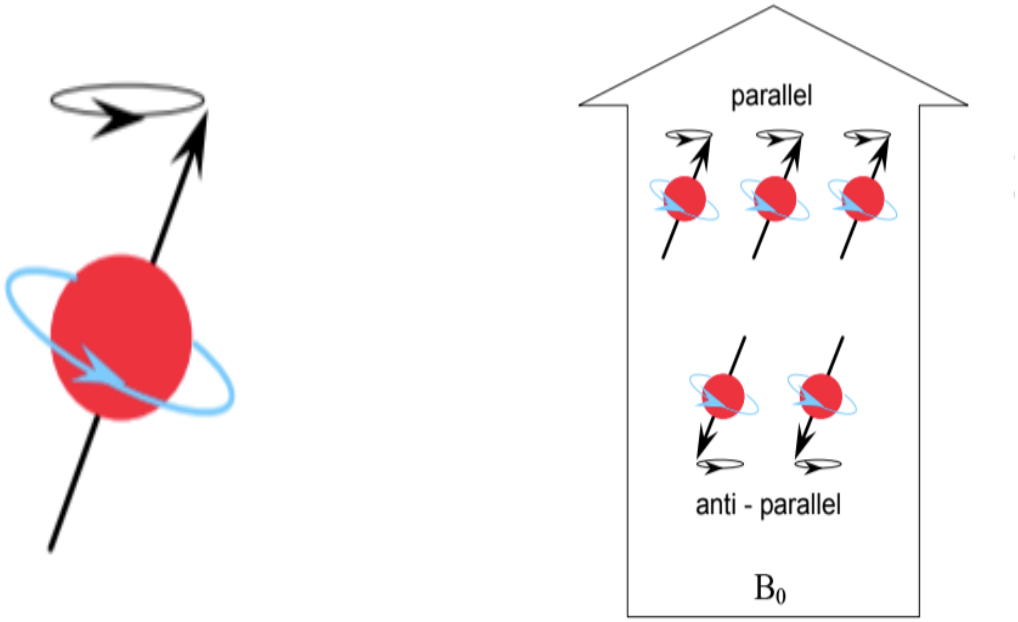
Figure 2.2: **(a, Left)** Spinning charged hydrogen nuclei align parallel and anti-parallel to strong external magnetic field, B_0. **(b, Right)** A net non-zero magnetization in the longitudinal direction (z-direction). Image source: Both the images are taken from [Blink, E. J. (2004)]

From rotational mechanics, we know that when a force is applied at a certain angle to the axis of rotation of a rotating object it tries to rotate along the direction of force. As a result of applying a force field on the axis of rotation of each proton, they start to precess [Figure 2.3 (a)] about the direction of B [Figure 2.3 (b)] with a frequency directly proportional to the magnetic field applied, also known as the Larmor frequency.

$$\omega = \gamma.B$$

Where, ⌉ is Precessional or Larmor frequency (MHz), © is Gyromagnetic Ratio (MHz/T) and B is the Magnetic Field Strength (T)

From quantum physics, we know that this gyromagnetic ratio is a constant but is different for different protons. Depending upon the applied magnetic field strength we can calculate the precessional frequency for each proton.



(a) **(b)**

Figure 2.3: **(a)** A spinning charged hydrogen nucleus precessing along vertical direction. **(b)** Spinning charged hydrogen nuclei aligned parallel and anti-parallel to external magnetic field, B0, precessing along the direction of B0. Image source: Both the images are taken from [Blink, E. J. (2004)]

The protons are subjected to radio-frequency waves, which increases their energy taking them to a higher energy state. The net magnetization in this higher energy state shifts at a certain angle to longitudinal direction (Z-direction) [Figure 2.4]. The angle is proportional to the strength of waves that the protons are subjected to.

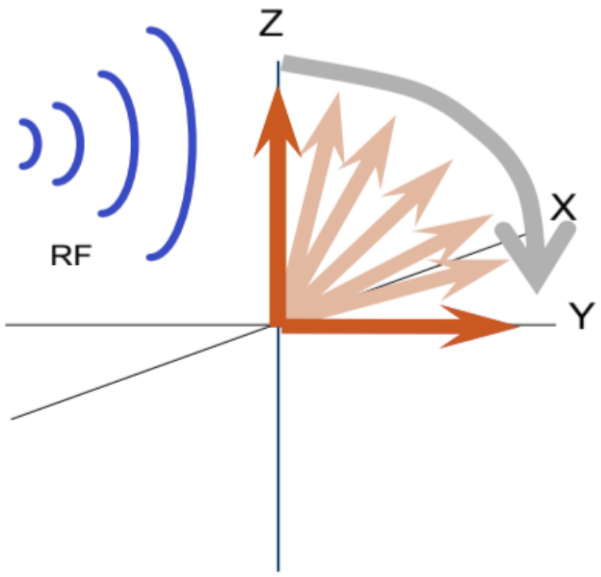


Figure 2.4: Hydrogen nuclei with net magnetization in Z-direction when subjected to radio-frequency waves shifts net magnetization from Z-direction to X-Y plane. Image-source: [Blink, E. J. (2004)]

Once the waves are switched off, protons tend to relax back to a lower energy state thereby emitting energy. Since each type of proton has different precessional frequency, the energy absorbed by each type is also different and hence the energy emitted is different as well. The energy emitted in this relaxation process is finally used to develop contrast images. [Blink, E. J. (2004)]

2.1.2.1 T1 Relaxation or Spin-Lattice Relaxation or Longitudinal Relaxation

Protons release energy (in general in the form of RF energy waves) while restoring themselves to the equilibrium state [Figure 2.5].

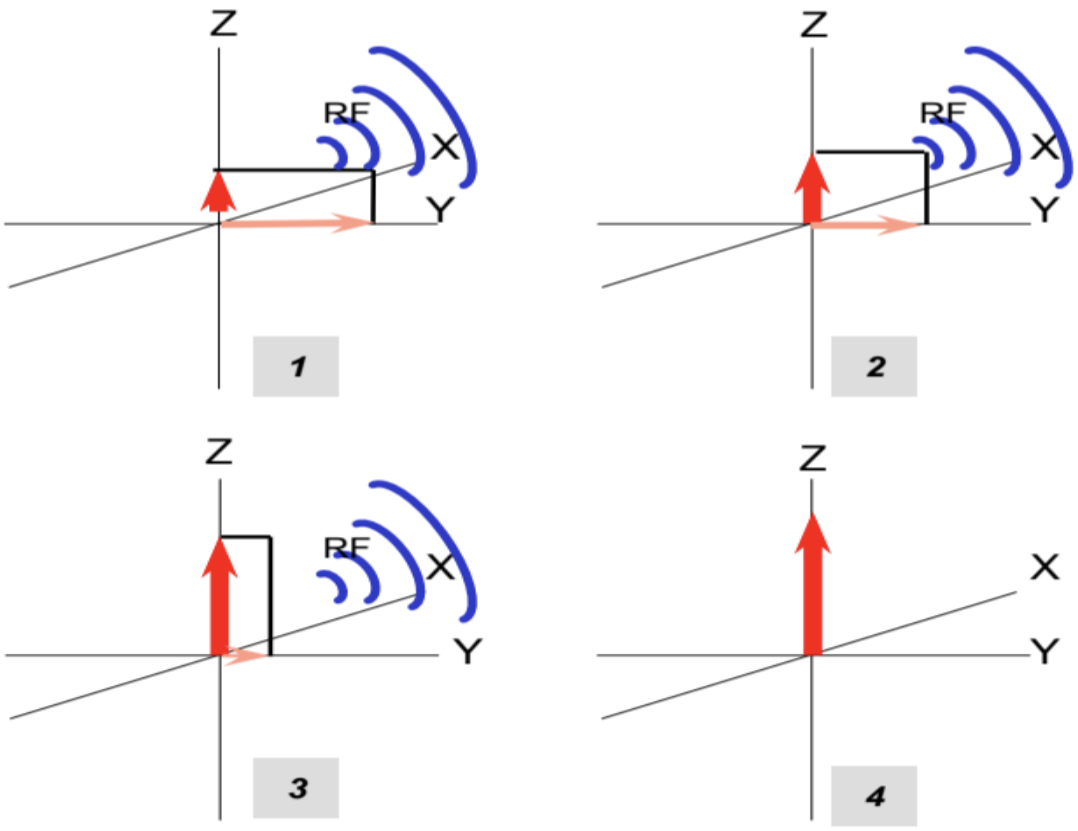


Figure 2.5: Restoration of magnetization in the longitudinal direction (Z-direction) once the RF-pulse is switched off. Protons emit energy in the form of RF-pulses while restoring their lower energy state. Image source: [Blink, E. J. (2004)]

The rate at which net magnetization starts developing again in longitudinal-direction is a measure of T1 relaxation. T1 is the time it takes to restore net-magnetization in longitudinal-direction to 63% of its original measure [Figure 2.6].

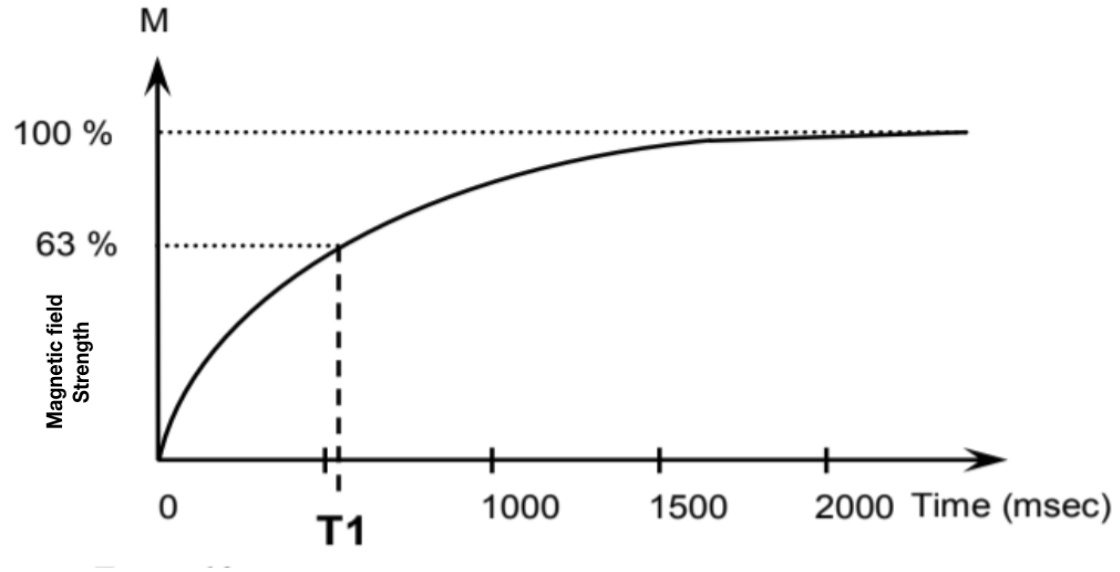


Figure 2.6: T1 relaxation curve. The time (X-axis) it takes for net magnetization (Y-axis) to reach 63% of its original measure in Z-direction is T1-relaxation time. Image source: [Blink, E. J. (2004)]

Since different tissues have different binding strengths for protons, the energy released in the surrounding and relaxation rate is also different for them making them differentiable from each other.

2.1.2.2 T2 Relaxation or Spin-Spin Relaxation or Transverse Relaxation

Before bombarding with RF energy waves there is no magnetization in transverse-direction (perpendicular to the longitudinal direction, say X-Y plane) since all protons were spinning out-of-phase of each other. If bombarded with a 90-degree energy wave (that is just enough energy to shift net magnetization by 90-degree), the magnetization is shifted to transverse-direction and protons start spinning in-phase and in-sync with each other resulting in net-magnetization in the transverse plane. Now, as soon as the pulse stops protons tend to go back to their equilibrium state and start to go out of sync with each other [Figure 2.7]. The dephasing is the resultant of different precessional frequencies with some protons gaining higher precessional frequencies than the other. Each of the protons experiences a slightly different net magnetic field due to the location of the other protons near it (based on the substance the proton belongs to). This inhomogeneity in a net experienced magnetic field is called the *local/internal field inhomogeneity*. Since we know that precessional frequency depends on the magnetic field experienced by the protons, the difference in precessional

frequencies is observed. The rate at which magnetization declines in the X-Y plane is the measure of T2-relaxation.

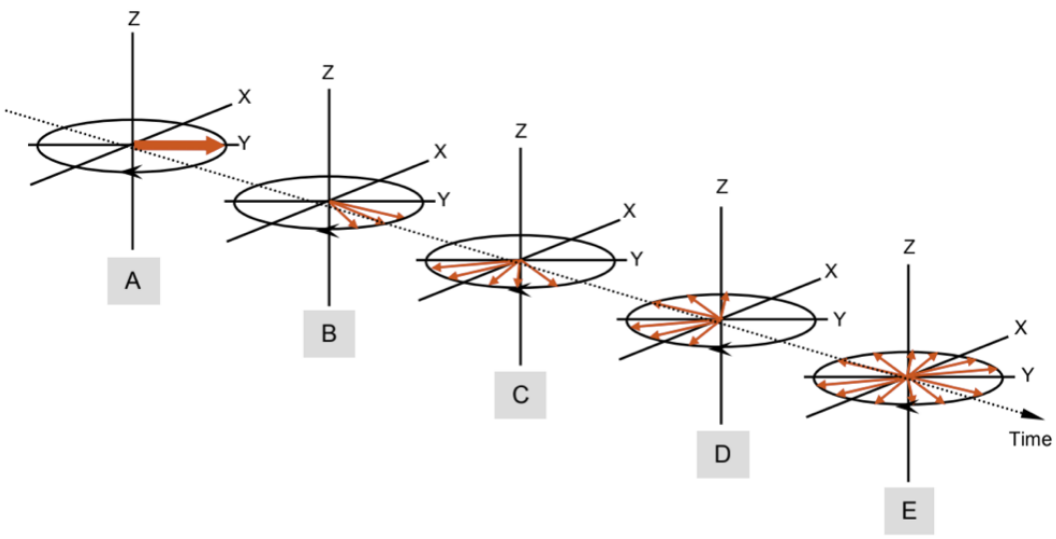


Figure 2.7: The restoration of net-zero magnetization along the X-Y plane as hydrogen nuclei attains equilibrium state and spin out-of-phase with each other. Image source: [Blink, E. J. (2004)]

T2 is the time it takes for protons to de-phase to 37% of the net transverse magnetization value [Figure 2.8]. Since protons are charged particles and interact with each other, hence named spin-spin relaxation.

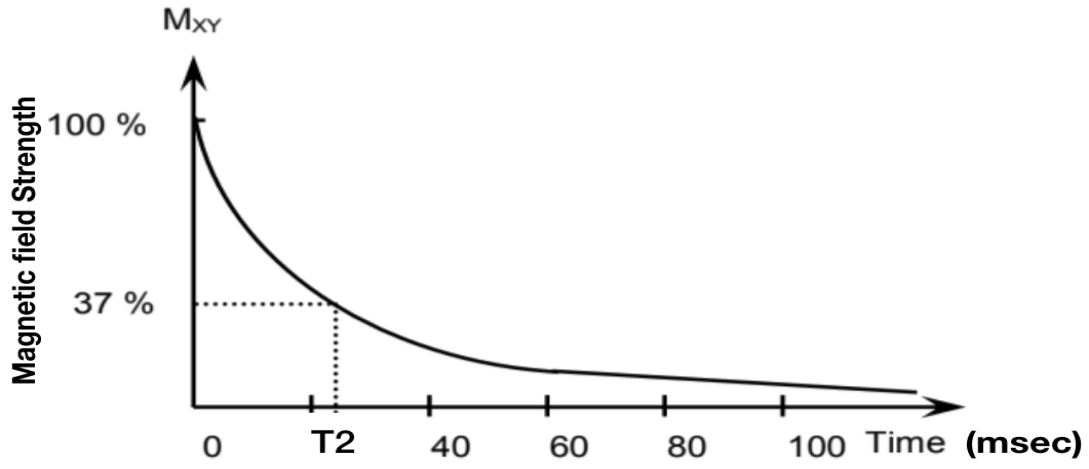


Figure 2.8: T2 relaxation curve. The time (X-axis) it takes for net transverse magnetization (Y-axis) to reach 37% of its net transverse magnetization value in the X-Y plane is T2-relaxation time. Image source: [Blink, E. J. (2004)]

2.1.2.3 T2* Relaxation

Along with the presence of internal field inhomogeneities there exist external field inhomogeneities as well which affect the dephasing of protons in the X-Y plane. These external inhomogeneities might be due to the type of scanner used for the signal collection or due to different object susceptibility and are unavoidable in MRI data collection. The relaxation recorded considering both internal and external inhomogeneities is T2*-relaxation. To understand this better, it is best to assume that T2 relaxation for a substance will always be the same irrespective of scanner (or scanner location) used to measure the relaxation value but T2* might differ for the same substance based on the scanner used. The T2* relaxation also depends upon the composition of the local blood supply and in particular on physiological state. This physiological state depends, in turn, on the neural activity. For this reason, measurement of the T2* parameter is an indirect measurement of neural activity.

2.1.2.4 Contrast Mechanisms (T1, T2, T2*)

Contrast mechanisms are ways of converting the collected signal from MRI scanners and into contrast images. The contrast in an image reflects different tissues either based on the properties of the tissue or by design. Contrasts are highly dependent on tissue density and tissue relaxation properties. Hence, all tissues (like muscles, ligaments, bones, etc.) have

different T1-, T2-relaxation times. T1 contrasts (or T1-weighted images) use T1-relaxation time and are primarily used for anatomical imaging of the brain. Whereas, T2*-weighted images, being a good measure of neuronal activity (refer: Section 2.1.2.3) are used for functional imaging of the brain. Different RF-pulse sequences are used to generate different contrasts [Bernstein, M. A., King, K. F., & Zhou, X. J. (2004)].

2.2 Functional Magnetic Resonance Imaging (fMRI)

2.2.1 Introduction

fMRI is a technique primarily used for localization of cognitive function within the brain. During an fMRI experiment, a participant is generally asked to respond to either physical sensations or simulation tasks while continuously being scanned in the MRI scanner. It is based on blood oxygen level dependent contrast (BOLD) , to identify changes in blood flow to different parts of the brain. These changes in blood flow reflect neuronal activity in the brain. fMRI works on a similar principle as MRI, exploiting the difference in magnetic susceptibility of oxygen-rich and oxygen-poor blood. Blood Oxygen Level Dependent fMRI imaging, also called BOLD-contrast imaging, has been identified to make inferences on the cognitive functioning of the human brain [Ogawa, S., Lee, T. M., Kay, A. R., & Tank, D. W. (1990); Ogawa, S., Lee, T. M., Nayak, A. S., & Glynn, P. (1990); Ogawa, S., & Lee, T. M. (1990); Ogawa et al. (1992)].

2.2.2 BOLD Physiology

Any activity in the brain is characterized by the electrical firings (so-called action potentials) in the neural cells (neurons). The electrical impulses pass between these neurons via connections, called synaptic junctions, which on receiving the signal from active neurons release chemical substances to modulate the activity in adjacent neurons and so on. Each neuron requires energy for its activity and this energy is supplied by glucose and oxygen in the blood but the neuron does not keep a reserve of them. Hence, every time any brain area gets activated blood has to be delivered to fulfil the energy requirements. This process is called *Hemodynamic response*. The oxygen consumption for blood is greater for active neurons compared to non-active ones. The hemodynamic response results in faster deoxygenation of blood in the active areas of the brain compared to non-active areas. This differential in oxygen content provides the base for BOLD-imaging. Deoxygenated hemoglobin in the blood(oxygen-poor blood) has paramagnetic properties while oxygenated hemoglobin in the blood(oxygen-rich blood) has diamagnetic properties and this difference in magnetic susceptibility acts as the

basis in the detection of active regions in BOLD-fMRI. This difference in oxygen concentration results in differential T2* time constant. The signal intensity of voxels (dimensional representation of a brain map) belonging to active areas of the brain is higher in the fMRI image due to longer T2* time constant. So, instead of measuring neuronal activity directly, BOLD-fMRI measures the combined effect of metabolic demands (oxygen consumption) of active neurons and rush of fresh blood into the area.

The regional cognitive activity changes are very small to be observed with bare eyes and requires advanced signal amplification and processing is required for analysis and visualization on cross-sectional images [Figure 2.9].

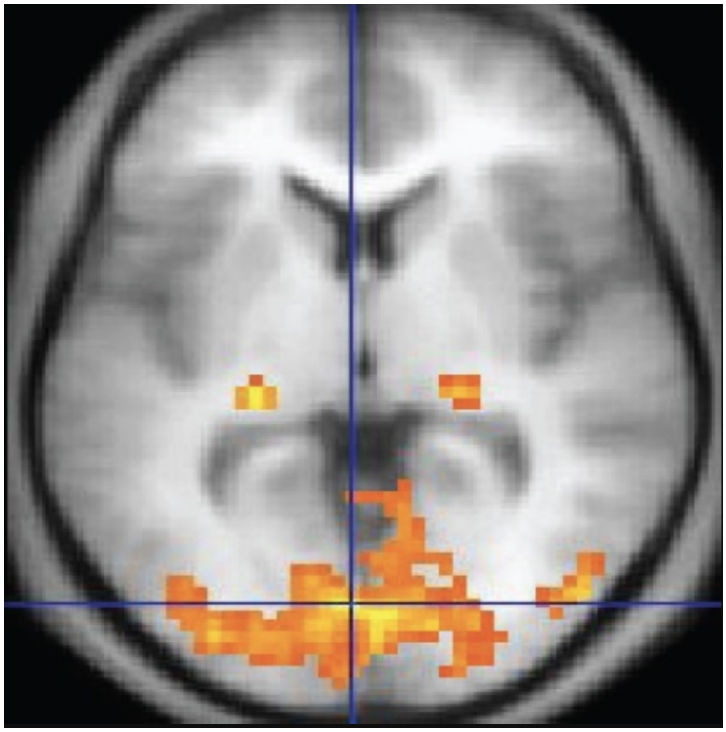


Figure 2.9: An fMRI image with increased activity in certain areas of the brain (experimental task-related compared to controlled condition) shown in yellow color.
Image source: https://commons.wikimedia.org/wiki/File:1206_FMRI.jpg
Licence: https://creativecommons.org/licenses/by/4.0/

2.3 Data preprocessing

Pre-visualization and analysis of the activation, the collected signals have to be preprocessed first [Figure 2.10]. There are various reasons for this, firstly, the collected raw data is a mixture of the response signal to experimental stimuli and other unwanted signals like erroneous data

due to subtle head movements, due to physiological pulsations like breathing, heartbeat, etc., artifacts introduced in data due to machine noise, etc. All these extra signals have to be filtered out from raw data, to maintain a high signal to noise ratio. Second, while collecting the brain imaging data from MRI scanner structural and functional data are separately obtained but to view the brain activations both have to be aligned to get spatial resolution. To perform analysis at the group level and to obtain comparable (from other studies around the world) results the collected data should align to a standard template. Few of the common preprocessing steps applied to image data before performing analysis are:

- **Slice-Timing Correction:** To acquire 3D volume image of the brain, the whole volume is taken as discrete slices and these slices are not scanned simultaneously (they are either taken sequentially or alternately (as in 1,3,..end,2,4,..end)). Also, the slices are taken in ascending or descending order. So basically they are temporally different, that is, say if one slice is collected at the time 't' then the other slice is collected at the time 't + delta' and so on. Since all slices are not collected at a single time point, each slice represents data at the different time and this difference in data is corrected using Slice-timing correction.
- **Realign:** motion artifacts have to be processed out of raw data. In the realigning stage, volumes/images from each run are matched to the first volume of their specific run. Then volumes from each run are matched to the chosen reference volume (by default it is set to the first volume of the first run).
- **Setting the origin:** Before normalization and coregistration steps, it's helpful to set the origin coordinates of the anatomical image. Because when we are trying to warp the anatomical and functional images to a common template there is better fitting if both the images start out at a common location (generally it is set to the reference origin in a template image).
- **Coregistration:** Once all the functional data is intra-aligned and corresponds to the same image space there comes the step of bringing functional and structural into common space, which is accomplished in the coregistration stage.
- **Normalization:** The coregistered images have to be normalised to a standard template (a brain map derived from scanning a large number of human subjects, and usually the 152 ICBM template). This step helps in normalizing warped anatomical and functional data to the standard template space.
- **Smoothing:** Since the brain activity is not just activity of individual voxels at source locations but a resultant of the group of voxels at those locations the collected signal has to be smoothed out at nearby voxels. Smoothing averages out the data values to nearby voxels. The main benefit of smoothing is that it increases the signal to noise ratio because the noise is generally averaged out across voxels and it gives a chance to signal to get amplified.

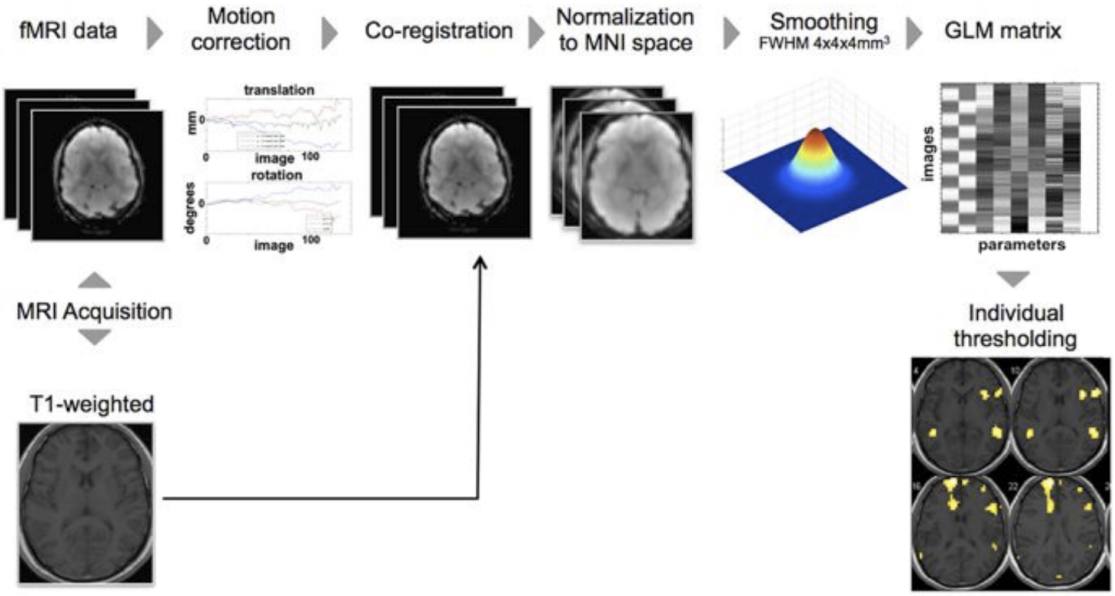


Figure 2.10: Stepwise illustration of the processing pipeline for the fMRI analysis. [Image source: Hassan et al. (2016)]

2.4 Signal Analysis

fMRI data from an average brain is a collection of time-series signals of hundreds of thousands of voxels and hence performing statistical analysis on fMRI data is a big-data problem. The analytical technique has to identify activations in brain regions, that is, brain-areas which exhibit increased or decreased neural activity in response to the experimental conditions compared to control conditions. Over the past few years, multiple techniques have been used to solve this problem. Some of the more commonly-used techniques are hypothesis-driven statistical data analyses (like General Linear Method (GLM)), classifier based multi-voxel pattern analysis (MVPA), and blind-source separation methods like independent component analysis (ICA), and supervised graph analytical methods, etc.

Statistical techniques are usually characterized by the number of dependent variables they try to predict. These techniques are thus majorly classified into two classes :

1. Univariate Analysis
2. Multivariate Analysis

2.4.1 Univariate Analysis

Univariate analysis, in the context of fMRI data analysis, is referred to as the technique of conducting voxel-based analysis. That is, in the case of fMRI it's not about the number of variables we are trying to predict but about the number of voxels we are simultaneously performing the analysis on. Each voxel's signal is analyzed and interpreted individually. It is a hypothesis-driven model-based statistical data analysis method that uses reference functions to model the mean and variation in the response variable.

2.4.1.1 GLM for fMRI: a bit of history

fMRI data, as we know it, is 4-dimensional data stored in a matrix format. The address (x,y,z,t) to each cell in the matrix is marked by a 3-dimensional space (x,y,z) representing the location of voxels in the brain from which the time-series has been extracted and by the time-dimension(t) representing the time at which scan has been taken. The response signal of any specific voxel in the brain over time can be extracted by traversing the time-dimension in the matrix for spatial coordinates of the voxel.

The very basic question that anybody seeks to answer in fMRI is "Which brain regions were specifically engaged or responded **more** to task processing during experimental conditions compared to control task?".

Initial Approach: Subtracting Mean Intensities

Introduction - A basic and intuitive way to approach this problem is subtracting the mean signal intensity during control task from that of the task when the stimulus was presented. That is,

- Extract out signal intensities from the brain volumes captured during the time interval the stimulus was presented and find the mean of the signal.
- Similarly, calculate the mean for signal intensities from volumes captured during control tasks.
- Subtract the mean signal during control tasks from the mean signal during presentation of the stimulus.

BOLD signal is composed of two different parts, one being the activity changes due to stimulus-related task and other being fluctuations due to noise where noise can be due to any of the factors be it noise due to MRI machine or due to head movements by the participant or due to the corresponding voxel being involved in other physiological activity as well. The

changes in signal due to task are also termed as explained variations whereas those due to noise are called as unexplained variations.

Statistical Significance - Assuming a difference in mean values is observed, how can one be sure that the observed difference is due to task-related changes and not a spurious spike due to noise related fluctuations? To ensure the significance of the difference in means observed and whether this is valid over the population, statistical tests can be performed, for example a simple 2 sample t-test or a f-test and the *null hypothesis* is applied. If the signal passes this significance test the null hypothesis is rejected and an alternate hypothesis is accepted signifying a difference due to task-related changes only.

Problems in the adopted model - Researchers started observing false negatives(Type-II error) in the data. The voxels which were previously reported to be part of the region involved in certain activity were getting falsely rejected because of them not passing the significance tests. They identified two major limitations in the working model of their approach.

- Problem-1
    - Statement: The prediction model in the current approach did not take the time-delay in BOLD signal (hemodynamics) into consideration leading to the wrong set of scanned volumes being chosen for calculation of mean activity in the voxel.
    - Solution: The prediction model was tuned to incorporate a 4-6 sec lag in the signal and choose volumes accordingly.
- Problem-2
    - Statement: The prediction model assumed a binary block-design approach where either signal is at the maximum intensity or zero. But BOLD signal, in reality, follows a response form, known as hemodynamic response function (HRF), under which the intensity achieves a peak with a time-lag and again tends to zero with a time-gap after achieving the peak.
    - Solution: A filter of HRF is applied to the prediction model where the prediction response form was convolved with HRF to give the final predictions.

Drawback - The final prediction model, after incorporating solutions to the above-mentioned problems, are found to be sub-optimal. Subtracting means approach is based on the binary representation of the prediction model where the contribution of each intensity value, belonging to different volumes, in the calculation of mean was equal. Convolving with HRF brought up the idea of unequal contributions, that is, a different weight to individual score to

mark the unequal contribution to signal. A different and new approach than simply calculating the averages was required.

2.4.1.2 GLM Approach

Any neural activity is a combination of baseline activity, either due to respiratory functions or other physiological activities, and task(event) based activity. The collected BOLD signal (Y) is thus an approximation of linear combination of signals due to factors affecting neural activity (X) where the contribution of individual signal due to each factor in resultant signal is dependent on the location of the voxel in the brain (®). Each part of the brain is involved in a certain set of specific physiological functions and contributes less in case of activities which are not part of this specific set, for example, the primary activity in visual cortex is observed when visual system is active and hence the contribution of predicted signal due to visual stimuli would be higher compared to those due to motor activities or others. Hence, the observed signal was hypothesized to be approximated resultant of a weighted linear combination of **independent factors**, factors being any predicted activity or function modulating neural activity, where weights signify contribution of an individual signal to resultant signal plus the erroneous signal (∑) due to non-task related physiological activity.

$$Y = X.\,® + \sum$$

This approach to analysis is dependent on the a-priori knowledge of the model of the experiment. A predicted model of activity is defined for an individual factor, called a *predictor*. The weight assigned to each predictor is called *beta-weight* which is the unknown variable to be calculated in the model. If each beta-weight corresponding to an individual factor is known, the contribution of each factor to the observed signal is known.

These beta-weights are calculated by minimizing the error.

2.4.2 Multivariate Analysis

2.4.2.1 Understanding ICA

Explanation of this relatively new technique of linear transformation applied to fMRI data analysis is generally given by the famous ***Cocktail Party Problem*** [Cherry, E. C. (1953)]. It is a blind-source separation method.

Cocktail Party Problem: A cocktail party has been organized in a hall and four microphones are kept in the four corners of the hall. Now, in general, in the scenario of a cocktail party, there are various independent sources of sound, like multiple groups of people conversing with each other, bands playing in the background, etc. The recording from each microphone gives the resultant of sounds by each independent source linearly mixed with other sounds. The aim of this cocktail party problem is to segregate these source sounds from the collected signals.

Problem statement

We have

$$x_1(t) = a_{11}s_1(t) + a_{12}s_2(t)$$
$$x_2(t) = a_{21}s_1(t) + a_{22}s_2(t)$$

where 'x_i' represent observed signals over time from the two microphones and 'a_{ij}' constitute the mixing matrix and 's_j' are the independent speech signals. That is, signals from multiple independent sources 's_j' linearly mix with each other in the proportions represented by 'a_{ij}' to give out the observed signal 'x_i'. The weights assigned to each speech signal in any observed signal depends on the distance of speech source from the respective microphone. In the real case scenario, we have access to observed signals without any knowledge of what the constituting signals are and in what proportion they are mixed. So the problem comes down to the estimation of original source signals from the observed signals where both mixing matrix and source signals are unknown. In terms of analogy to linear algebra, this problem is similar to finding the basis set for linearly transformed data where the transformation matrix is unknown.

Approach to solution

The below explanation tries to cover an overview of ICA methodology and does not enter the in-depth analysis of the approach [Comon, P. (1994); Bell, A. J., & Sejnowski, T. J. (1995) (a); Bell, A. J., & Sejnowski, T. J. (1995) (b)].

The separation of source components from multivariate signal through ICA is based on two assumptions :

1. *Independent components*: The source components, s_j, must be statistically independent.
2. *Non-gaussian distributions*: The independent components must have non-gaussian distributions.

Prerequisite Knowledge : In probability theory, the *Central Limit Theorem* states that if multiple observations are made for random variables such that the value of one observation does not depend on other observation (that is, independent random variables) then the distribution of the sum of these observations tends closer to a Gaussian distribution than any of source random variables.

Where and how these assumptions and knowledge are useful is explained below.

Let's start by representing the observed multivariate signal in vector-matrix notation.

$$\begin{pmatrix} x_1 \\ x_2 \end{pmatrix} = [a_{11}\ a_{12}\ a_{21}\ a_{22}\ ] \begin{pmatrix} s_1 \\ s_2 \end{pmatrix}$$

$$\mathrm{x} = \mathrm{A}\ \mathrm{s}$$

where x is the vector representation of observations, A is the mixing matrix and s represents the source vector.

$$\mathrm{s} = \mathrm{A}^{-1}\,\mathrm{x}$$

$$\mathrm{s} = \mathrm{Z}\,\mathrm{x}$$

Now, we see that each row of 'Z', that is the inverse of 'A', matrix multiplied by 'x' vector gives us source signals but how do we compute that because 'Z' is an unknown entity. If we can somehow estimate the mixing matrix, then, from the above equation using 'Z' we can compute independent components.

$$s = \sum_i \quad z_i x_i$$

This is where the assumptions and central limit theorem comes into the picture. Here, from the central limit theorem, we understand that any linear combination of independent random variables is more gaussian compared to components hence the linear combination of '$z_i x_i$'

becomes least gaussian when it becomes equal to the source component. From here, this problem reduces to an optimization problem of finding an approximation which maximizes the independence between the components. Different algorithms have been designed (like Infomax [Bell, A. J., & Sejnowski, T. J. (1995) (b)], FastICA [Langlois, D., Chartier, S., & Gosselin, D. (2010)], etc.) which use different techniques to achieve the task of maximization of component independence. Two of the main techniques used to measure independence are:

1. Minimization of mutual information
2. Maximization of non-gaussianity

These techniques can further use different measures to measure mutual information (like Kullback-Leibler Divergence, maximum entropy) or non-gaussianity (like kurtosis, negentropy) and different algorithms differ in the choice of technique to achieve maximization of component independence [Lee, T. W. (1998)].

2.4.2.2 Group Inference using ICA

In the case of ICA, making group inferences is a challenge but is essential. ICA divides the multivariate signal into independent components where each component represents activity in brain regions sharing similar temporal response patterns. But these components are arranged in no particular order and for this reason, comparing components across participants becomes difficult.

Attempts at different approaches [Calhoun, V. D., Adali, T., Pearlson, G. D., & Pekar, J. J. (2001); Esposito et al. (2005)] have been made to make group inferences using group ICA. One of the most prevalent approaches [Calhoun et al. (2001); Schmithorst, V. J., & Holland, S. K. (2004)] (also implemented in GIFT (Medical Image Analysis Lab, http://mialab.mrn.org/software/gift/index.html) software package) uses an approach where every participant's raw data is concatenated to make single group data, also known as temporal concatenation, and then an ICA is run on this group data to generate the un-mixing matrix which then goes through a step called back-reconstruction to generate participant-wise components. This approach ensures the relative ordering of components to be consistent across participants making it easier to make group inferences.

2.5 Statistical significance tests and analysis

Significance testing lets one analyze if the results have statistical significance. That is, the results are not just due to random chance but in fact, have a basis in the sample and generalize to larger populations.

2.5.1 T-Test

The t-test is the most commonly used significance test in statistics which analyzes if the mean of the population in the case of an experimental task is significantly different from the mean in the case of a controlled task. To calculate the significance, it takes into account the contribution of unexplained variations in the data and finds the significance of explained variations given the former is present in data. For this purpose, it finds the ratio of explained variation to that of unexplained ones and the resultant value is termed as t-value. Higher the t-value less likely it is that the resultant observation is by chance resulting in higher belief in the contribution of explained variations.

$$t = \frac{Explained\ Variations}{Unexplained\ Variations} = \frac{M_1 - M_2}{measure\ of\ noise}$$

Where, M_1 is mean of observations related to task (wanted signal) and, M_2 is mean of observations not related to task (unwanted signal)
In the context of fMRI experimental data analyses, the t-test estimates significance of the strength of a signal over the surrounding noisy fluctuations or non-stimulus related condition where signal corresponds to activity due to tasks performed during the experiment. Using the resultant t-value as a probability, p is calculated which represents how likely it is to reject the null hypothesis and a value below threshold represents the belief in the statistical significance of data. Though a low threshold, 0.05 (or 5%) is an accepted demarcation criterion for statistical significance, to ensure task signals are not rejected with stricter thresholds. So at $p < 0.05$ the data is believed to be statistically significant.

2.5.2 Correlation Analysis

Correlation analysis is another technique applied to test the strength of association between two variables. One of the major drawbacks of the t-test approach described above is that it does not exploit any linear relationship between variables. One of the most common and widely used measures of correlation is the Pearson correlation.

$$r_{xy} = \frac{\sum_{i=1}^{n} \quad (x_i - \underline{x})(y_i - \underline{y})}{\sqrt{\sum_{i=1}^{n} \quad (x_i - \underline{x})^2}\sqrt{\sum_{i=1}^{n} \quad (y_i - \underline{y})^2}}$$

Where, n is the sample size. x_i, y_i are the individual sample points indexed with i. $\left\{\underline{x} = \frac{1}{n}\sum_{i=1}^{n} \quad x_i\right\}$ represents the sample mean and analogously the same for y.

Few methods are Kendall rank correlation, Spearman correlation, etc. The value of any correlation coefficient lies, in general, between +1 to -1. The correlations are :

- *Positive correlation*: Positive correlation between two variables represents that variation in one variable is directly proportional to the variation in other, that is if one goes up the other goes up and if one goes down the other goes down as well. A positive correlation is generally marked by the +1 value of the correlation coefficient.
- *Negative correlation*: Negative correlation between two variables represent that variation in one variable is inversely proportional to the variation in other, that is if one goes up the other goes down and vice-versa. A negative correlation is generally marked by -1 value of the correlation coefficient.
- *No correlation*: No correlation means there is no relationship established between the variations of two variables and hence the variation in one cannot be inferred from variation in another. No correlation is represented by 0 correlation coefficient.

2.6 Toolboxes

A major goal of performing fMRI experiments is to localize brain areas involved in cognitive processes. Once the data has been collected using MRI scanner it needs to be analyzed in order to regress out brain areas involved in brain activity. For the purpose of our data analysis we have used two of the most widely used tool boxes, which have incorporated the preprocessing methods (explained above) and the statistical analysis:

1. SPM
2. GIFT

2.6.1 SPM

Statistical parametric mapping (SPM) (Wellcome Trust Centre for Neuroimaging, London, United Kingdom, http://www.fil.ion.ucl.ac.uk/spm/software/spm8) is a software toolbox which helps with performing GLM statistical analysis on brain imaging data. The complete data analysis pipeline has been divided primarily into 3 main sections in the toolbox :

1. Data preprocessing
2. Data analysis using the GLM approach
    a. First Level: Analysis at individual subject level
    b. Second Level: Analysis at the group level.
3. Results visualization

2.6.1.1 Data preprocessing

The first section in the toolbox window covers the preprocessing steps. The preprocessing functionalities presented by the toolbox are:

- Realign
- Coregister
- Normalize
- Segment
- Smooth
- Slice Timing Correction

Functionality for each preprocessing step is implemented in the toolbox itself and as defined in the above sections dealing with preprocessing.

2.6.1.2 Data analysis

Once the data is preprocessed it is passed through GLM analysis of both first and second level. In this, the design matrix [Figure: 2.11] is prepared by indicating all the regressors of interest. Each of the processes that are presumed to contribute to raw data form the regressors of interest. The start and end scan/time of each of those regressors are specified. Since the GLM approach in SPM is a hypothesis-driven model-based approach, making group level inferences is not difficult because the hypothesized response model/design matrix is the same for all the participants. Once the design matrix is fed to the GLM model it prepares the parametric maps (beta-weights) for each of the conditions of interest specified in the design matrix. Now, each of the contributing processes is represented by these spatially-independent component maps. Each component map consists of brain regions (involved in that particular

process/task) which may or may not overlap with areas involved in other component maps. Interaction contrasts [Figure 2.12] can then be used for each of these conditions in order to investigate the differences in the activity of one condition versus the other.

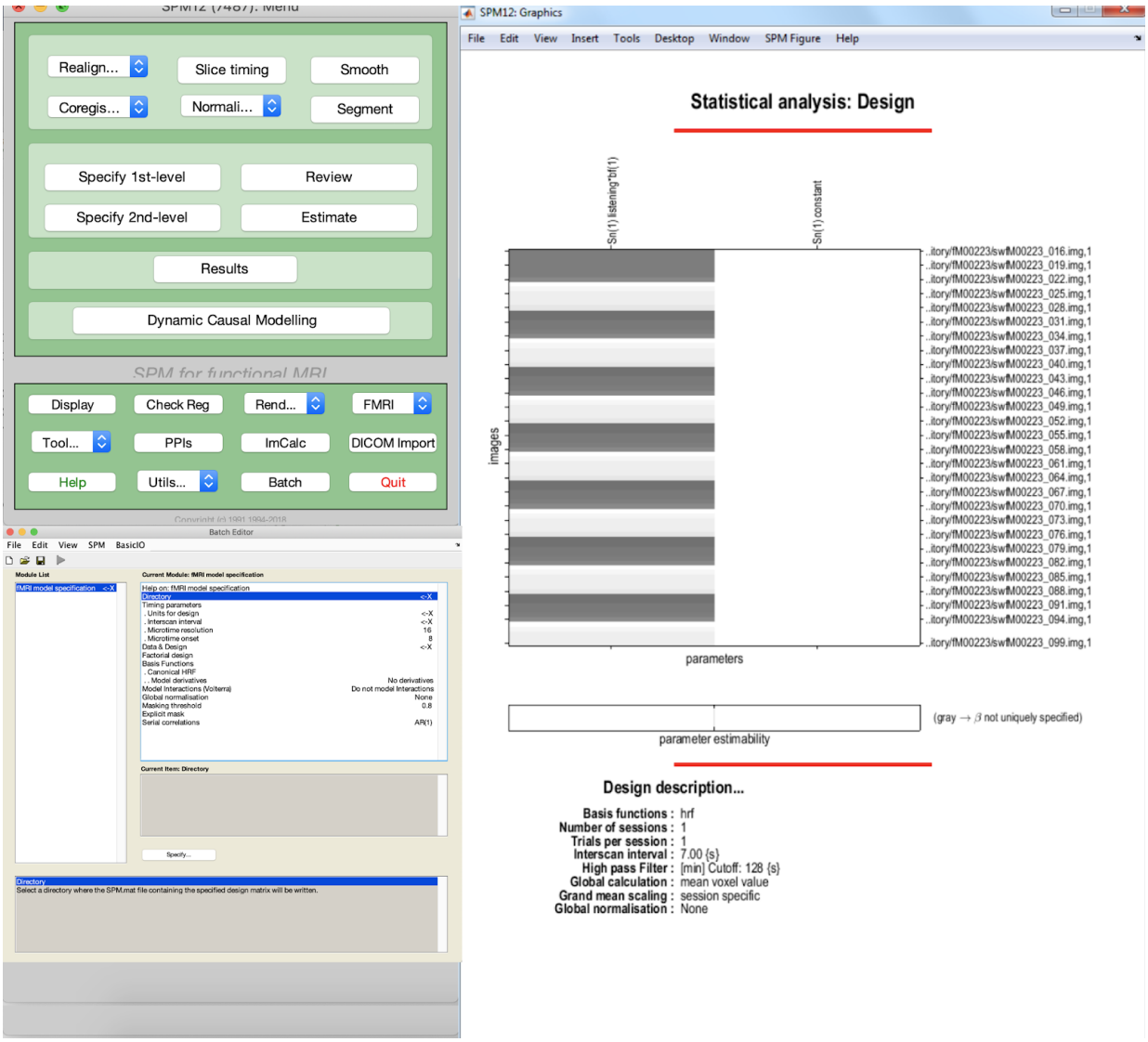


Figure 2.11: Top Left: Depicts the SPMs base window which consists of three sections i) Pre-processing ii) Model design, review and estimation iii) inference. Bottom Left: Batch editor window from SPM to specify and design the model for GLM. Right: SPMs graphic window showing the design matrix with onset and offset duration of one condition of interest during the experimental task on the left and base condition on the right. [Image source: Reproduced from *Statistical parametric mapping manual*]

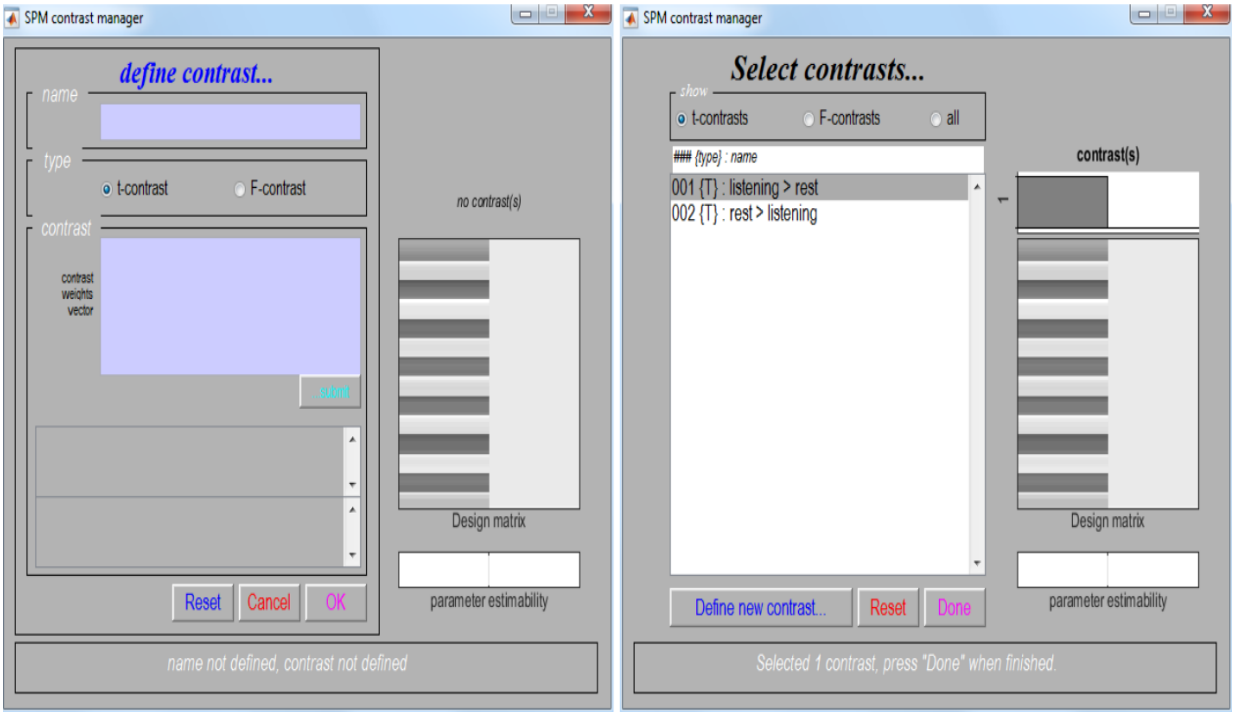
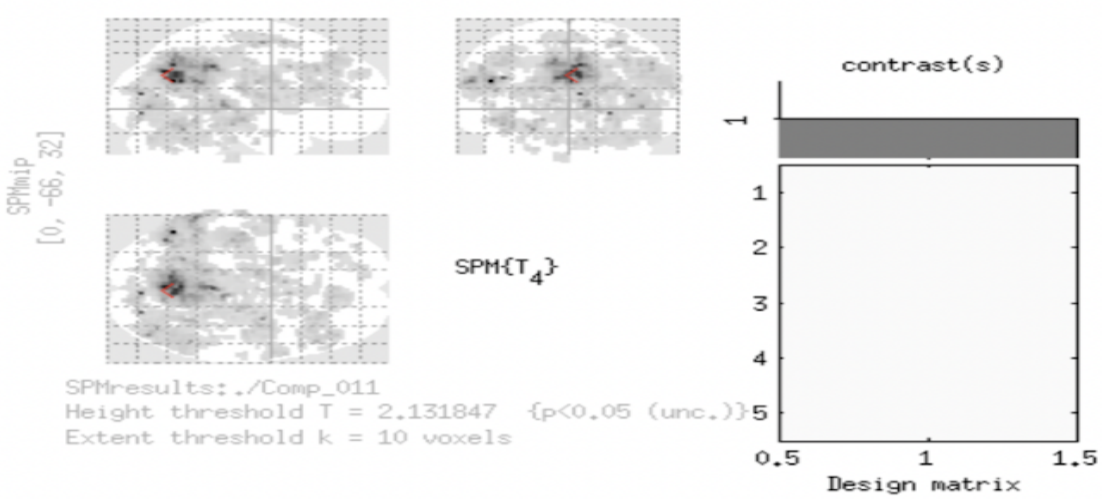
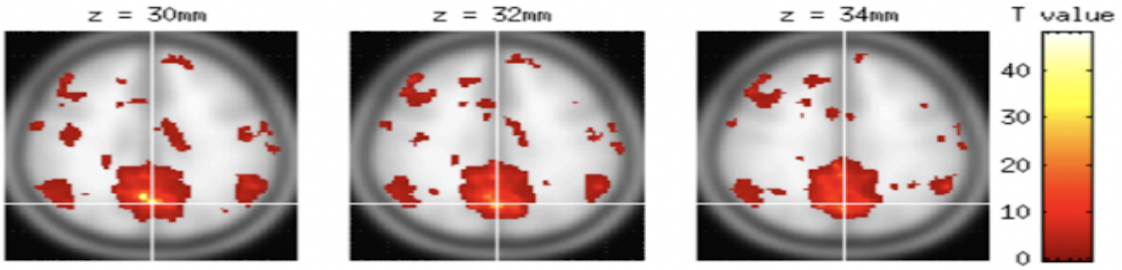


Figure 2.12: Left: Depicts the window from SPM to define the contrasts of interests. Right: Contrast selection window in SPM. Once the contrasts are defined they can be selected. [Image source: *Statistical parametric mapping manual*]


SPMmip
[0, -66, 32]
SPM{T4}
contrast(s)
1
1
2
3
4
5
0.5
1
1.5
Design matrix
SPMresults:./Comp_011
Height threshold T = 2.131847 {p<0.05 (unc.)}
Extent threshold k = 10 voxels


z = 30mm
z = 32mm
z = 34mm
T value
40
30
20
10
0

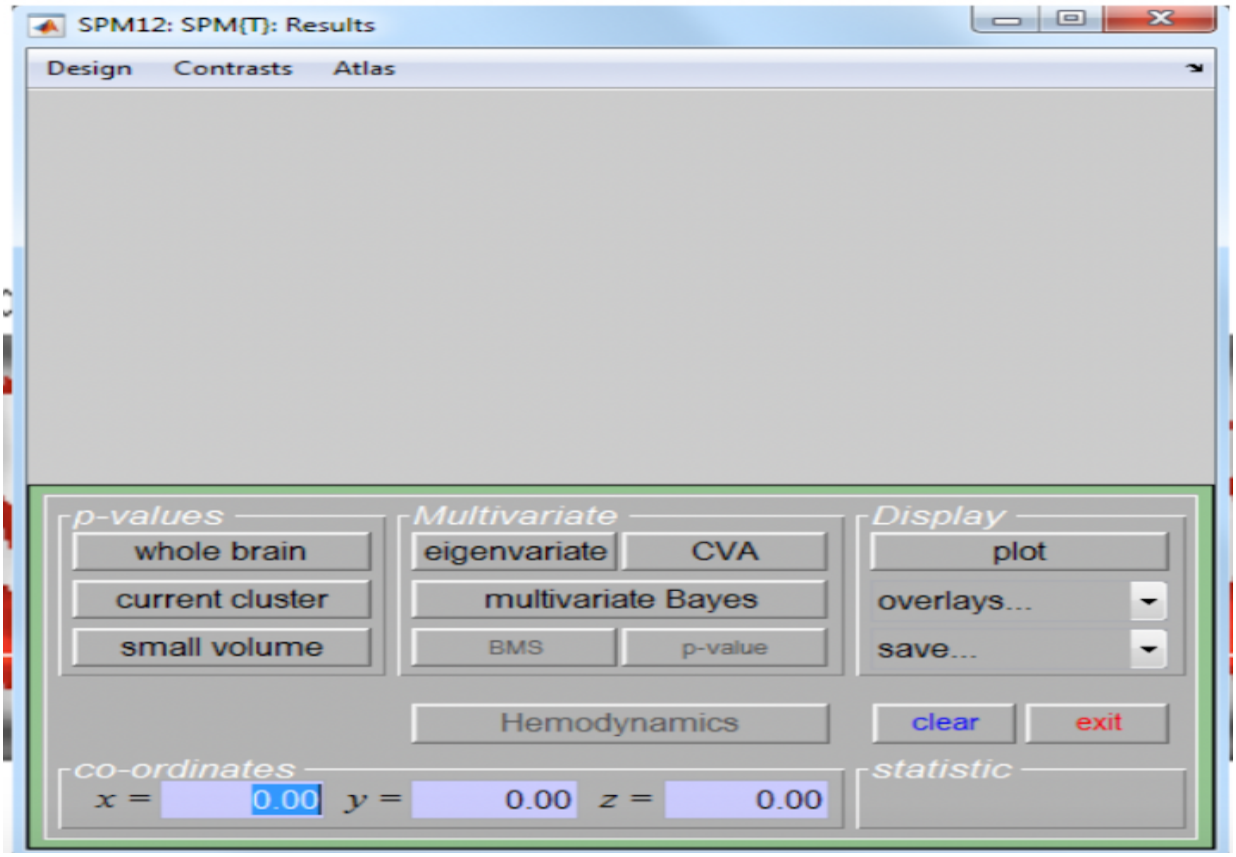

SPM12: SPM{T}: Results
Design
Contrasts
Atlas
p-values
whole brain
current cluster
small volume
Multivariate
eigenvariate
CVA
multivariate Bayes
BMS
p-value
Display
plot
overlays...
save...
Hemodynamics
clear
exit
co-ordinates
x = 0.00
y = 0.00
z = 0.00
statistic

Figure 2.13: Bottom: SPMs results assessment window. Results (physiological activity) are produced and plotted on brain template images. Top: Graphic window in SPM showing resultant activity in brain overlayed on template brain image and the respective design matrix used to produce the shown results. [Image source: *Statistical parametric mapping manual*]

2.6.2 GIFT

GIFT (Medical Image Analysis Lab, http://mialab.mrn.org/software/gift/index.html) is a group ICA toolbox which implements algorithms to find temporally correlated but spatially independent estimates for the task as well as non-task-related responses in the brain for brain imaging data. GIFT doesn't provide the functionality to perform preprocessing on raw data before performing ICA analysis and uses preprocessed data (from other sources like SPM) as input data. Analysis pipeline using GIFT also consists of 3 primary sections:

- **Analysis Setup**: In this step, we specify basic information needed to run the analysis like structure of input data, calculation of number of independent components (GIFT implements this using MDL criterion [Li, Y. O., Adalı, T., & Calhoun, V. D. (2007)]), ICA algorithm to use (example: FastICA, Infomax, etc.), output directory, which all analysis steps from pipeline to use, etc. GIFT uses all this information to generate and store results.
- **Data Analysis**: Once the analysis setup is complete, GIFT uses specified information and applies the algorithm and performs analysis of the input data.
- **Data visualization**: GIFT comes with integrated visualization tools to represent and visualize the generated results. 4 different visualization panes have been provided with GIFT to visualize the data.
    - *Component viewer*: This viewer allows to visualize either individual independent component subject-wise or mean components across the group or mean components session-wise.
    - *Subject viewer*: This viewer allows to visualize specified components across subjects, sessions or groups.
    - *Orthogonal viewer*: This viewer allows visualization of each component from all three planes (coronal, sagittal and axial) across subjects, sessions, and groups.
    - *Composite viewer*: This viewer is similar to the orthogonal viewer with a difference that it allows to compare activations between multiple (maximum being 5) components.

Chapter- 3

Measurement of implicit social bias of career/profession

Introduction

The number of rape incidents shows an increase across the world, partly attributed to social awareness and systems instituted by society and governments for safe reporting. The decades of activism has led to an increase in convictions and comparatively speedier justice. While security, social awareness and a strong legal system can be a deterrent and deviant behavior conditioner, it is important to understand the culprit's (rapist) neural differences for extracting reasons for propensity towards violence. In addition, one needs to also understand the attitude of observers, especially empathy response, to a rape victim modulated by social bias because it is not only critical for stopping future crimes but also helps the victim recover from the trauma of the assault. Social status/standing of a person is believed to be one of the many factors that influence the empathic response in the observer towards the perceived pain of others [Varnum, M. E., Blais, C., Hampton, R. S., & Brewer, G. A. (2015)] and most widely studied in the context of sexual assault on women as a crime. Women in different professions are not accorded the same respect and hence suffer differences in empathy responses. To qualify the role of perceived respectability according to professions women follow and specific empathy response, we use narratives of alleged rape incident narrated in first-person by a purported victim.

The law and order personnel are the first responders to crime scenes and hence an empathic response to the victim will help her overcome the trauma and give the confidence to provide evidence without fear required as per the law. While the police personnel are part of the civilian society, the training and exposure to different cases modulates and shapes their perceptions. In most cases it is positive - that is they are able to support the victim through emotional trauma better than the immediate family and friends of the victim. Though occasionally they are accused of being callous and unsympathetic, which can be due to the effect of over-exposure to crime or in rare

individual cases due to misogynistic attitude. Hence, two surveys were commissioned, the first was aimed to score respect as a function of the profession of a woman, and in the second we designed a narrative of an rape incident of victims in profession of low to high respect scores as accorded in the first. This was administered to police personnel and the civilian population. The main aim was not to look for differential empathy response between the two participant cohorts, rather to observe for differences as a function of the rape victim's perceived social status by the job/profession. Secondly, the results of empathy response to narrative will form the basis for the stimuli/design for the functional neuroimaging experiment presented in the next chapter.

3.1 Professions Respectability Order (Survey-1)

3.1.1 Hypothesis

Our hypothesis is that there is a social bias associated with professions considered less respectable according to stereotypic society norms and hence women in those professions are more prone to assaults like rape. We believe that there is a significant variation in empathy response proportional to subjective bias based on the profession of the victim.

3.1.2 Methodology

Towards confirming our hypothesis, a general survey has been initially taken to find how people accord less or more respect for different professions. In this survey, we listed 21 professions commonly women consider in the country. The professions that were part of this survey are :

- Doctor
- Teacher
- Fashion Designer

- Bar Manager
- Receptionist
- Actress
- Clerk
- Secretary
- Nurse
- Event Manager
- Chef
- Saloonist
- Sales Manager
- Model
- Sports Coach
- Air hostess
- Lawyer
- Movie Director
- Formula-1 Racer
- Engineer
- Physiotherapist

The task in this survey was to rate each of the professions on a scale of 1(Least) to 10(Most) of “Respectability” accorded to each, if being considered as a profession by a close “Female” relative. The aim of the survey was to arrange these professions in an order of increasing/decreasing ‘Respect’.

3.1.3 Participants

The survey was hosted online and filled by 149 participants (34 females and 115 males), belonging to the age range of 17-54 years (mean = 24.78 years, standard deviation = 6.2581). The participants themselves belonged to a range of different professions including teacher, engineer, doctor, chef, clerk, secretary, event-manager, etc. The aim for soliciting responses from the larger society is to reduce familiarity bias.

3.1.4 Results

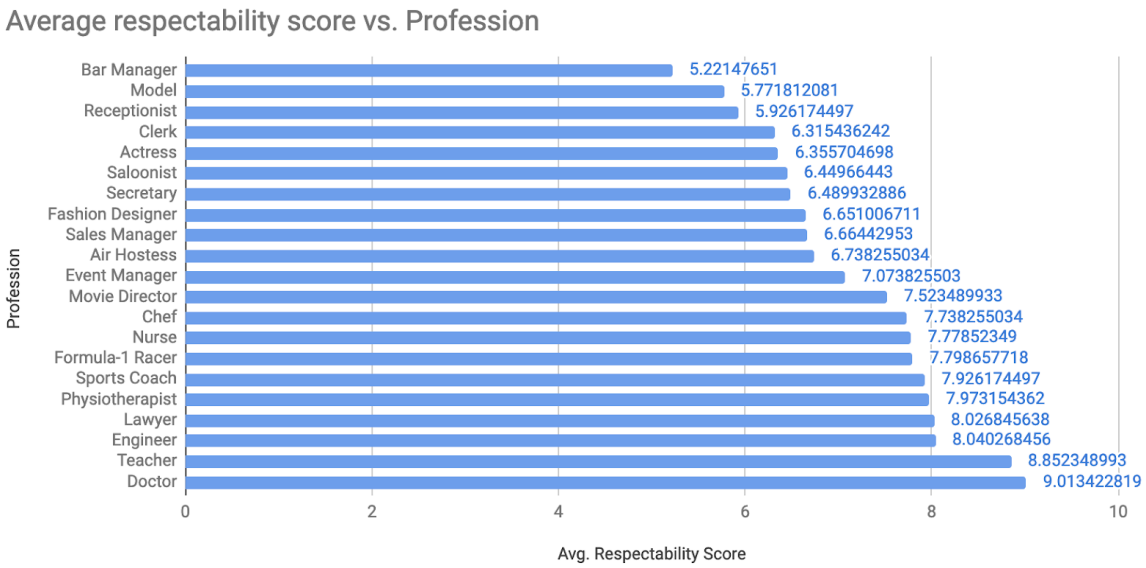


Figure 3.1(a): Histogram showing average respectability score (Mean: 7.158517098, Standard Deviation: 1.013450545) on a scale of 1-10 (10 being the maximum) accorded to each profession considered by a close “Female” relative

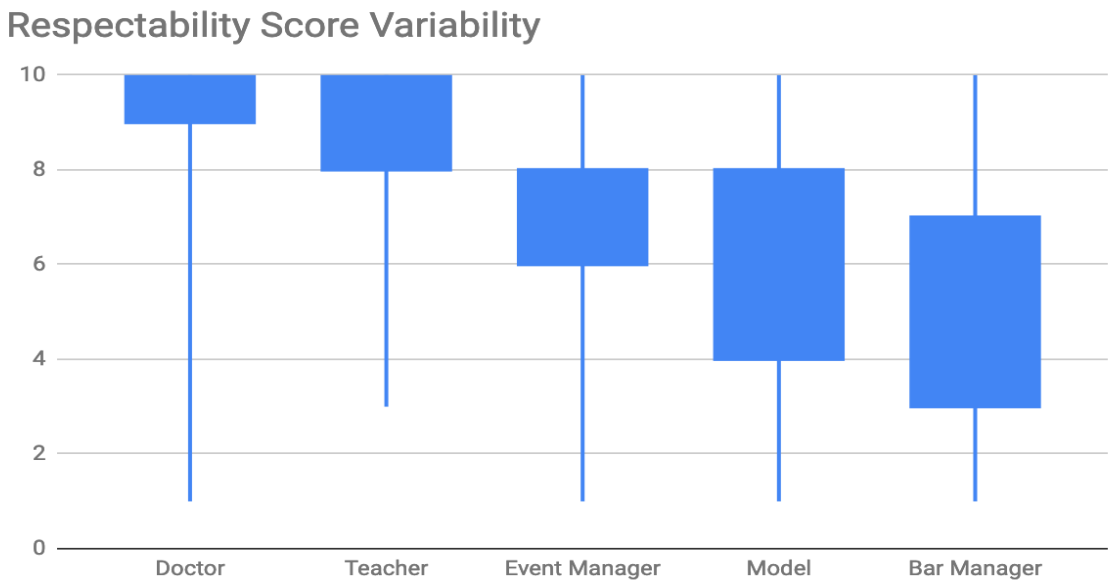


Figure 3.1(b): Above chart shows the variability observed in respectability score data given by the participants to the professions Doctor, Teacher, Event Manager, Model and Bar Manager. The professions have been selected in a way to choose two belonging to the higher end of average respectability score, two from the lower end and one from the middle.

From [Figure 3.1(a), 3.1(b); Table 3.1], it is clear that people consider professions like doctors, teachers, etc as highly esteemed professions and find these people more respectable while professions like bar manager, secretary, etc are comparatively considered less respectable, confirming our observations from the society.

Table 3.1: Welch's T-test results for respectability score data given by the participants to the professions Doctor and Bar Manager (both belonging to extreme ends of average respectability score). The statistical significance (p-value) scores (less than 0.0001) indicate the difference between the scores of both groups to be statistically significant.

Welch's T-Test Results	Doctor		Bar Manager		t-statistic	Statistical significance (p-value)
	Mean	Variance	Mean	Variance		
	9.013422819	2.134953746	5.22147651	7.592508616	14.8407	P < 0.0001

3.2 Narrative-Based Survey (Survey-2)

3.2.1 Objective

The objective of the second survey was to gauge empathy response towards a rape victim. In the introduction chapter, I have discussed the complexity of empathy responses, especially how contextual setting modulates it, that is, for one to understand and experience feelings similar to the other's, the underlying reason for the state and the conditions leading to it enhances the self-experience. Presentation of the situation in a format with maximum impact is critical - examples being the news articles of rape victims in conflict zones, of child victims - and has the power to change strongly entrenched perceptions too. But, most studies on rape victim empathy [Deitz, S. R., Littman, M., & Bentley, B. J. (1984); Feldman-Summers, S., & Lindner, K. (1976)] use questionnaires without setting the context of the crime or the victim's perspective. This method while being effective in gauging generalised responses falls short of evoking empathy as it does not address the premises the observer is making. As an example, a two line news style report of a rape incident leaves it to the reader/viewer to make inferences of the

circumstances leading to the crime. Inferences could be incorrect and also very subjective due to lack of information thus leading to lower empathic response. Hence, to reduce both the subjective variations and false inferences due to lack of information, empathy response is best studied under conditions when full information is presented. A narrative of a rape-incident as described by a purported victim was considered to be highly effective in measuring empathy.

3.2.2 Methodology

To find out change in empathic responses due to preconceived or social stereotyping of victims based on her profession fictional rape incident first-person narratives were generated. A survey was prepared with 9 hypothetical narratives describing the rape-crime incident from a victim's perspective and the post-traumatic stress it caused her. Eight were narrated with the mention of the profession of the victim and one without it (No Profile). Seven professions out of the 8 were chosen from the list of professions of the previous survey including the ones with highest and lowest rating and the rest were chosen at random with scores in between. An extra profession "Maid" was added in the list to also include a profession chosen by women belonging to the lower economic class. The list of professions chosen from the previous survey are:

- Teacher
- Engineer
- Event Manager
- Fashion Designer
- Sales Manager
- Secretary
- Beautician

The narratives were based on true events reported by the media. In the case of offline survey taken from police personnel, with the consideration in mind that many people do not prefer to read news articles in the English language and would probably be able to deeply connect and understand if presented in native language (Telugu in our case) we

provided readers with a translated version of each narrative as well (Refer Appendix of this thesis). It was left to the will of the reader to choose the language of preference from the two (English and Telugu) to read the narratives in.

In the first respectability survey, professions like bar manager, model, receptionist scored lower than fashion designer but were not considered due to already existing strong social bias to these professions. Second, the goal was to extract subtle bias present even for professions that are perceived to be independent of social power structure.

3.2.2.1 Questionnaire design

To correlate to the empathy responses to the narrative, selected questions from the standard IRI empathy index [Davis, M. H. (1980)] were also administered.

3.2.2.1.1 Interpersonal Reactivity Index (IRI)

IRI is a 28-item questionnaire, which tries to measure individual differences in empathy on four different subscales of empathy. The subscales being :

1. Personal distress (PD)
2. Fantasy
3. Perspective taking (PT)
4. Empathic concern (EC)

For the purpose of this study, two questions (of +ve and -ve valence) each from three subscales (excluding fantasy), were chosen and presented to the participants. The response to each question was taken on the 5-point Likert scale ranging from “Does not describe me well” to “Describes me very well”. The six questions that were part of the survey are :

1. *I often have tender, concerned feelings for people less fortunate than me. (EC)*

2. *Other people's misfortunes do not usually disturb me a great deal. (EC-)*
3. *I try to look at everybody's side of a disagreement before I make a decision. (PT)*
4. *I sometimes find it difficult to see things from the "other guy's" point of view. (PT-)*
5. *Being in a tense emotional situation scares me. (PD)*
6. *I am usually pretty effective in dealing with emergencies. (PD-)*

3.2.2.1.2 Narratives (19-Item Questionnaire)

The design of narratives in this survey was to represent immense pain and suffering of the victim with a perfect balance between evoking appropriate emotions in the participants and not leaving them in a distressed state after reading. After weeks of regressive discussions and many versions tested with lab members and also checked by independent members to ensure proper usage of language, final narratives were written. The narrative was :

*"I am a **'profession of the victim'**. I left my workplace near Jubilee hills check post later than usual at 9:00 pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away*

to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital."

A 19-item questionnaire was prepared in-house (after regressive discussions), based on Rape-victim empathy scale (REMV, [Smith, C. A., & Frieze, I. H. (2003)], Rape-myth acceptance (RMA, [Burt, M. R. (1980)]) and Interpersonal reactivity index (IRI, [Davis, M. H. (1980)]). This questionnaire was specifically prepared in context to the narrative. The idea was to capture the intensity of participants' empathic responses (captured through REMV) considering all the social stereotypes that are ingrained as part of their socio-cultural relationships (as covered in RMA) and how well were they able to understand and feel the pain of victim (addressed by IRI).

The modified versions were required as the standard rape-victim empathy scales, like REMV and Rape-empathy scale (RES, [Deitz, S. R., Blackwell, K. T., Daley, P. C., & Bentley, B. J. (1982)]), are a good measure of psychological construct of thoughts and perceptions in general population towards rape victims but it does not capture all the socio-cultural stereotypes or perceptions that shape the empathic responses in different demographics. Empathy, in general, is highly modulated by the perceptions one holds within a socio-cultural setting and for that reason, this custom made questionnaire used as a survey tries to capture myths and stereotypes entrenched in Indian culture related to women. In the given survey, question 1 and 5 try to capture perceptions of participants who believe the incident was an outcome of apparent bad choices, like staying back late at work when she should have known that night is not safe for women or waiting at a desolated bus stop with no one around to save her. Question 4 represents the perception of women being considered weak and men as strong protectors. Questions 6,8,10 and 11 probe the propensity of laying the blame on the victim by insinuating that she is lying, might not have tried hard enough to save herself or might have given apparent wrong signals to men leading them to believe she's interested. Questions 2,7 and 9 try to capture the empathic concern and support for the victim. Through questions 3,12,13 and 14 we wanted to capture the effect of beliefs of participants about rape incident as a crime on their empathic score. Questions 15-19, unlike questions 1-14, are the self-oriented evaluation of components of empathy in the context of the narrative where the participants needed to rate their feelings and emotions after they read the narrative.

The 19-items finally included as part of the survey were:

1. *The woman should not have stayed back so late at work.*
2. *She did nothing to provoke rape.*
3. *The incident is highly disturbing as it could happen to anyone.*
4. *If she had a male colleague escort her home late in the evening she would have been safe.*
5. *She should not have waited at the desolated bus stop.*
6. *Accusations of rape by a woman should be viewed with suspicion.*
7. *The woman should not blame herself for the rape.*
8. *It was not possible to rape the woman against her will.*
9. *It is easy to take the perspective of the woman.*
10. *She may not have tried hard enough to escape when the car stopped and the men were trying to drag her into the shed.*
11. *Fear may have prevented the woman from resisting rape.*
12. *Most women are psychologically damaged by rape.*
13. *Rape is a serious crime.*
14. *Rape prevention is a community responsibility.*
15. *I can imagine how she must have felt during the rape.*
16. *I can feel the fear and pain she experienced.*
17. *I got fully involved with the trauma the woman went through.*
18. *As I read about the incident, I was not disturbed.*
19. *I can experience the shame and humiliation she would have to go through*

The participants were asked to rate each of these questions on a scale of 1 to 5. First 14 questions were to be rated from *Strongly Disagree* (1) to *Strongly Agree* (5) and last 5 questions were to be rated from *Does not describe me well* (1) to *Describes me very well* (5).

3.2.2.2 Positive emotion reinforcement paragraph

To ensure that participants are not left with any distressing emotion post reading the narrative, a paragraph with positive emotional content(prepared after intra-group discussions) was presented to each participant after the main narrative and post-answering the questions. The content of the final paragraph was :

“The culprits were caught by police within 24 hours and booked under various sections. After this incident lights and cameras were placed on the main streets of the city. To reinforce the belief of common people in police special 24 hours helpline service was started. Many NGOs are working today in the country for preparing women/men to fight in the worst situations.”

3.2.2.3 Task

Each participant was presented with the six questions from IRI, one of the nine narratives, a 19-item questionnaire, positive emotion reinforcing paragraph and personal details section (which included age, gender, city, profession, dominant hand). Each participant was randomly assigned one of the nine narratives which they had to read and based on it provided responses to the 19-item questionnaire.

3.2.3 Results

This questionnaire was presented separately to police personnel (offline) and the civilian population. The survey was filled up by 206 participants (Female:77; Male:127; Other:2) online from the civilian population [Figure 3.2].

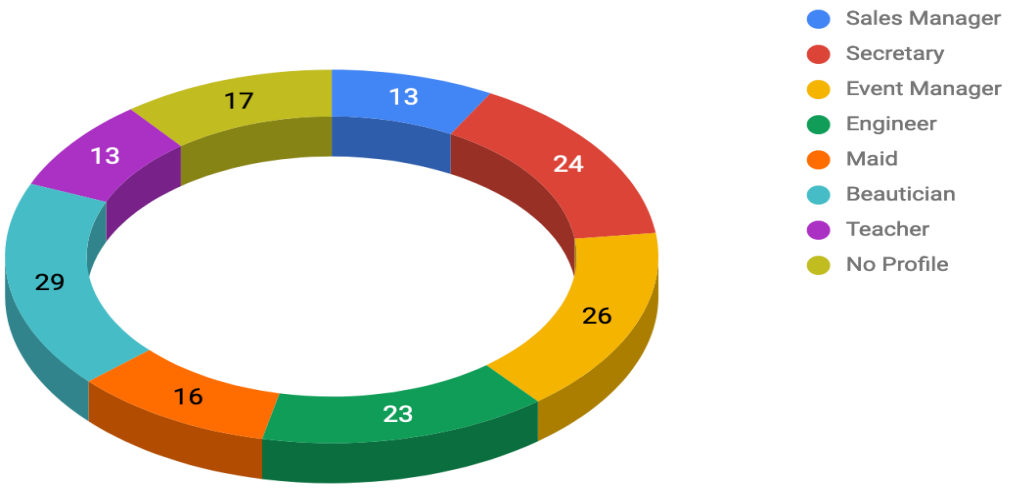
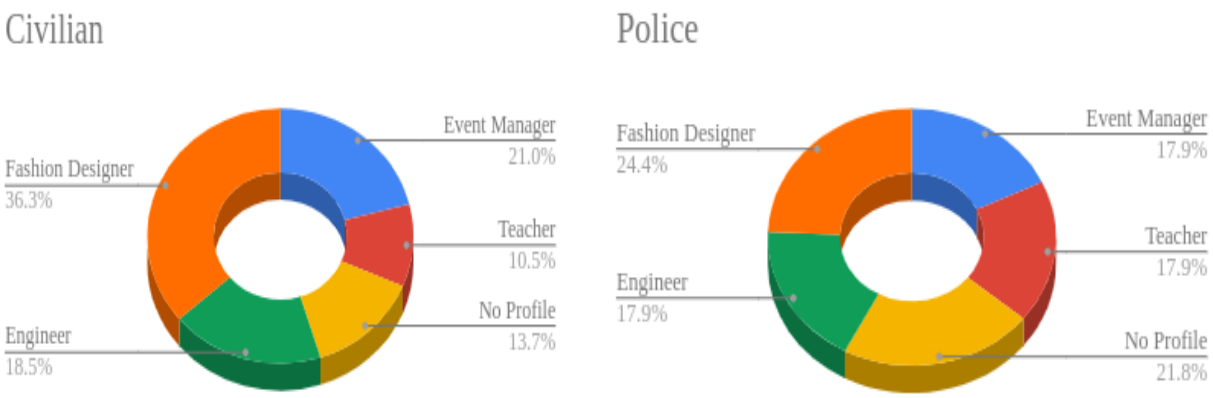


Figure 3.2: Each pie slice in the above pie chart represents the number of civilian participants (Total : 206) who filled the narrative based survey for each profession marked with the same colour in the legend on the right side of the graph.

Due to limited number of police personnel (78, all male in the age group 27 - 40 years, of cadre sub-inspector and above in designation), and to make each narrative read by a statistically good number of participants, instead of presenting them with all of the nine narratives they were presented with only five of them. Hence, a total of 124 civilians and 78 police personnel filled up the survey for selected five narratives [Figure 3.3(a) & 3.3(b)]. One of the five represents the higher end of the respectability scale(teacher), three representing the mid-range(fashion designer, engineer and event manager) and one is no profile. We did not choose professions belonging to the extreme lower end of the respectability scale with the aim of selecting professions that are perceived to be independent of social power structure. A variability in respectability scores of professions was ensured to observe any empathy-related differences.



(a) **(b)**

Figure 3.3(a) & 3.3(b): Each pie slice in the above pie charts (both civilian and police) represents the percentage of participants (out of the total of 124 for civilians and 78 for police) who filled the narrative based survey for respective profession marked with the indicated legend

3.2.3.1 IRI questionnaire

Interpersonal reactivity index is an established good measure of empathic emotions in an individual. It encompasses the measurement of different components of empathy. The sub-scales measured through this survey are indicators of how well the participant is able to understand and feel the pain of others. After accounting for reverse-scoring of the 3 questions, an average score for each of the component sub-scale was calculated for both civilians and police personnel. The average empathic score was then plotted for civilians vs police. An overall higher mean value is observed for civilians thereby confirming higher empathic emotions in civilians than police personnel. The respective scores are presented below.

Adjustment: Since, in the case of police personnel, the above survey was taken offline on paper 6 participants missed marking answers for questions. For analysis purposes, taking neutral response (3) on the Likert scale as their response to the missed questions.

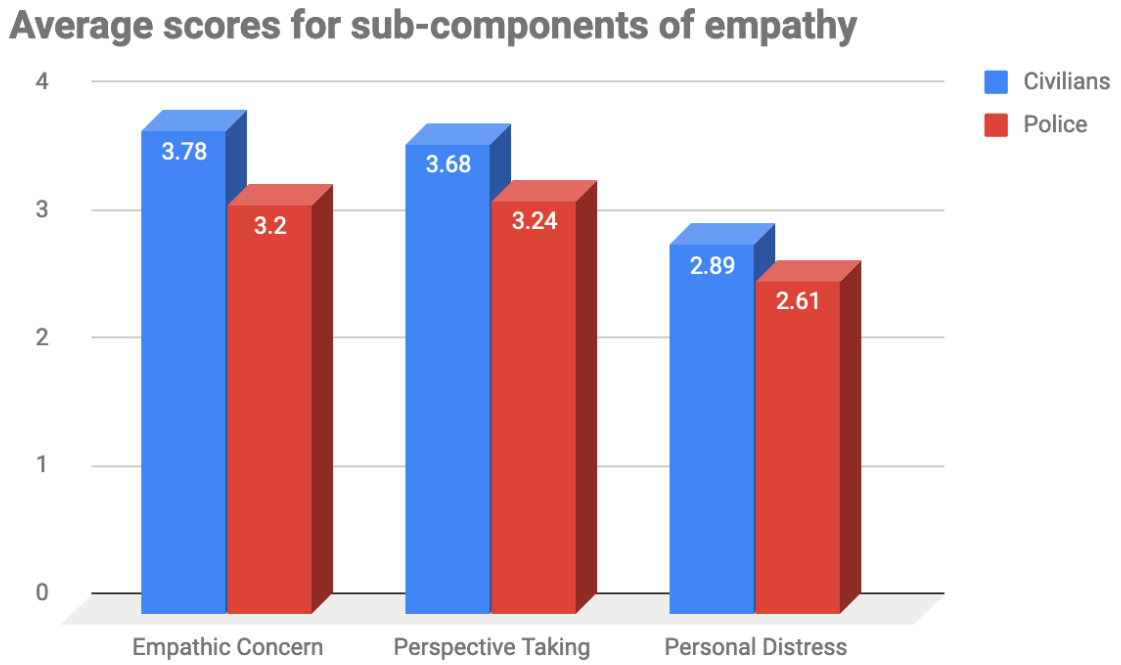


Figure 3.4: Average empathy scores on multiple sub-scales of empathy (empathic concern, perspective taking and personal distress of the IRI index) for civilians (red) and police personnel (blue).

Some of the major observations drawn from the above data [Figure 3.4] are

- In both, police and civilians, overall personal distress is relatively less than empathic concern and perspective taking. Considering that police are constantly investigating crimes, including rape, as expected personal distress was lower.

- A significant difference in empathic concern scores and perspective taking scores show that civilians have an overall higher empathic response compared to police personnel.

The main observations from the survey experiment was that participants are more able to project themselves into the victim's shoes and have feelings of concern but relatively feel less distressed. Empathy is understanding and feeling the pain of others but with a distinction of self from the other. Perspective taking and having a concern for others are other-oriented components of empathy where the observer understands the pain of others with a clear distinction so as to not put themselves in their place and feel the exact emotion. This self-other distinction might be the reason for the above observation on all the indexes. The scores are interesting to compare as the civilian population had both male/female participants and still shows only slightly higher average values to the all-male police numbers.

Table 3.2: Welch's T-test results for civilian vs police personnel average empathic score on IRI questionnaire. The statistical significance (p-value) scores (less than 0.05 threshold on all three subscales of empathy) indicate the difference between the scores of both groups to be statistically significant.

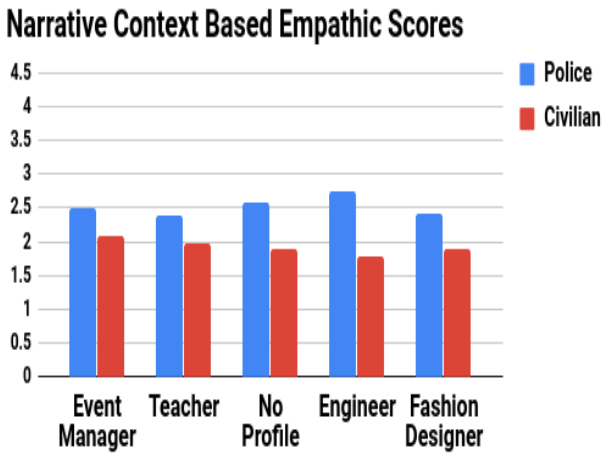
Welch's T-Test Results	Police		Civilian		t-statistic	Statistical significance (p-value)
	Mean	Variance	Mean	Variance		
Empathic Concern	3.199	0.651	3.782	0.676	-4.8691	$p < 0.05$
Perspective Taking	3.24	0.487	3.685	0.612	-4.1384	$p < 0.05$
Personal Distress	2.61	0.696	2.89	0.881	-2.1510	$p < 0.05$

To check whether the difference in the means for both civilians and police personnel was statistically significant, the two sample sets (observed to be sampled from Gaussian distributions) were put through Welch's t-test. The results are tabulated above [Table 3.2]. The t-statistic and statistical significance values confirm significant differences in empathic scores for civilians and police.

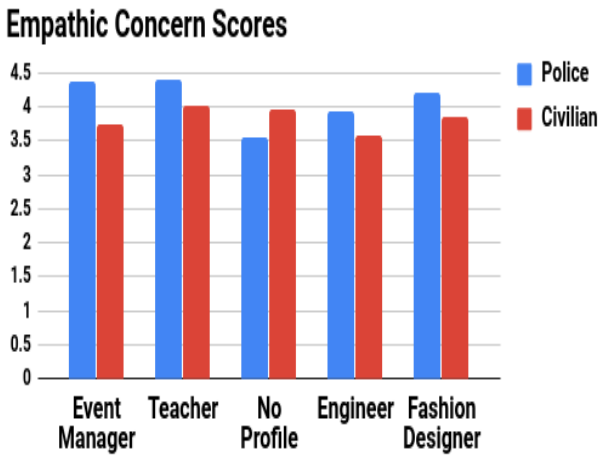
3.2.3.2 19-item questionnaire

This questionnaire was designed to measure overall context based empathic scores for each participant. For analysis purposes, the first 14 questions (listed in the section 3.2.2.1.2) representing the other-oriented empathy, after incorporating for reverse scoring of the negative questions, have been averaged to generate an overall narrative context based empathic score and the last 5 questions representing the self-oriented empathy have been divided into scales representing components of empathy, that is, empathic concern scale(EC) and perspective taking scale(PT) and personal distress scale(PD). The overall average scores for four subscales, that is EC, PT, PD and context-based empathic score have been represented below in graphical format. The graphs [Figure 5 (a, b, c & d)] represent the comparative analysis of each subscale between responses received from participants presented with different narratives.

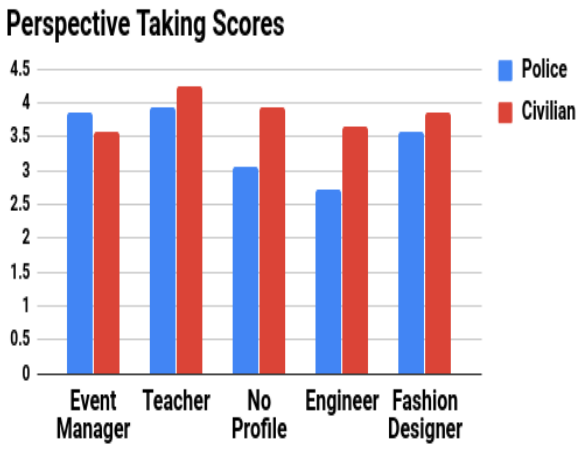
Adjustment: Since, in the case of police personnel, the above survey was taken offline on paper around 10 participants missed marking answers for 2-3 questions each. For analysis purposes, taking neutral response(3) on the Likert scale as their response to the missed questions.



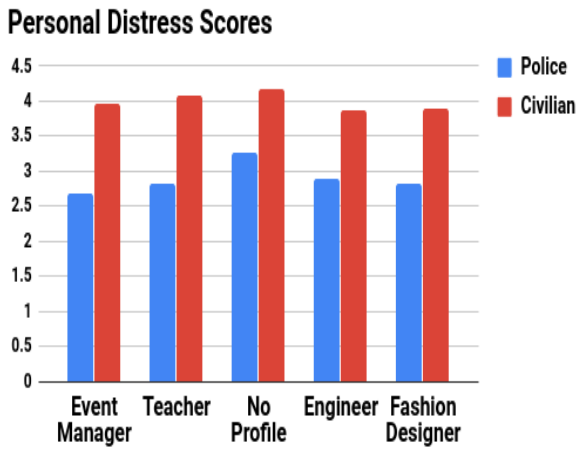
(a)



(b)



(c)



(d)

Figure 3.5 (a, b, c, d): The above figures represent average empathy scores (sub-divided into four subscales: Narrative context-based empathic scores (Figure 3.5(a)), Empathic concern (Figure 3.5(b)), Perspective taking (Figure 3.5(c)) and Personal Distress (Figure 3.5(d))) given by civilian population (red) and police personnel (blue). Each score (each

histogram, red or blue) on the graph represents the average empathic score by the respective group to the profession (Event Manager, Teacher, Engineer, Fashion Designer and No Profile) given in the survey.

Some of the key observations in this survey were

- In the cases where the profession is provided, overall empathic concern (Figure 3.5(b)) of police personnel was higher compared to civilians (but was not statistically significant - [Table 3.3]). It is interesting to note that empathic concern in civilians was observed higher than police in the case when no context (narrative) was provided.
- The personal distress (Figure 3.5(d)) in police personnel was observed significantly less compared to civilians irrespective of context provided by narratives.
- The major highlight in observations was the overall lower intensity of other-oriented empathic scores from narrative context based questions (Figure 3.5(a)) compared to self-oriented empathic scores from other components (Figures 3.5(b), 3.5(c) and 3.5(d)) on the Likert scale.
- In the case of perspective taking component (Figure 3.5(c)), civilians scored on an average higher compared to police personnel except in the case of the event manager. This observation failed to pass the significance test as well.
- Both empathic concern (Figure 3.5(b)) and perspective taking (Figure 3.5(c)) scales revealed the highest scores for the teacher profession by both civilians and police personnel.
- Further when it comes to self-oriented personal distress (Figure 3.5(d)) scale we observed a slightly different pattern with highest scores of empathy for ‘no profile’ profession.
- In the case of civilians we noticed narratives with event manager, engineer and fashion designer professions to have lower scores compared to narratives with no-profile and teacher profession (Figure 3.5(b), 3.5(c) and 3.5(d)).

From the observations above, we can infer that when a context is provided the overall intensity of context-based empathy is reduced comparatively. A possible explanation for this could be empathy being contextual or situational dependent. That is, while one can

have generic empathy, rape incident might possibly evoke lower empathy response. Another possible explanation could be the inability to self-direct a pain or trauma not self-experienced (self-other distinction) and at the other end, over-focus on rape news in media (which was seen at the time this survey was conducted).

The pattern of police personnel feeling less personal distress compared to civilians is maintained when the context is provided. The reason for this might be the direct involvement of police personnel in criminal cases compared to civilians who just listen or read about the crimes in the news only. Aligned with the hypothesis of this study, the teacher profession was able to evoke comparatively higher empathic concern and perspective taking empathy scores. Interestingly, we observed higher scores of empathy in case of 'no profile' narrative compared to others with professions (except teacher). A possible reason for this could be the imaginative power of the participants where they might have imagined someone closely related to them as part of the narrative and were able to relate at a deeper emotional level with the character.

But the biggest outcome was that a narrative of an alleged rape incident, evokes lower empathy response which could be attributed to victim blame - either due to followed profession (bar manager or dancer) or being out late in the evening in a public places, because there is a general implicit notion that public spaces belong to men and women need to take extreme safety measures.

Table 3.3: Welch's T-test results for civilian vs police personnel average empathic score on 19-item questionnaire. The statistical significance (p-value) scores (less than 0.05 threshold on two subscales (narrative context-based empathy and personal distress) and greater than 0.05 on other two subscales (empathic concern and perspective taking)) indicate the difference between the scores of both groups to be statistically significant only in cases of narrative context-based empathy and personal distress subscales while not in cases of empathic concern and perspective taking subscales.

Welch's T-test Results	Police	Civilians	t-statistic	

		Mean	Variance	Mean	Variance		Statistical significance (p-value)
Narrative context based empathic subscale	Event Manager	2.505	0.124	2.071	0.088	3.9232	***
	Teacher	2.383	0.204	1.983	0.157	2.4472	*
	No Profile	2.584	0.224	1.886	0.135	4.8023	***
	Engineer	2.745	0.227	1.767	0.06	7.1328	***
	Fashion Designer	2.41	0.098	1.881	0.103	6.16	***
Empathic concern	Event Manager	4.357	1.132	3.75	1.265	1.687	0.1027
	Teacher	4.39	0.24	4	1.29	1.1518	0.2663
	No Profile	3.56	0.87	3.971	0.671	-1.3671	0.1814
	Engineer	3.928	1.302	3.565	1.416	0.9242	0.3633
	Fashion Designer	4.21	1.009	3.86	0.916	1.0144	0.3172
Perspective taking	Event Manager	3.86	2.75	3.58	1.85	0.5418	0.5934
	Teacher	3.93	1.46	4.231	0.86	-0.7328	0.4708

	No Profile	3.06	2.31	3.94	1.18	-1.9467	0.0617
	Engineer	2.71	2.37	3.65	2.05	-1.8432	0.0767
	Fashion Designer	3.58	2.03	3.84	1.41	-0.7137	0.4811
Personal distress	Event Manager	2.68	1.02	3.96	0.998	-3.8422	***
	Teacher	2.82	1.45	4.08	0.49	-3.3402	**
	No Profile	3.26	0.88	4.18	0.37	-3.36	**
	Engineer	2.89	0.78	3.87	1.21	-2.9717	**
	Fashion Designer	2.82	1.2	3.89	0.896	-3.7227	***

* represents P < 0.05, ** represents P < 0.01 and *** represents P < 0.001

3.3 Conclusion

In conclusion, confirming our hypothesis about the existence of biases among the society that people associate with certain professions considered less respectable according to stereotypic society norms and women in those professions are more prone towards incidents like rape, we observed this in survey-1 data.

With the inclusion of context of an alleged incident in survey-2 and revealing the victim's profession in the narrative of the incident, we observed differences in the empathic scores given by participants to different narratives. We observed participants feel varying

intensities of emotions as per context with other-oriented empathy scores to be relatively much lower compared to self-oriented empathy scores. Narratives with teacher profession and ‘no profile’ were able to elicit relatively higher empathic behaviour on all the subscales of empathy. This observation further strengthens the argument of the existence of socio-cultural bias, against women in different professions, in the society (be it civilians or police-personnel). Confirming the hypothesis, this was one of the crucial observations from the study. One of the other major observations from the above survey was the difference in empathic responses from police personnel compared to civilians. Although police personnel belong to same society as other civilian participants, their empathy towards the pain of others have significant difference from that of civilian population and one of the possible reasons for this could be their constant exposure to crime and to perform their duty they have to focus on solving the crime and that’s why they make themselves feel less distressed over criminal rape incidents. The findings are also in accordance with reports of security personnel and those in health care, displaying lower empathy response as a mechanism to protect self from personal distress and also to make better unbiased judgments [Johnson, H., Hughes, J. G., & Ireland, J. L. (2007); Neumann, M. (2011); Newton, B. W., Barber, L., Clardy, J., Cleveland, E., & O'Sullivan, P. (2008)]. But this police or societal empathy for a rape victim in particular is crucial to help heal and importantly for faster justice.

In conclusion, knowledge of the profession does make a difference in empathic responses towards the pain of a woman rape victim.

Chapter- 4

Neural correlates of empathy response to rape incident as narrated by a purported rape victim

Introduction

In general, in our day-to-day routine, we come across situations where we observe discrimination of some kind or the other, be it based on skin colour [Hersch, J. (2011)], gender [Abrams, K. (1989)] or ethnicity [Neumann, D. L., Boyle, G. J., & Chan, R. C. (2013)] etc. These discriminations based on strong bias and supported by socio-cultural stereotypes influence one's response to another human – extending from basic social interactions, access to fair judicial process, job/career opportunities and fundamental human rights. In this particular study, we wanted to research on a specific type of discrimination and its correlation to empathy response from bystanders or civilians i.e. difference in empathic responses to different (difference being the profession opted by person as career) woman in similar situation (women rape victims). The aim of the study was to establish the existence of differential empathic responses as a function of profession followed by women and then explore the difference in neural correlates for signatures at the biological level.

In the previous chapters of this thesis we started off by introducing the concept of empathy, its components and some of the factors believed to be modulating this emotion

both from the psychological and neurological point of view. Then with the help of a survey we established that there does exist a difference in respectability scores one accords to different professions opted by women as career. Moving further from there, applying another survey, we found differences exist in empathic responses to perceived pain as described in a first-person narrative by a rape victim, given the knowledge of profession of the victim.

In this chapter, we present the findings from the fMRI experimental paradigm to explore the neural correlates of empathy in individuals using rape narratives (in text format). The analysis was conducted to extract the differences in empathy supported networks for each narrative. The next few sections in this chapter give a brief introduction to rape myths and importance of context to rape victim empathy followed by the details on fMRI experiment and data analysis.

Rape Myths and sociocultural bias

Sexual assault on women, an atrocious act, has been documented since the ancient times where the conquerors plundered the conquered and as a message of power, kidnapped and raped women. With a complete disregard to one's dignity and identity, women have been merely seen as commodities for personal leisure or as objects [Fredrickson, B. L., & Roberts, T. A. (1997)]. Most researchers including psychiatrists, psychologists and neurologists working in this field have focused on understanding the factors modulating the social perceptions related to women [Sleath, E., & Bull, R. (2017); Angelone, D. J., Mitchell, D., & Grossi, L. (2015); Feldman-Summers, S., & Lindner, K. (1976); Jones, C., & Aronson, E. (1973); Hinck, S. S., & Thomas, R. W. (1999); Frese, B., Moya, M., & Megías, J. L. (2004); Abrahams, N., Jewkes, R., & Mathews, S. (2013)]. The objective of these studies was to evolve interventions to improve women's status and worth in a society that sexually objectifies the female body to the extent of justifying rape and acceptance of it in many societies (for example, in a study on students in Jakarta, [Poerwandari, E. K., Utami, C. P., & Primasari, I. (2019)]). One of the major reasons for such an attitude towards rape crime are the myths and stereotypes attached with the crime which were first discussed in literature [Brownmiller, S. (1975); Clark, L. M., & Lewis, D. J. (1977)]. Very recently, [Hill, S., & Marshall, T. C. (2018)] performed a cross-cultural study and showed a greater acceptance of rape myths in a more traditional culture, like India, compared to a more egalitarian culture, like Britain. Some of the myths that these studies talked about were "a

rape cannot happen against the will of woman" or "woman ask for it". Due to these stigmas that exist in society, victims hesitate to even report the crime [Koss, M. P. (1992)] in order to save themselves and family members from the psychological trauma. Sexual assault is the only crime where the victim has to first prove her innocence to the system and society before appealing for justice.

The acts of violence as reported against women, in homes, workplaces and public spaces have increased in recent times (could be attributed to increase in reporting too) that it cannot be ignored. In addition to social perceptions, the prosecutions are also low, statistical data and evidential proofs indicate that sexual assault as a crime is not considered as critical or serious (or brutality and victimization is undermined in case of rape) as other crimes of similar severity [Feild, H. S., & Bienen, L. B. (1980); Bieneck, S., & Krahe, B. (2011); Sizemore, O. J. (2013)]. The judicial process is detrimental to the rape victim. There have been many times where the victim is the only witness of the crime. Thus, several extra-evidential factors play a vital role in attribution of blame for the sexual assault [Angelone, D. J., Mitchell, D., & Pilafova, A. (2007); Bell, S. T., Kuriloff, P. J., & Lottes, I. (1994); George, W. H., & Martínez, L. J. (2002); Luginbuhl, J., & Mullin, C. (1981); Mitchell, D., Angelone, D. J., Kohlberger, B., & Hirschman, R. (2009)]. From the characteristics of the victim to the conservative beliefs or attitudes of the observer, many factors have been surveyed and studied in detail [Angelone et al. (2015)]. It has been shown how the attribution of blame varies with the victim's gender [Grubb, A. R., & Harrower, J. (2009)], race [Bell et al. (1994); George, W. H., & Martínez, L. J. (2002)], physical attractiveness [Feldman-Summers, S., & Lindner, K. (1976); Deitz et al. (1984)], relationship with perpetrator [Angelone et al. (2015); Frese et al. (2004)], resistance shown by the victim during the crime [Angelone et al. (2015); Ong, A. S., & Ward, C. A. (1999); Deitz et al. (1984)], and respect in a society based on her marital status [Feldman-Summers, S., & Lindner, K. (1976)].

However, researchers started to realise that it is not only the victim's characteristics or situational factors that modulates the attribution of blame but also the observers' notions and beliefs about the society or the perceived similarity with the victim [Osman, S. L. (2016); Grubb, A. R., & Harrower, J. (2009)]. Studies have been conducted to show how participants' rape-supportive attitudes [Burt, M. R. (1980)], gender-role stereotypic ideas about society [Anderson, K. B., Cooper, H., & Okamura, L. (1997); Lonsway, K. A., &

Fitzgerald, L. F. (1995)], rape-myth acceptance [Hinck, S. S., & Thomas, R. W. (1999)], respectability accorded to victim [Feldman-Summers, S., & Lindner, K. (1976); Jones, C., & Aronson, E. (1973); Luginbuhl, J., & Mullin, C. (1981); Kahn, A. (1977)] affects their perception of crime.

Of relevance to our study are these rape myths, which cause tangible harm by constantly building, molding, and reinforcing beliefs about sexual violence. It clouds the reality of sexual violence and its traumatic effects. The natural but horrific result of believing in rape myths is that the person starts to doubt, blame, and stigmatize the survivor. Rape myths and gender-role stereotypic ideas about society tamper the logical thinking and reasoning abilities of a person and lead to misguided assumptions about the character of the victim [Brownmiller, S. (1975)]. These assumptions influenced by over emphasized beliefs make a person pass a moral judgement against the victim. That is, attribution of belief and biases plays a very vital and central role in moral reasoning [Sellaro et al. (2015); Young, L., Camprodon, J. A., Hauser, M., Pascual-Leone, A., & Saxe, R. (2010); Koster-Hale, J., Saxe, R., Dungan, J., & Young, L. L. (2013)], a crucial process as moral cognition encompasses the ability of deducing the intentions behind someone's behavior and actions.

Neuroscience of empathy

Empathy is defined as an assembled module made of separable components but shared sensorimotor representations, emotional and cognitive components [Decety, J., & Svetlova, M. (2012)]. It was shown to be involved in rational judgement processing and moral reasoning [Decety, J., & Meyer, M. (2008)] and to be affected by the inferred intentions and perceived agency [Akitsuki, Y., & Decety, J. (2009)]. In their experiment, [Akitsuki, Y., & Decety, J. (2009)] studied the role of intentionality/social context on empathy and implicit moral reasoning. They found anterior medial cingulate cortex, insula, somatosensory cortex to have increased activity for perception of pain in others and an increase in activity in temporal-parietal junction, medial prefrontal cortex, inferior frontal gyrus and orbitofrontal cortex in response to the perceived presence of another individual causing the pain. In a study, [Feldman-Summers, S., & Lindner, K. (1976)] have looked specifically at how the social status or standing of the victim influences empathy and prosocial behavior. These studies highlight the importance of to understanding empathy

response, as cognitive control affecting moral judgement modulate responses towards rape victims.

As detailed in chapter 1, the initial neural studies to investigate empathy response was by using pain response when infected on self and other (familiar/stranger). Lamm et al. (2011) provide meta-analytic evidence for neural networks involved in empathy for pain in others. They analysed 9 fMRI studies which used image-based paradigms(both picture-based and cue-based) and also provided coordinate-based meta-analysis on 32 other fMRI studies. They found a core neural network involving brain areas covering the bilateral anterior insular cortex, medial/anterior cingulate cortex and inferior frontal gyrus to show increased activation both in case of directly experienced pain and perceiving or visualizing others in painful situations. Thus, giving the validation for "shared representation" models of empathy [Preston, S. D., & De Waal, F. B. (2002); Decety, J., & Jackson, P. L. (2004); Gallese, V., Keysers, C., & Rizzolatti, G. (2004)] for pain in others.

Several other authors have used different modalities to confirm the involvement of AI and ACC as critical for the ability to empathize with the suffering of others. Studies done by [Akitsuki, Y., & Decety, J. (2009); Chen, Y. C., Chen, C. C., Decety, J., & Cheng, Y. (2014); Danziger, N., Faillenot, I., & Peyron, R. (2009); Decety, J., & Michalska, K. J. (2010); Lamm, C., & Singer, T. (2010)] used fMRI to assess the modulation of sensory and affective responses during empathy for pain. Decety, J., Lewis, K. L., & Cowell, J. M. (2015) used the EEG/ERP paradigm to examine emotional responses when viewing people in physical distress. Cheng, Y., Chen, C., & Decety, J. (2014) did an EEG/ERP investigation of the development of empathy in early and middle childhood. Bufalari, I., Aprile, T., Avenanti, A., Di Russo, F., & Aglioti, S. M. (2007) used transcranial magnetic stimulation to show activity in the primary somatosensory cortex of the onlooker on perceiving pain in others.

Empathy response and role of context as presented by narratives

Most of the initial studies were done using static images depicting a part of the human body being pricked with a needle, or of possible harm – like a hand on the door frame or very close to a knife cutting vegetables. Empathy responses to facial expressions [Baron-Cohen, S. (1995); Keysers, C. (2011)] was studied to understand

causality between empathic reactions and cognitive processing. A few other studies also used theory of mind cartoons [Gallagher et al. (2000)] to investigate the attribution of false beliefs or ignorance of the characters. A more naturalistic paradigm was by use of movie clips [Keysers, C. (2011); Raz, G. et al. (2012); Vemuri, K., & Surampudi, B. R. (2015)] and whole brain analysis to look at networks supporting empathy. Movies are fictional but empathic engagement is the movie maker's ability to create a transportative experience and the viewer's capacity to vicariously feel the target characters' feelings [Singer, T., & Lamm, C. (2009)]. The narrative or story format allows the viewer/reader to cognitively process the reason for the particular state of the target and allow oneself to take the perspective and experience similar feelings. Due to the dynamic nature of narratives/movies, both empathic response and target character might vary as a function of the story, which makes empathy response studies a challenge but also very realistic.

In the current fMRI study, we used a narrative paradigm with the intention of setting the context, allowing oneself to apply cognitive processing and for situational awareness/setting. Given the objective of the study (to look at role of social respect for the work description/profession of the rape victim in empathy response), a first person narrative of the circumstances of the rape incident was critical. Hence, the focus on investigating the neural processes responsible for differences in empathic responses to rape narratives was approached by generating rape incident narratives with change in the profession of the rape victim.

4.1 Methodology

4.1.1 Preparation of Narratives

From the previous experiments it is established that the empathic response is a function of the audio/visual narrative with little or no familiarity bias [Vemuri, K., & Surampudi, B. R.

(2015)]. It infers the power of the narrative and supports the transportation theory of fiction. Hence we have prepared hypothetical rape victim narratives inspired by real life incidents (Ref: Appendix at the end of this thesis). As our objective also includes the relation between the role of social class/profession of the victim and empathy response, we initiated the experiment with a survey of different professions which are prominently taken up by women (Chapter 3). We hypothesized that women in all professions are not seen with the same amount of respect and suffer differences in empathy responses towards them because of their professions, which was confirmed by the analysis of the survey scores reported in chapter 3. We used our findings from above survey to select the professions that have either low or high respect for writing the rape victim narratives.

Next, the emotional valence, brutality and build up of the narratives had to be balanced. For this we designed another survey with 9 hypothetical narratives describing the rape-crime incident from victim's perspective and the post-traumatic stress it caused them. This survey highlighted that independence of women to be in public spaces was a function of the profession she was practicing. (Ref: Chapter-3 of this thesis)

For the fMRI experiment we took a total of four narratives with different plots. Three of them were rape narratives and one was general empathy based narrative. The general empathy based narrative was a non-rape first person narrative of a visually challenged person. Out of three rape narratives two had profession of the victim included and one without. In two profession-based narratives we choose one highly respectable profession i.e. Teacher and one with least respect i.e. Bar Dancer. The nature of all the four narratives presented was visual text format. The medium of instruction/narratives was English. The narratives are provided in the appendix.

4.1.2 Experimental Paradigm

This experiment was designed with the help of e-prime software (Psychology Software Tools, Inc. , https://www.pstnet.com/eprime.cfm). It employs the visual paradigm. The stimuli were projected using a MRI compatible LCD monitor. The paradigm contains the selected narratives presented to participants in blocks of sizes of 80 s (for rape-related narratives) and 60s (for general-empathy narrative) separated by a gap period of 18 s.

Before the start of the experiment, a high resolution T1-weighted structural scan followed by a 3 min resting-state scan of each participant was taken [Figure – 4.1]. During the experiment, participants were asked to read the narratives carefully and try to connect with the characters in the narratives. A post-experiment behavioural survey was collected from each participant. The survey had questions from Davis Empathy Index, Rape-Empathy Index and questions related to the narratives presented.

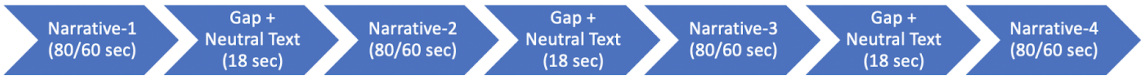


Figure – 4.1: fMRI experimental design used for data collection

To avoid any effect of ordering of narratives, the experimental design was counter-balanced among participants. 5 different paradigms (each presented to 4 different participants) were prepared in correspondence to counter-balancing (listed below).

1. N1 : Bar Dancer, N2 : Teacher , N3 : No Profile , N4 : General Empathy
2. N1 : No Profile , N2 : Teacher , N3 : Bar Dancer, N4 : General Empathy
3. N1 : Teacher , N2 : No Profile , N3 : Bar Dancer, N4 : General Empathy
4. N1 : Bar Dancer, N2 : General Empathy , N3 : No Profile , N4 : Teacher
5. N1 : General Empathy , N2 : Teacher , N3 : No Profile , N4 : Bar Dancer

4.1.3 Human Subjects

This study was approved by the ethics committee of the International Institute of Information technology, Hyderabad. 20 university student volunteers(age range of 21-34; mean 27.35; std deviation = 3.8653) participated in the study. All the participants were from male population. Participants were informed about the content of the study and they have provided written consent for participation in the study. A small amount (Rs 1000/-) was paid to each participant for their participation. All the methods were performed in accordance with the guidelines provided by the ethics committee.

4.1.4 MRI Acquisition

Magnetic resonance images were acquired using a 3T Philips Achieva scanner(National Brain Research Centre, Manesar, India). Functional images were acquired using T2*-weighted gradient echo, echo-planar imaging (GE-EPI) sequence with each volume of scans composing of 30 transverse slices with TR = 2 s, TE = 35 ms, flip angle = 90, acquisition matrix = 64 x 64, slice thickness = 5 mm, gap = 1 mm, REC voxel MPS: 1.8 x 1.8 x 5 mm, and acquisition voxel MPS: 3.5 x 3.5 x 5.0 mm. A three-dimensional T1-weighted structural image using a fast field echo (FFE) technique and a Turbo Field Echo sequence was recorded with a TR = 8.39 ms, TE = 3.7 ms, 150 slices, flip angle of 8, Field of view (FOV) = 250 x 230 mm and voxel volume: 0.98 x 0.98 x 1.0 mm.

4.1.5 Data Preprocessing

The 20 subjects' datasets were pre-processed using Statistical Parametric Mapping (SPM8, Wellcome Trust Centre for Neuroimaging, London, United Kingdom, http://www.fil.ion.ucl.ac.uk/spm/software/spm8). The data was firstly corrected for head motion using Realignment procedure. In this, the collected volumes for each participant were realigned to their mean image. An inclusion criterion for a maximum head motion of < 2 mm was used. All of the subjects passed this threshold. Residual movement-related effects were adjusted by using a motion parameters file, generated by realignment, as a regressor in the model estimation step. The high resolution anatomical image was then registered with the mean functional image of the subject, using the Coregister procedure, so as to bring all the functional data to conform to the subject's anatomical space. The data were normalised to 2 x 2 x 2 mm^3 Montreal Neuroimaging Institute(MNI) echo-planar imaging (EPI) template(provided in SPM8 package) to bring the data into a standard anatomical space. Functional images were spatially smoothed using a Gaussian filter with a full-width at half maximum (FWHM) parameter set to 6 mm. The observation models applied to the data was the univariate general linear model [Friston, K. J. (1994); Friston, K. J. et al. (1994)] and the multivariate independent component analysis (ICA) decomposition methods. Though the stimuli was timed for 80 seconds, and paradigms wherein GLM in statistical parametric mapping (SPM) toolbox is applied recommends a

block length of not greater than 20s to reduce drift and drop in signal [Henderson, H. (2006); Visscher, K. M. et al. (2003)], though this can be mitigated by adjusting the cut-off of the high-pass filter. But, GLM was applied on the data with modifications to the design matrix by considering the narrative flow. We present the results from both the methods to look at empathy supporting areas and networks.

4.1.6 fMRI Data Analysis

4.1.6.1 GLM

We chose to use statistical parametric mapping because it is the most prevalent approach to characterize task-related physiological responses in the brain into experimental factors, confounds of no interest and residual variability at the voxel level. With SPM we can estimate and infer from the regions of interest in the brain. Interaction effect of contributing variables was analyzed using the first-level GLM model implemented in SPM8 application (https://www.fil.ion.ucl.ac.uk/spm/software/spm8/). Four narratives were used as the conditions of interest and a motion parameter file generated during realignment was used as a confound regression in the first-level analysis. The prepared model was estimated to get the parameters (Beta-weights) for each of the conditions and each participant. Interaction contrasts were prepared for each of these conditions in order to investigate the differences in activity of one narrative versus the other. The contrasts prepared were :

1. Session contrasts
    a. B
    b. T
    c. Nop
    d. GE
2. Comparative contrasts
    a. B > T
    b. T > B
    c. B > Nop
    d. Nop > B

e. B > GE
f. GE > B
g. T > Nop
h. Nop > T
i. T > GE
j. GE > T
k. Nop > GE
l. GE > Nop

(where; Bar Dancer - B; Teacher - T; No Profile - Nop; General Empathy - GE)

Each of the comparative contrasts were evaluated with a statistical threshold of $p < 0.01$ uncorrected with an extent threshold of 10 voxels. The activations in comparative contrast did not survive the more stringent Family wise error (FWE) and the False discovery rate (FDR) thresholds, stated to address Type -I errors or false positives. Whereas the activations from session-wise contrasts were able to cross the FDR corrections (Bar Dancer at 0.05, Teacher at 0.01, No profile at 0.001 and General empathy at 0.01) [Table 1].

The MNI (in mm) coordinates for all the voxel clusters which passed the threshold for each session and at first-level were fed to Anatomy toolbox (http://www.fz-juelich.de/inm/inm-1/DE/Forschung/_docs/SPMAnatomyToolbox/SPMAnatomyToolbox_node.html), to get the regional labels for these coordinates.

4.1.6.2 ICA

The independent component analysis of our data has been done using the group ICA toolbox, GIFT (Medical Image Analysis Lab, http://mialab.mrn.org/software/gift/index.html). GIFT is a toolbox which implements algorithms to find temporally correlated but spatially independent estimates for the task as well as non-task related responses in the brain for functional magnetic resonance imaging data. ICA has been shown to have the ability to detect and separate artifactual physiology-related responses, non-task related signals and task-related time courses present in the measured haemodynamic signals in fMRI. It is a

purely data-driven approach and has majorly found its application in cases where a-priori model or hypothesis is not present. The average number of independent components for our group data was estimated using the minimum description length (MDL) criteria. This is the number of components that is extracted from each subject's data. The FastICA algorithm was used to extract the independent sources of signal. Since ICA is an optimization technique it is generally preferred to do multiple runs of the algorithm to check for reliability or stability of the results and the ICASSO toolbox was used to perform the stability analysis. ICA has the ability to extract every low or high frequency signal but whether it is of any significance or not has to be verified.

For the purpose of data analysis in our experiment we chose to perform ICA on individual session level (i.e. combine the fMRI data for each participant for respective session) and not at the group average level so as to not lose the variations contributed by individual sessions during the back-reconstruction step involved in group ICA algorithm implemented by the toolbox. Post analysis, through visual inspection, we selected networks (of interest to the topic of our experiment) of neural activity from the data output of individual sessions.

4.1.6.3 Why GLM and ICA - Need, pros and cons

GLM, by its nature, is a confirmatory approach, that is, equipped with a set of hypothesized waveforms (regressors). It tries to fit the linear combination of these hypothesized models over to each voxel's response and find weight parameters signifying each regressor's contribution to the signal. Based on literature review of application of GLM to long duration stimuli and fMRI experimental design we selected intervals/scans corresponding to the sections of narratives with high emotional valence to get their contribution in the response signal. For example, for a narrative displayed for 80 seconds (a time arrived at after pilot reading tasks), an assumption was made that the 40 seconds into scan-time (of each narrative) the reader will be at a certain part of the narrative.

This approach allowed us to extract signals in correspondence to desired aim (for example: response to highly empathy evoking parts of the narrative) of the study. Also, since in the GLM approach we apply the same regressors to all subject's data it allows us

to make more accurate inferences about the data at multi-subject level. A major matter of concern in using GLM was the duration of the selected time-series blocks in the data for our analysis. In block designs (GLM) the duration is suggested to be not greater than that of 40-50 seconds (though optimal is not more than 20 seconds. But it has also been suggested that longer durations would not be an issue if a) the high-pass filter is at least twice the fundamental frequency (in our study it was set to 256 seconds as the block duration was 80 seconds with 18 seconds of gap period) and b) assuming that longer stimuli do not allow the participants to fall asleep inside the scanner.

Although, GLM allows us to easily (comparative to data-driven methods) make strong inferences at multi-subject level, usage of these correlation analysis based approaches (like GLM), their specificity to fMRI data analysis have been questioned [Baumgartner, R., Somorjai, R., Summers, R., Richter, W., & Ryner, L. (2000)] and have been shown prone to Type-I errors (false positives). Second, for experiments wherein the tasks are presented for long duration as a naturalistic paradigm and are neither block or event designs the GLM method has been reported for efficiency in temporal resolution. Whereas, blind-source separation using methods like ICA allow one to look at functional connectivity networks and time-varying activation of the network and regions of interest. ICA was also applied as a confirmatory analysis of results obtained from the GLM approach. It takes in raw data and attempts to find common features from different sources (heartbeat, breathing, motion-related artifacts, etc.) of fluctuations among the data. It seeks to uncover non-trivial attributes from the data which might have been missed out by hypothesis-driven approaches. This analysis based on blind source separation will give activations independent of the characteristics or features of the stimuli and is especially important for naturalistic stimuli wherein the exact time or event coordinate is not marked, though from the time signal data, change in activation at specific time instances can be elicited. One of the drawbacks of the ICA method, compared to the GLM, is the inability to make inferences from individual subject's neural activation, as the widely accepted approach (used in our data analysis) is to concatenate each subject's data [Calhoun et al. (2001); Svensén, M., Kruggel, F., & Benali, H. (2002)] into group data and compute ICA on this data as a whole and back-reconstruct participant specific data. This does facilitate comparisons of the differences among participants at each individual component level [Erhardt, E. B., Rachakonda, S., Bedrick, E. J., Allen, E. A., Adali, T., & Calhoun, V. D. (2011)]. In this process, the back-reconstructed IC's for each subject is the weighted

average distribution rather than actual activation at each area in the IC's and specific to the subject. Hence, GLM was also applied to look at activations at regions of interest to empathy responses.

4.1.7 Post-fMRI survey

Along with the study of neural systems in case of task-based fMRI experiments, the importance of concurrently studying behavioral responses and running correlations is important [Karuza, E. A., Emberson, L. L., & Aslin, R. N. (2014); Raz, G. et al. (2012); Vemuri, K., & Surampudi, B. R. (2015)]. While fMRI allows the experimenter to peek into the neural processes responsible for changes in internal representations, self-reports by surveys allow the researcher to tap into the information on individual perspectives.

Post scanning each participant was presented with a questionnaire (composed of 3 different sections) to record self-reported scores of empathy. A post-fMRI survey was presented to avoid any occurrence of familiarity confounds or cues from the task of rating influencing the processes in the scanner. In the first section of this survey, participants were presented with questions from standard Rape Myth Acceptance (RMA) questionnaire [Payne, D. L., Lonsway, K. A., & Fitzgerald, L. F. (1999)]. This survey is divided into four subscales (*she-asked-for-it*, *he-didn't-mean-to*, *it-wasn't-really-rape*, and *she-lied*) to cover all factors of a participant's myth acceptance. As the section headers indicate, the questions in the section *she-asked-for-it* test for acceptance of the myth that certain actions/decisions of the female lead to the rape. The benefit of doubt myth on the perpetrator is tested by the scale *he-didn't-mean-to*. The myth that the act of rape was consensual is implied in the scale *it-wasn't-really-rape*, while the integrity and honesty of the victim is tested in the myth scale *she-lied*.

Higher the overall score lower is their acceptance of myths. Next the participants were presented with selected questions from the standard Interpersonal Reactivity Index (IRI) questionnaire [Davis, M. H. (1980)]. This section of the survey is similar to the one presented to the participants in pre-experiment surveys (refer Chapter – 3 of this thesis). Finally, in the last section of the survey, participants were again presented with three rape narratives - one with Teacher as profession, other with Bar Dancer and the last with No

Profile and participants were asked to give rating on a scale of 1-5 (5 being the maximum) for pity, compassion, sympathy and empathy for each of the narratives.

The scores from the standard questionnaires gave us a way to get a self-evaluated report of each participant on different subscales of empathy and rape myth acceptance enabling us to correlate the results obtained from fMRI data with those from behavioral data.

4.2 Results

4.2.1 GLM Results

The main interest for our analysis was to identify the effect of knowledge of profession on haemodynamic responses in areas supporting empathy when engaged in a task of reading highly empathic narratives.

4.2.1.1 Session-wise Results

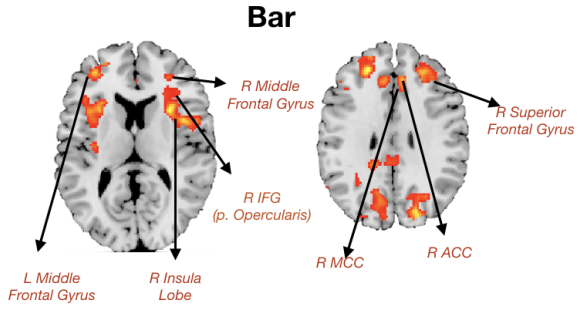
The first level session contrasts were critically thresholded using the family wise error (FWE) correction and false discovery rate (FDR) correction. None of the activations survived the FWE correction whereas a few survived the FDR corrections. The activations corresponding to the Bar Dancer session were thresholded using the FDR correction of 0.05 with voxel extend of 10. The threshold used for the Teacher session was with FDR correction of 0.01, No Profile session was FDR correction of 0.001 and General Empathy session was FDR correction of 0.01 with voxel extend of 10 in each case [Table 4.1, Figure 4.2]. The differential threshold was applied as some of the sessions showed extremely high activation in certain voxel clusters and correspondingly very high T-value. The whole-brain contrasts for each condition revealed increased activations in superior frontal gyrus (in case of Bar Dancer), middle frontal gyrus (in case of Bar Dancer, Teacher and No Profile) along with a small cluster of inferior frontal gyrus (in case of Bar Dancer). These coactivations along with activations in anterior and middle cingulate cortex represents possible cognitive empathy network [Bernhardt, B. C., & Singer, T. (2012); Cochin, S., Barthelemy, C., Roux, S., & Martineau, J. (1999)]. The contrasts for each

condition also revealed a distributed network of coactivations in insular lobe (in case of Bar Dancer, Teacher and General Empathy) rolandic operculum (in all 4 cases), the regions reported to play roles in emotional empathy network [Altmann, U., Bohrn, I. C., Lubrich, O., Menninghaus, W., & Jacobs, A. M. (2012); Walter, H. (2012)].

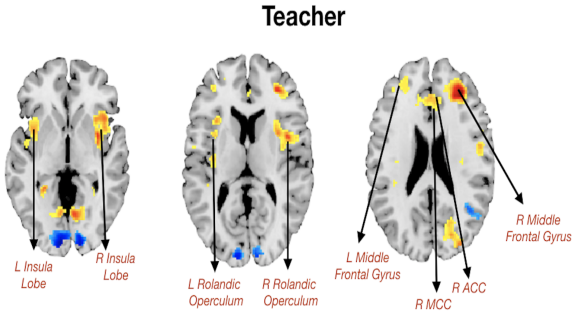
Table 4.1: SPM results for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy). The FDR threshold along with extend threshold (V) applied over activations belonging to that session is indicated. The Hemispherical side of the brain, Region of brain, MNI *x,y,z* coordinates, T and Z values showing activation in the areas that support empathy networks.

	Hemisphere	***Region***	***cluster K***	***T***	***Z score***	***x y z {mm}***
Bar Dancer (FDR 0.05, V=10)						
	R	Superior Frontal Gyrus	93	6.91	4.83	26 44 22
	R	Middle Frontal Gyrus	93	4.75	3.81	36 42 24
	L	Middle Frontal Gyrus	22	5.54	4.22	-22 44 30
	R	IFG (p. Opercularis)	14	4.94	3.91	56 10 18
	R	ACC	30	5.48	4.19	10 32 26
	R	MCC	30	5.28	4.09	12 36 34
	R	Insula Lobe	166	5.44	4.17	34 18 14
	R	Rolandic Operculum	17	5.16	4.03	46 6 12
Teacher (FDR 0.01, V=10)						
	R	Middle Frontal Gyrus	591	10.66	6.01	34 42 22
	L	Middle Frontal Gyrus	75	5.49	4.2	-38 28 34
	R	ACC	298	4.88	3.88	6 24 26
	R	MCC	298	5.8	4.35	8 32 32
	R	Insula Lobe	812	7.21	4.95	36 18 -10
	L	Insula Lobe	20	5.47	4.19	-32 6 14
	R	Rolandic Operculum	812	6.38	4.61	46 4 10

	L	Rolandic Operculum	37	5.56	4.23	-36 -36 16
No Profile (FDR 0.001, V=10)						
	R	Middle Frontal Gyrus	128	7.25	4.96	30 42 24
	L	Middle Frontal Gyrus	26	6.32	4.58	-26 40 30
	L	ACC	249	6.98	4.86	-6 28 16
	L	MCC	249	6.99	4.86	0 22 36
	R	Rolandic Operculum	55	6.59	4.7	50 4 12
General Empathy (FDR 0.01, V=10)						
	R	ACC	447	6.27	4.56	6 26 16
	L	ACC	447	8.98	5.55	-4 30 24
	L	Insula Lobe	70	6.44	4.63	-36 -6 -10
	R	Rolandic Operculum	68	6.15	4.51	52 6 2



(A)



(B)

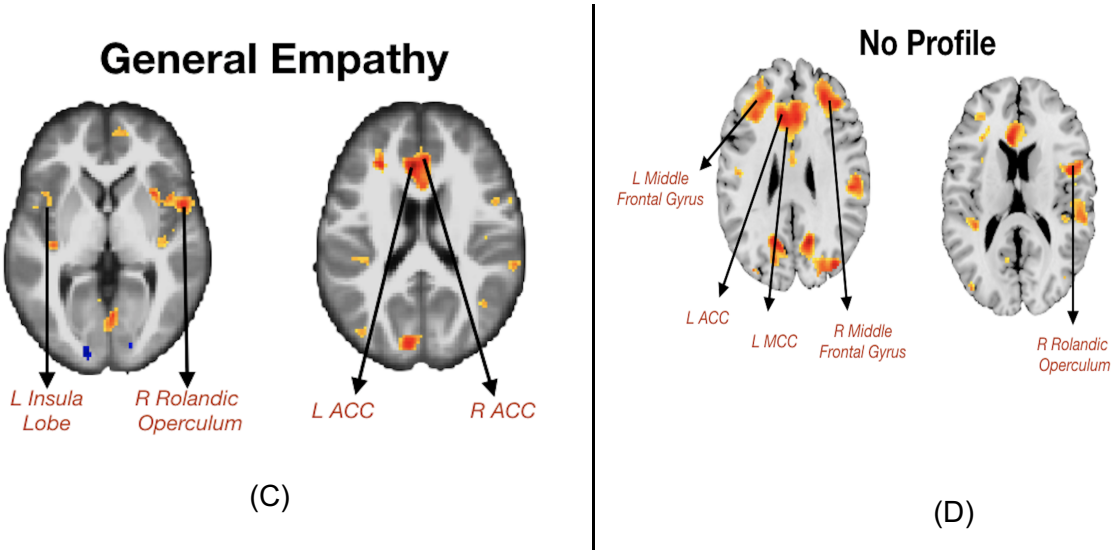


Figure 4.2: Depicts neurological activations overlaid on template brain image from the first level random effects analysis performed using SPM toolbox for all four sessions. The regions of interest have been labeled at each brain image for every session. **(A)** Bar Dancer: An FDR correction of 0.05 was used with an extend threshold of 10. **(B)** Teacher: An FDR correction of 0.01 was used with an extend threshold of 10. **(C)** General Empathy: An FDR correction of 0.001 was used with an extend threshold of 10. **(D)** No Profile: An FDR correction of 0.01 was used with an extend threshold of 10.

[Table - 4.1; Figure – 4.2] reveals activations in rolandic operculum for whole-brain contrasts for all the sessions. Rolandic operculum, in literature, has been reported to be involved in empathy for pain in a social exclusion study [Novembre, G., Zanon, M., & Silani, G. (2014)]. Clusters of activations from parts of the cingulate cortex (especially anterior and middle) were observed and specifically the anterior cingulate cortex has been identified to be part of network modulating ethics, emotions and morality [Sevinc, G., Gurvit, H., & Spreng, R. N. (2017); Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006)]. Session contrasts revealed predominant activations in superior and inferior (in case of Bar Dancer) frontal gyrus in addition to activations in bilateral middle frontal gyrus (except in the case of general empathy). These areas have been reported to be part of cognitive empathy network [Shamay-Tsoory et al. (2009)]. Also, significant activations

were noted in the insula lobe reported to be active for pain understanding and perception [Lamm et al. (2011)]. Of significance is the activation in the areas of right insula, ACC and frontal cortex area for the narratives with the rape victim as Teacher and Bar Dancer. Though the social respect score for a bar dancer is significantly lower than a teacher, the presence of neural activation in areas supporting empathy is significant. The narrative for general empathy was the state of a visually challenged person navigating in a highly visual sensory based world, showing activation in the left insula, an area also reported for empathy response.

Application of differential thresholds on individual session's activation responses revealed a lower signal strength for Bar Dancer session compared to other sessions. This can be confirmed from data where activation responses from the Bar Dancer session, unlike other sessions, when passed through stricter thresholds (FDR correction of 0.01 and 0.001) did not reveal any significant results. Another very interesting observation was made in the case of the No Profile session which revealed this session to have the highest signal strength compared to other sessions. The correctness of this can be established from data where activation responses from No Profile session gave significant results at the highest threshold (FDR correction of 0.001) while intensity of activations from no other session were able to survive the threshold (activations from other sessions gave significant results at less stringent thresholds of 0.01 and 0.05).

4.2.1.2 Comparative Analysis Results

The whole-brain contrasts at second-level analysis (a > b; a,b are sessions) were also prepared. These contrasts were thresholded using an uncorrected value of 0.01 with the extend threshold of 10 [Table 4.2, Figure 4.3]. The FWE and FDR corrections were also applied but none of the activations survived. The activations from comparative contrasts *Bar Dancer* > *Teacher* and *Bar Dancer* > *General Empathy* did not survive the threshold. The contrast *Bar Dancer* > *No Profile* showed activations in superior and inferior frontal gyri, the regions reported to be part of cognitive empathy network. The contrasts, *Teacher* > *Bar Dancer*, *Teacher* > *No Profile* and *Teacher* > *General Empathy*, showed significant activations in superior, middle and inferior frontal gyri along with activations in posterior-medial frontal and insula lobe. The contrasts *No Profile* > *Teacher* and *No Profile* >

General Empathy show activations in brain areas (superior and middle frontal gyrus and posterior-medial frontal) reported to be the part of cognitive empathy network whereas the contrast *No Profile* > *Bar Dancer* showed significant activations in cingulate cortex along with rolandic operculum which are crucial parts of emotional and cognitive empathy networks. In the case of contrasts *General Empathy* > *Bar Dancer*, *General Empathy* > *Teacher* and *General Empathy* > *No Profile*, an interesting trend was observed where in addition to areas supporting cognitive empathy network (superior-, middle-, inferior- and posterior-frontal region) the areas belonging to emotional empathy network (insular lobe and rolandic operculum) were observed in all the three cases.

Table 4.2: SPM results for all the 2nd level contrasts (a > b; a, b are sessions). The Hemispherical side of the brain, Region of brain, MNI *x, y, z* coordinates, T and Z values showing activation in the areas that form part of the empathy networks.

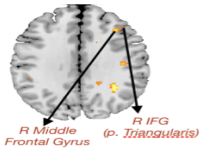
	Hemisphere	*Region*	*cluster K*	*T*	*Z score*	*x y z {mm}*
Bar Dancer > Teacher						
	No data passed the threshold					
Teacher > Bar Dancer						
	R	Superior Frontal Gyrus	58	3.67	3.15	20 58 12
	R	Posterior-Medial Frontal	27	3.65	3.14	10 -20 48
	R	Middle Frontal Gyrus	45	3.48	3.02	36 32 32
	R	IFG (p. Triangularis)	22	3.2	2.82	52 30 26
Bar Dancer > No Profile						
	L	Superior Frontal Gyrus	117	4.44	3.63	-10 56 36
	R	IFG (p. Triangularis)	13	3.88	3.29	46 28 4
No Profile > Bar Dancer						
	R	Middle Frontal Gyrus	1637	6.81	4.79	28 4 54
	L	Middle Frontal Gyrus	350	3.22	2.84	-32 38 28

	R	Superior Frontal Gyrus	1637	5.9	4.39	26 6 62
	L	Superior Frontal Gyrus	256	5.14	4.02	-18 10 54
	R	Posterior-Medial Frontal	17	3.2	2.83	6 8 60
	L	Posterior-Medial Frontal	75	2.76	2.5	-8 -10 66
	R	ACC	253	4.74	3.8	4 14 26
	L	ACC	253	3.48	3.02	2000 2 28
	L	MCC	253	3.42	2.98	-2 -4 36
	R	Rolandic Operculum	94	4.31	3.56	62 0 8
	L	Rolandic Operculum	25	3.42	2.98	-38 -30 12
Bar Dancer > General Empathy						
	No data passed the threshold					
General Empathy > Bar Dancer						
	R	Superior Frontal Gyrus	80	3.53	3.06	20 16 48
	R	Middle Frontal Gyrus	108	3.62	3.12	28 32 44
	L	Middle Frontal Gyrus	46	3.08	2.74	-24 10 56
	R	IFG (p. Triangularis)	28	4.43	3.63	48 34 4
	L	IFG (p. Triangularis)	16	2.86	2.57	-52 36 8
	R	IFG (p. Orbitalis)	26	3.12	2.77	34 28 -16
	L	Posterior-Medial Frontal	73	3.59	3.1	-8 -2 46
	R	MCC	148	4.31	3.56	14 -22 42
	R	ACC	767	4.07	3.41	6 24 16
	R	Insula Lobe	26	3.19	2.82	28 22 -18
	L	Insula Lobe	94	3.42	2.98	-36 -4 -12
Teacher > No Profile						
	L	Superior Frontal Gyrus	12	3.23	2.85	-10 18 56
	L	IFG (p. Triangularis)	28	3	2.68	-46 26 2
	R	Posterior-Medial Frontal	26	3.14	2.78	14 -4 48
	R	Insula Lobe	98	3.28	2.88	36 -14 22

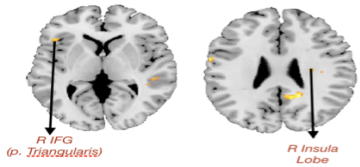
No Profile > Teacher						
	R	Superior Frontal Gyrus	199	4.18	3.48	26 12 60
	R	Middle Frontal Gyrus	199	4.09	3.42	28 8 52
	R	Posterior-Medial Frontal	63	3.44	3	14 -12 64
Teacher > General Empathy						
	R	Middle Frontal Gyrus	53	3.34	2.93	38 36 30
	L	Posterior-Medial Frontal	35	2.85	2.57	-10 -6 60
	R	Insula Lobe	12	2.96	2.65	38 20 -4
	L	Insula Lobe	13	3.25	2.87	-30 10 16
General Empathy > Teacher						
	R	Superior Frontal Gyrus	10	3.55	3.07	36 -4 62
	R	Middle Frontal Gyrus	54	4	3.36	22 28 42
	L	Middle Frontal Gyrus	37	3.64	3.13	-26 30 38
	R	IFG (p. Orbitalis)	25	3.63	3.13	36 28 -16
	R	ACC	18	4.36	3.58	6 26 16
	L	ACC	45	3.79	3.23	-4 30 14
	L	MCC	22	2.99	2.68	-12 -36 42
	R	Insula Lobe	22	3.45	3	38 2 10
No Profile > General Empathy						
	R	Superior Frontal Gyrus	11	2.93	2.62	20 44 22
	R	Middle Frontal Gyrus	162	3.92	3.31	38 36 32
General Empathy > No Profile						
	L	Superior Frontal Gyrus	17	3.05	2.72	-16 54 32
	R	Posterior-Medial Frontal	14	3.01	2.68	8 -24 54
	R	IFG (p. Triangularis)	52	3.99	3.36	48 28 4
	R	Insula Lobe	23	3.9	3.3	28 22 -18
	R	Rolandic Operculum	17	3.2	2.82	48 -24 18

Teacher

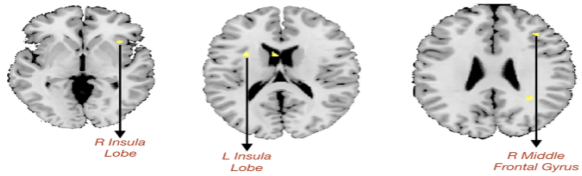
Con 1: P2 > P1



Con 2: P2 > P3

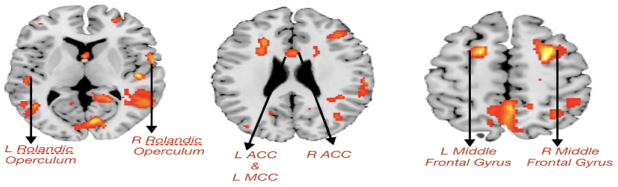


Con 3: P2 > P4

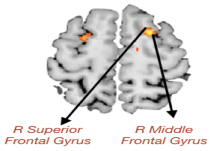


No Profession

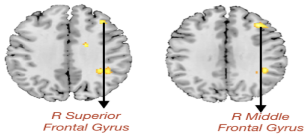
Con 1: P3 > P1



Con 2: P3 > P2

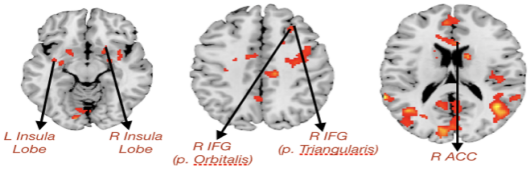


Con 3: P3 > P4

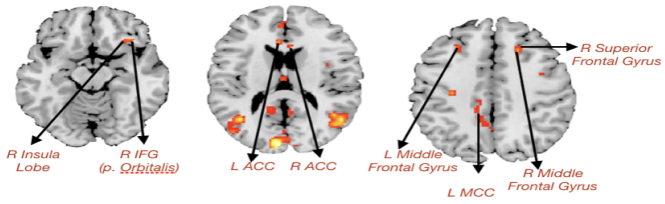


General Empathy

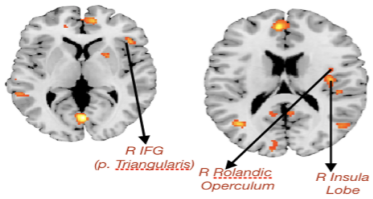
Con 1: P4 > P1



Con 2: P4 > P2



Con 3: P4 > P3



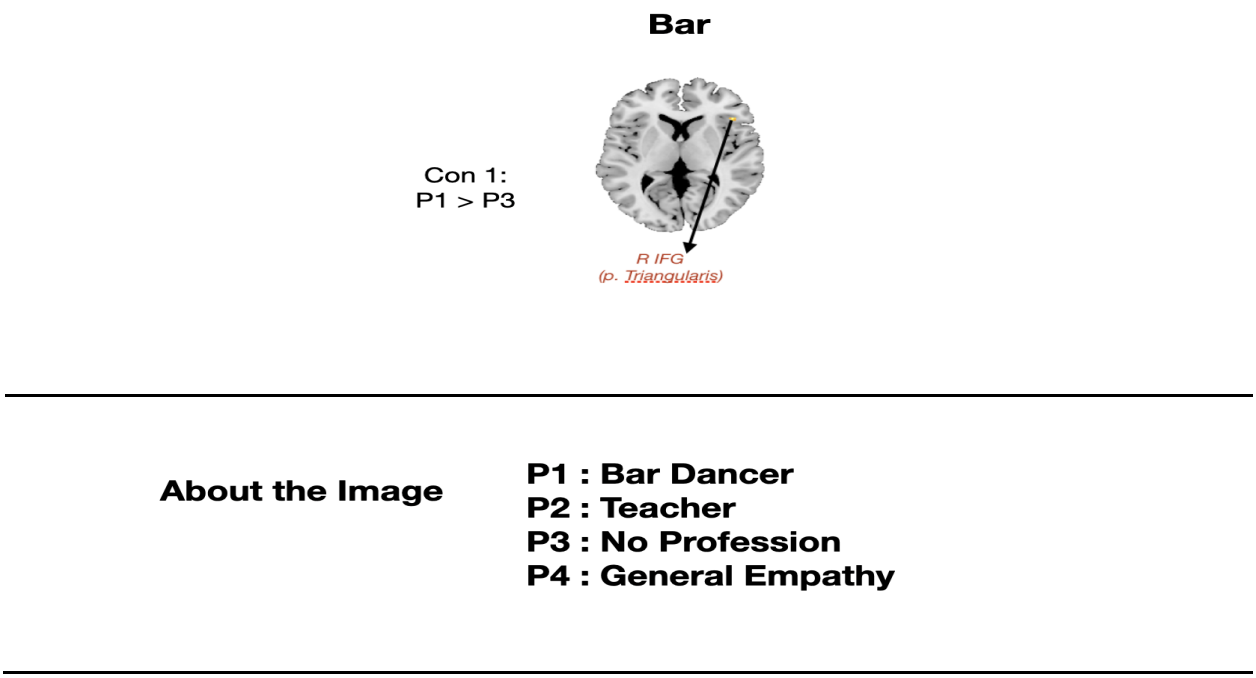


Figure 4.3: Depicts neurological activations overlaid on template brain image from the group level random effects analysis (comparative contrasts) performed using SPM toolbox for all four sessions. The regions of interest have been labeled at each brain image. These contrasts were thresholded using an uncorrected value of $p < 0.01$ with the extend threshold of 10. The contrasts *Bar Dancer* > *Teacher* and *Bar Dancer* > *General Empathy* have been excluded from the results for they didn't survive the threshold. The codes P1 to P4 have been assigned among sessions randomly and are used in depicting comparative contrasts. Teacher depicts comparative contrasts "Teacher session > Other sessions". No Profession depicts comparative contrasts "No Profession session > Other sessions". General Empathy depicts comparative contrasts "General Empathy session > Other sessions". Bar Dancer depicts comparative contrasts "Bar Dancer session > Other sessions".

4.2.2 ICA Results

Application of group ICA on fMRI data gave temporally correlated intrinsic networks of spatially segregated areas. All of the extracted ICN's were then passed through a filtering procedure to identify the network of interest – empathy in particular. The selection was done via first labelling active regions in each independent selected network using the Anatomy toolbox (in SPM). Then by visual inspection of the IC's by IC networks with activations covering areas like visual cortex, default mode network (posterior), temporal poles were identified though not considered for further analysis in this thesis. Of interest were ICN's with activations in the frontal cortex, insula, ACC,MCC, limbic areas of thalamus, amygdala - all areas supporting empathy responses. Via this procedure we also filtered out all networks with non-task related (physiological artifacts) activity. Post filtering we selected 4 ICN's. All the filtered networks show activations in accordance with the areas reported from previous studies.

4.2.2.1 Session-wise Results

All the selected networks from the four different sessions (Bar Dancer, General Empathy, No Profile and Teacher) were critically thresholded using the family-wise error (FWE) correction of 0.05.

Selected IC Network - 1

[Table - 4.3, Figure – 4.4] In all of the experimental sessions, significant activations were noted in insula lobe, an area reported to play pivotal role in moderation of affective component of empathy [Nummenmaa et al. (2008); Cox et al. (2011)]. Activities in areas of temporal pole and superior temporal gyrus (Bar Dancer session) were noted. These areas have been associated with perspective taking, information processing and also play a crucial role in cognitive and motor empathy networks. Clusters of activations from parts of the cingulate cortex (especially anterior and middle) were observed. Anterior cingulate cortex have been identified to be part of network modulating ethics, emotions and morality [Sevinc, G., Gurvit, H., & Spreng, R. N. (2017); Jackson, P. L., Brunet, E., Meltzoff, A. N.,

& Decety, J. (2006)]. Distributed activations in areas such as rolandic operculum, area reported to be involved in empathy for pain towards social exclusion [Novembre, G., Zanon, M., & Silani, G. (2014)], Precuneus, area involved while recalling the episodic memories [Fletcher et al. (1995)] and frontal gyri (superior, middle and inferior), areas reported to play executive functions in cognitive empathy, were noted.

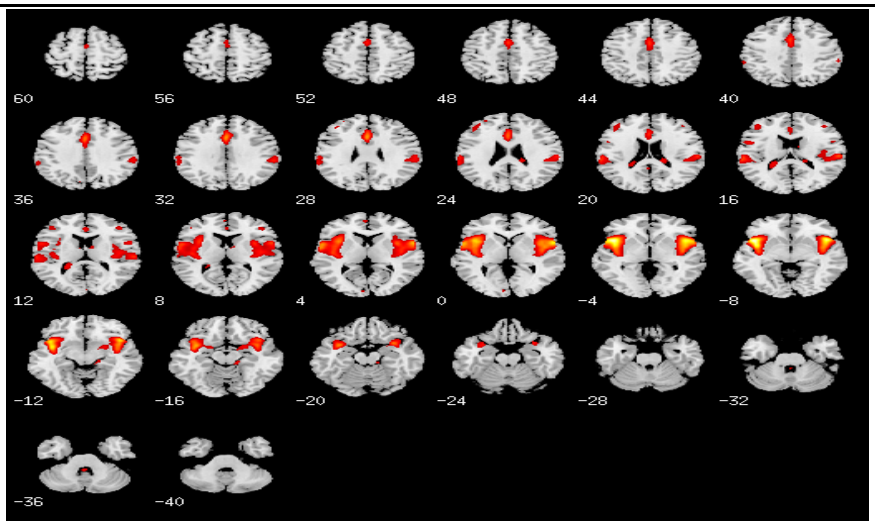
Table 4.3: Independent component analysis results for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-1. The session column also indicates the FWE threshold applied over activations belonging to that session. The Hemispherical side of the brain, Region of brain, voxel cluster size, MNI *x, y, z* coordinates, peak activation and Z values showing activation in the areas that form part of the empathy networks.

Session (applied correction)	***Hemisphere***	***Region***	***cluster K***	**Peak T**	***Z score***	***x y z {mm}***
Bar Dancer (FWE-0.05)						
	L	Insula Lobe	2531	19.61	7.54	-42 -10 4
	R	Insula Lobe	2715	18.46	7.4	44 10 -6
	L	Temporal Pole	2531	17.7	7.3	-54 4 0
	R	Temporal Pole	22	9.35	5.66	26 2 -14
	L	Superior Temporal Gyrus	358	11.34	6.17	-60 -20 14
	R	Superior Temporal Gyrus	2715	15.51	6.98	62 -20 12
	L	ACC	530	15.39	6.96	-2 18 28
	R	ACC	530	12.28	6.38	2 26 30

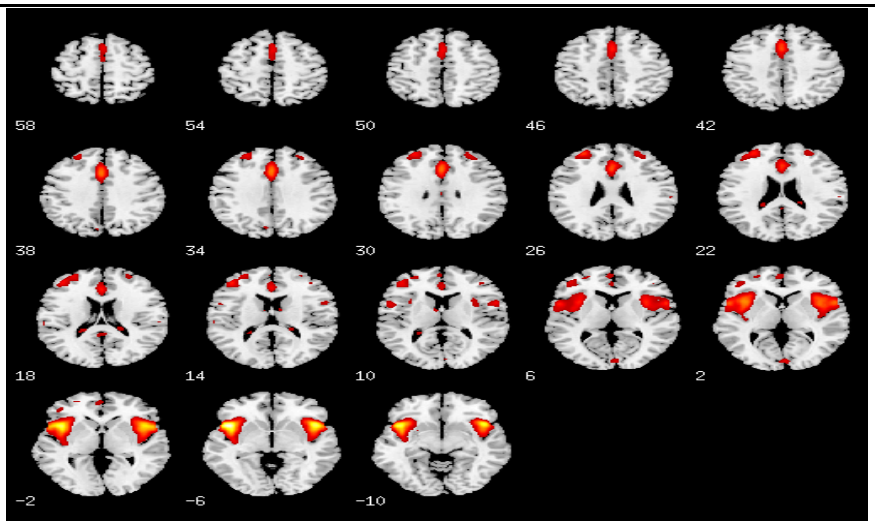
	R	MCC	13	9.65	5.74	2 -10 44
	L	SupraMarginal Gyrus	358	10.12	5.87	-58 -28 20
	L	Postcentral Gyrus	358	10.56	5.99	-64 -22 34
	L	Posterior-Medial Frontal	46	9.33	5.65	0 10 50
	R	Posterior-Medial Frontal	15	8.45	5.38	4 -6 58
	L	Middle Frontal Gyrus	12	8.37	5.36	-40 40 28
	R	Middle Frontal Gyrus	50	8.83	5.5	42 44 12
	L	Hippocampus	31	8.4	5.37	-26 -42 10
Teacher (FWE-0.05)						
	L	Insula Lobe	1892	22.44	7.84	-40 6 2
	R	Insula Lobe	1835	21.49	7.75	38 8 6
	L	Temporal Pole	1892	16.23	7.09	-42 8 -14
	R	Rolandic Operculum	1835	16.96	7.2	58 10 6
	R	ACC	709	13.96	6.71	4 34 20
	L	ACC	709	12.43	6.41	-2 36 14
	L	Middle Frontal Gyrus	332	11.88	6.3	-42 46 14
	R	Middle Frontal Gyrus	54	8.68	5.45	32 48 30
	L	Superior Frontal Gyrus	332	12.05	6.33	-28 56 26
	L	Superior Medial Gyrus	17	8.41	5.37	-2 52 8
	L	Precuneus	27	10.83	6.05	-4 -48 16

No Profile (FWE-0.05)						
	L	ACC	938	25.61	Inf	0 30 34
	L	ACC	938	14.01	6.72	-6 38 16
	L	Superior Medial Gyrus	938	15.21	6.93	2 24 48
	R	IFG (p. Orbitalis)	1361	21	7.7	40 20 -4
	L	IFG (p. Orbitalis)	1734	17.86	7.32	-40 14 -6
	R	Insula Lobe	1361	19.96	7.58	42 12 -4
	L	Insula Lobe	1734	18.42	7.39	-34 18 8
	R	Temporal Pole	1361	20.25	7.62	56 6 2
	R	Middle Frontal Gyrus	22	10.5	5.97	34 42 22
	L	Middle Frontal Gyrus	33	10.36	5.93	-32 46 26
	R	SupraMarginal Gyrus	24	9.72	5.76	64 -30 32
General Empathy (FWE-0.05)						
	L	MCC	1800	16.85	7.18	-4 -34 46
	R	MCC	1800	13.41	6.61	6 -36 44
	R	Precuneus	1800	11.77	6.27	2 -42 58
	R	Rolandic Operculum	269	15.35	6.95	64 -18 18
	R	Insula Lobe	269	11.28	6.16	44 -18 16
	L	Insula Lobe	97	10.27	5.91	-38 0 8
	L	Superior Temporal Gyrus	97	11.85	6.29	-54 -2 6
	R	Posterior-Medial Frontal	378	11.59	6.23	2 -8 60

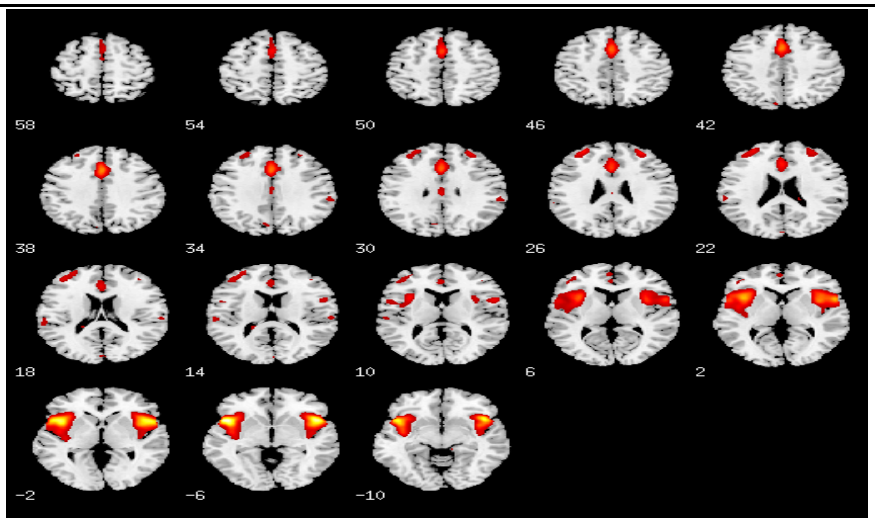
	L	SupraMarginal Gyrus	21	8.77	5.48	-58 -44 34
	L	Postcentral Gyrus	47	8.82	5.5	-52 -18 38
	R	Postcentral Gyrus	18	10.75	6.03	44 -32 44
	L	Superior Temporal Gyrus	15	7.94	5.21	-60 -30 20



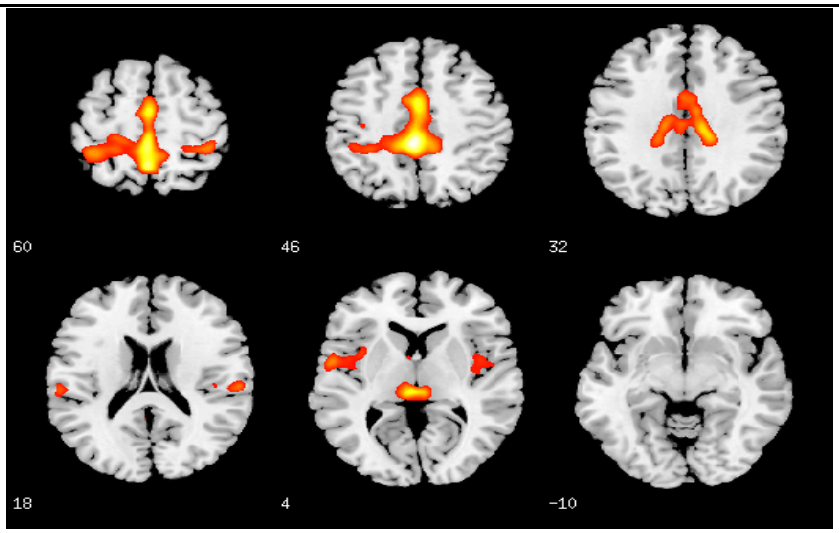
Bar Dancer



Teacher



No Profile



General Empathy

Figure 4.4: Activation maps for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-1 for when the participants read the narratives inside the fMRI scanner. The areas and other details have been listed in Table 4.3 and have also been discussed in detail in the following text (Ref: Selected IC Network - 1). Primarily, activations (in areas belonging to selected IC network-1) were noted in Insula lobe, Temporal pole, Superior Temporal Gyrus, ACC, MCC and Rolandic operculum.

Selected IC Network - 2

[Table - 4.4, Figure - 4.5] In case of selected IC network 2, from all sessions, synchronised but distributed network of activations were noted in angular gyrus, middle temporal gyrus and precuneus. The areas in the IC have also identified as default-mode network reported in studies as resting-state network [Biswal, B., Zerrin Yetkin, F., Haughton, V. M., & Hyde, J. S. (1995); Raichle, M. E. et al. (2001); Fox, M. D. et al. (2005)]. This network is of particular interest to study for task paradigms as it is shown to decrease in connectivity as task-related attention increases (McKiernan et al., 2003). Individually, the areas of angular gyrus (in association with posterior part of cingulate cortex) has been reported to be

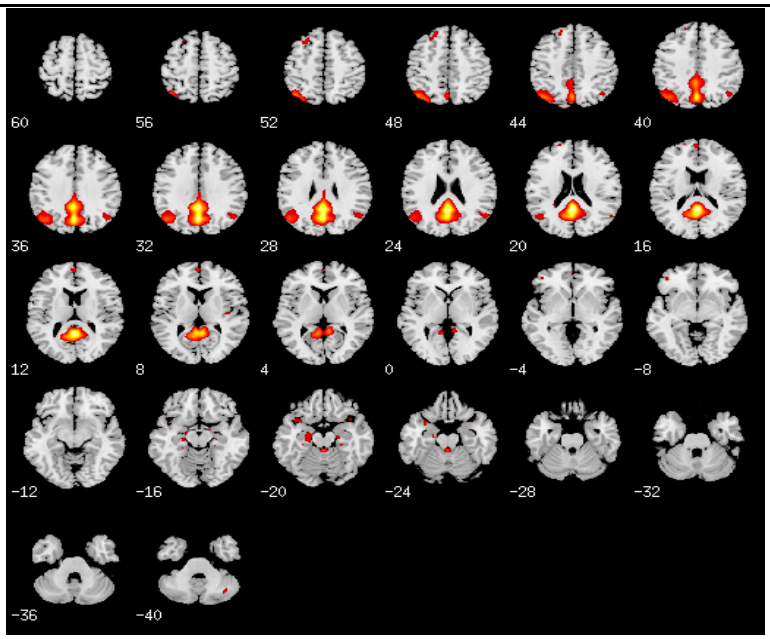
involved in processes related to language including processing semantics out of visually presented inputs (words from the narratives in our case) [Horwitz, B., Rumsey, J. M., & Donohue, B. C. (1998)]. Angular gyrus also plays part in mediating memory retrieval [Seghier, M. L. (2013)]. While the angular gyrus region of brain is researched to be involved with semantic processing of written text, the syntactic understanding of words and getting their meaning has been attributed with involvement of middle temporal gyrus [Acheson, D. J., & Hagoort, P. (2013)]. Precuneus on the other hand has also been identified to play a significant role in accessing self [Kjaer, T. W., Nowak, M., & Lou, H. C. (2002); Lou, H. C. et al. (2004)].

Table 4.4: Independent component analysis results for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-2. The session column also indicates the FWE threshold applied over activations belonging to that session. The Hemispherical side of the brain, Region of brain, voxel cluster size, MNI *x, y, z* coordinates, peak activation and Z values showing activation in the areas that form part of the empathy networks.

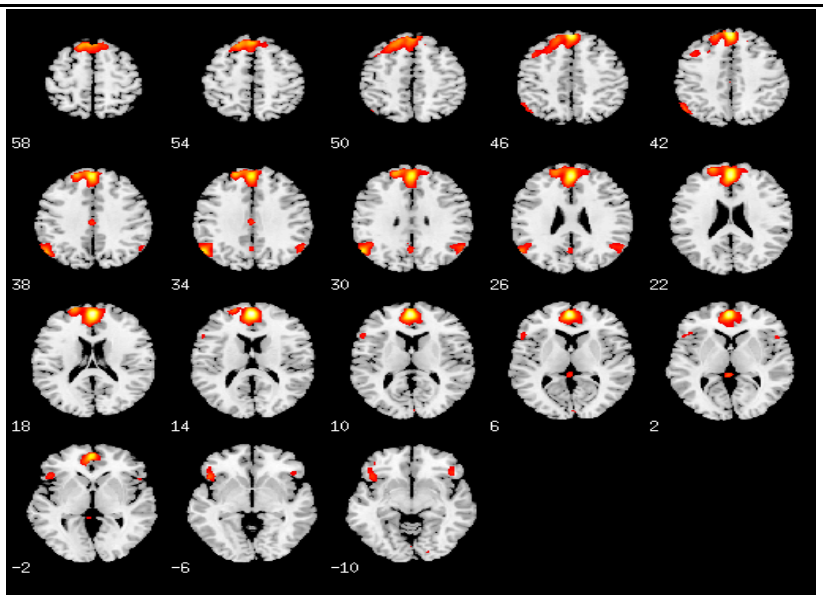
Session (applied correction)	***Hemisphere***	***Region***	***cluster K***	**Peak T**	***Z score***	***x y z {mm}***
Bar Dancer (FWE-0.05)						
	L	PCC	2935	16.98	7.2	0 -50 28
	R	PCC	2935	14.34	6.78	4 -46 22
	L	Precuneus	2935	14.19	6.75	-4 -66 30
	L	Angular Gyrus	454	11.66	6.25	-42 -64 34
	R	Angular Gyrus	61	8.58	5.42	50 -64 36
	L	Middle Temporal Gyrus	454	10.16	5.88	-48 -58 28
	R	Middle Temporal Gyrus	61	8.76	5.48	46 -58 24

	R	Fusiform Gyrus	10	8.71	5.46	32 -32 -14
Teacher (FWE-0.05)						
	R	Superior Medial Gyrus	3570	18.5	7.4	6 60 22
	L	Superior Medial Gyrus	3570	17.02	7.2	-4 54 18
	L	ACC	3570	18.16	7.36	-4 48 8
	R	ACC	12	8.71	5.47	6 34 30
	L	Angular Gyrus	177	12.88	6.5	-56 -62 30
	R	Angular Gyrus	117	8.81	5.49	56 -62 32
	L	Inferior Parietal Lobule	177	8.31	5.34	-54 -60 42
	L	Middle Temporal Gyrus	177	8.21	5.3	-50 -52 28
	R	Middle Temporal Gyrus	117	10.02	5.84	46 -58 24
	R	SupraMarginal Gyrus	117	10.79	6.04	62 -54 32
	L	Middle Frontal Gyrus	33	10.26	5.91	-40 24 42
	R	IFG (p. Orbitalis)	63	11	6.09	44 32 -12
	L	IFG (p. Orbitalis)	51	9.31	5.64	-40 24 -10
No Profile (FWE-0.05)						
	R	Precuneus	1440	24.23	Inf	8 -54 26
	R	Precuneus	1440	19.04	7.47	4 -66 34
	L	Precuneus	1440	15.43	6.96	-6 -58 34
	L	Superior Medial Gyrus	2414	19.14	7.49	-2 60 14
	L	Angular Gyrus	601	14.37	6.78	-48 -68 40

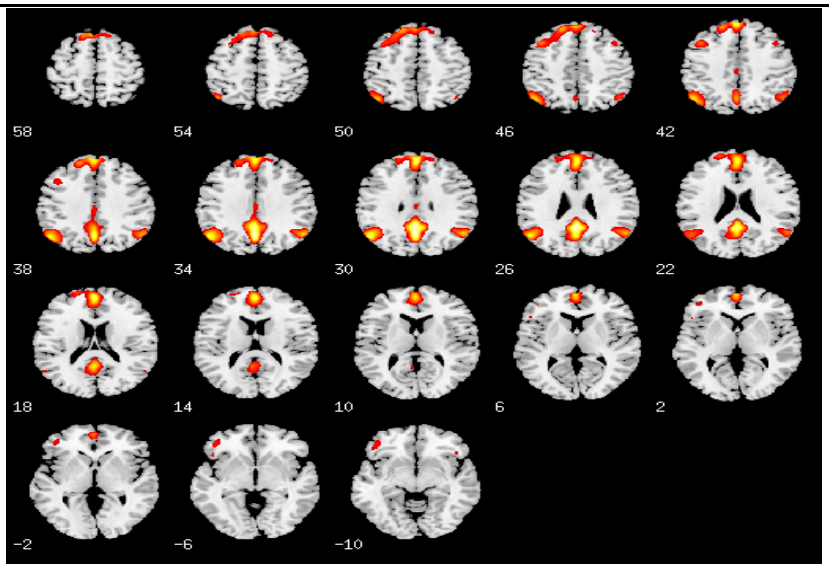
	R	Angular Gyrus	342	13.86	6.69	56 -60 34
	L	Middle Temporal Gyrus	601	16.08	7.06	-50 -66 28
	R	Middle Temporal Gyrus	342	12.42	6.41	50 -60 26
	L	Middle Frontal Gyrus	47	8.5	5.4	-40 18 46
	R	Superior Frontal Gyrus	14	9.1	5.58	20 40 50
	R	Cerebelum (Crus 1)	26	8.92	5.53	28 -76 -32
	L	Cerebelum (Crus 2)	17	8.71	5.46	-22 -84 -40
General Empathy (FWE-0.05)						
	L	PCC	2412	19.2	7.49	-2 -44 34
	R	PCC	2412	16.16	7.08	10 -52 28
	R	Superior Temporal Gyrus	723	11.65	6.24	54 -62 28
	L	Middle Temporal Gyrus	1024	13.71	6.67	-48 -56 28
	L	SupraMarginal Gyrus	1024	13.63	6.65	-52 -52 34
	R	Angular Gyrus	723	12.02	6.33	52 -64 36
	L	Superior Medial Gyrus	16	10.79	6.04	-6 52 42
	R	Superior Medial Gyrus	350	9.23	5.62	6 52 18
	L	Middle Frontal Gyrus	35	10.56	5.98	-24 28 50
	R	Superior Frontal Gyrus	11	8.13	5.28	14 42 44



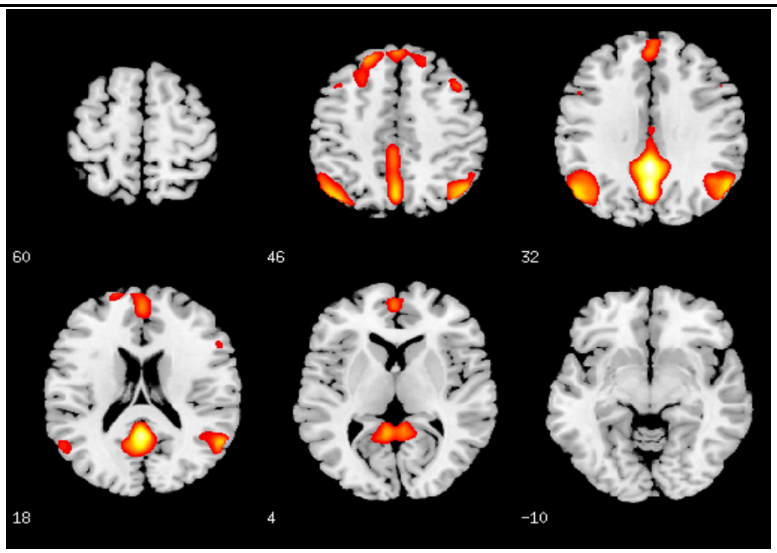
Bar Dancer



Teacher



No Profile



General Empathy

Figure 4.5: Activation maps for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-2 for when the participants read the narratives

inside the fMRI scanner. The areas and other details have been listed in Table 4.4 and have also been discussed in detail in the following text (Ref: Selected IC Network - 2). Primarily, activations (in areas belonging to selected IC network-2) were noted in Precuneus, Angular gyrus, Superior medial gyrus and PCC.

Selected IC Network - 3

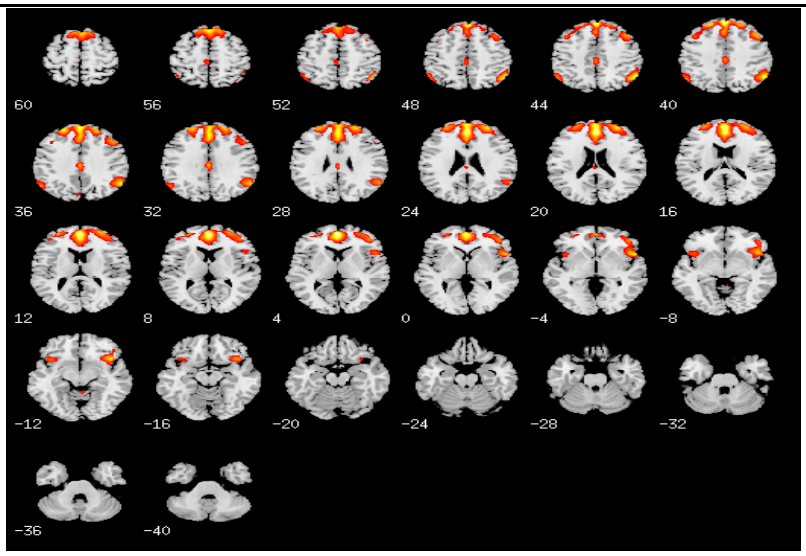
[Table - 4.5, Figure – 4.6] It can be seen from selected IC network 3 from all the sessions that the areas showing predominant activations were superior and inferior frontal gyri with small clusters in anterior and middle parts of the cingulate cortex. In literature, one of the many reported functions of frontal lobe covering the middle/superior frontal gyrus, IFG and ACC is in cognitive processing and perspective taking of feelings of others pertaining also supporting cognitive empathy [Bernhardt, B. C., & Singer, T. (2012); Cochin, S., Barthelemy, C., Roux, S., & Martineau, J. (1999)]. From our previous discussion on Pain Matrix (Ref: Chapter-1) we know that the frontal cortex and cingulate cortex have been crucial in empathizing to the pain of others. Simultaneously, a network of activations were observed in areas belonging to inferior parietal lobule, supramarginal gyrus, superior medial gyrus with little activations in angular gyrus, all being reported to be crucial for modulating cognitive empathy network.

Table 4.5: Independent component analysis results for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-3. The session column also indicates the FWE threshold applied over activations belonging to that session. The Hemispherical side of the brain, Region of brain, voxel cluster size, MNI *x,y,z* coordinates, peak activation and Z values showing activation in the areas that form part of the empathy networks.

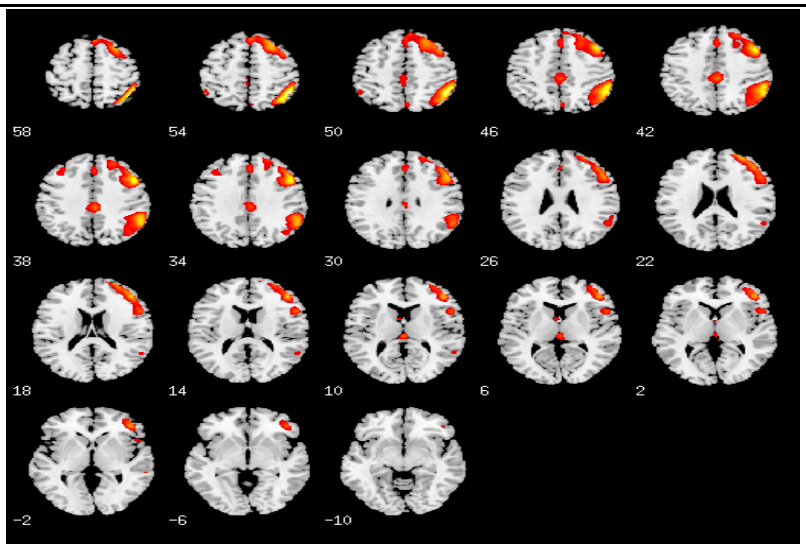
Session (applied correction)	***Hemisphere***	***Region***	***cluster K***	**Peak T**	***Z score***	***x y z {mm}***
Bar Dancer (FWE-0.05)						

	R	ACC	5860	19.81	7.57	2 46 18
	L	MCC	52	11.05	6.11	0 -24 44
	L	Superior Medial Gyrus	5860	18.85	7.45	-6 48 16
	L	Superior Frontal Gyrus	5860	18.34	7.38	-18 46 38
	R	SupraMarginal Gyrus	530	16.5	7.13	62 -54 30
	L	Angular Gyrus	119	12.58	6.44	-54 -62 34
	R	Angular Gyrus	530	12.82	6.49	54 -58 30
	R	Middle Temporal Gyrus	13	10.05	5.85	60 -22 -4
	L	Inferior Parietal Lobule	119	9.33	5.65	-54 -60 46
	L	Cerebellum (VII)	15	10.55	5.98	-40 -58 -40
	L	Middle Frontal Gyrus	45	10.5	5.97	-38 32 40
	L	IFG (p. Orbitalis)	11	10.19	5.89	-38 14 -8
	R	IFG (p. Triangularis)	12	10.1	5.86	58 18 6
Teacher (FWE-0.05)						
	R	SupraMarginal Gyrus	911	17.46	7.27	52 -42 42
	R	Angular Gyrus	911	12.96	6.52	40 -54 42
	R	Superior Frontal Gyrus	240	9.58	5.72	24 16 58
	L	Middle Frontal Gyrus	31	8.53	5.41	-36 32 36
	R	Middle Frontal Gyrus	96	14.75	6.85	22 40 34
	R	IFG (p. Triangularis)	510	12.98	6.53	42 22 32

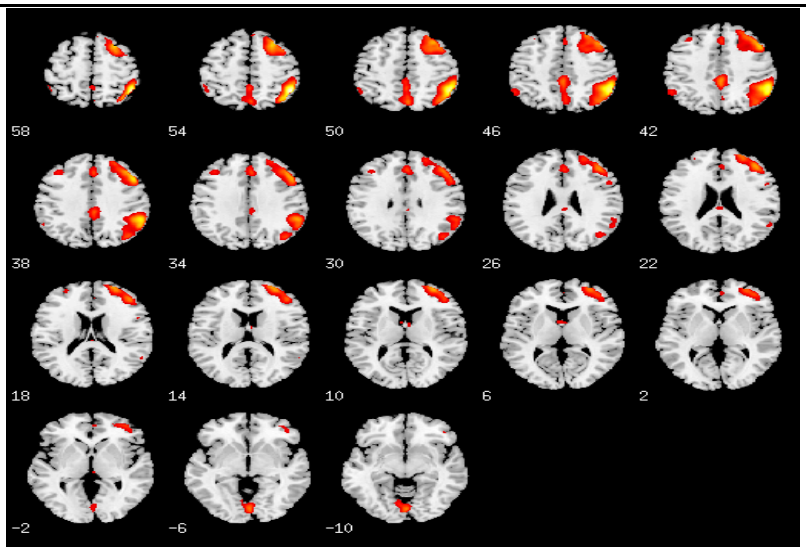
	R	IFG (p. Opercularis)	240	12.7	6.47	46 14 44
	R	MCC	102	9.98	5.83	4 34 40
	L	Superior Medial Gyrus	102	7.69	5.12	2 40 28
	L	Cerebellum (Crus 2)	14	9.46	5.69	-34 -68 -38
No Profile (FWE-0.05)						
	R	SupraMarginal Gyrus	1558	18.84	7.45	56 -38 46
	R	Inferior Parietal Lobule	1558	14.8	6.86	52 -42 54
	R	Superior Frontal Gyrus	197	10.06	5.85	26 20 56
	R	IFG (p. Triangularis)	1042	14.04	6.73	46 26 34
	R	Middle Frontal Gyrus	1042	11.66	6.25	38 36 30
	R	MCC	116	11.87	6.29	6 -30 44
	L	ACC	113	11.58	6.23	2 38 30
	L	Cerebellum (VII)	18	7.84	5.18	-40 -58 -40
	L	Cerebellum (Crus 1)	142	9.83	5.79	-18 -74 -28
	L	Cerebellum (Crus 2)	142	9.67	5.75	-28 -74 -32
General Empathy (FWE-0.05)						
	L	IFG (p. Opercularis)	439	12.32	6.39	-46 4 32
	L	IFG (p. Triangularis)	439	10.54	5.98	-54 18 28
	L	Precentral Gyrus	16	8.59	5.43	-42 2 56
	L	Middle Temporal Gyrus	19	9.79	5.78	-58 -16 -8



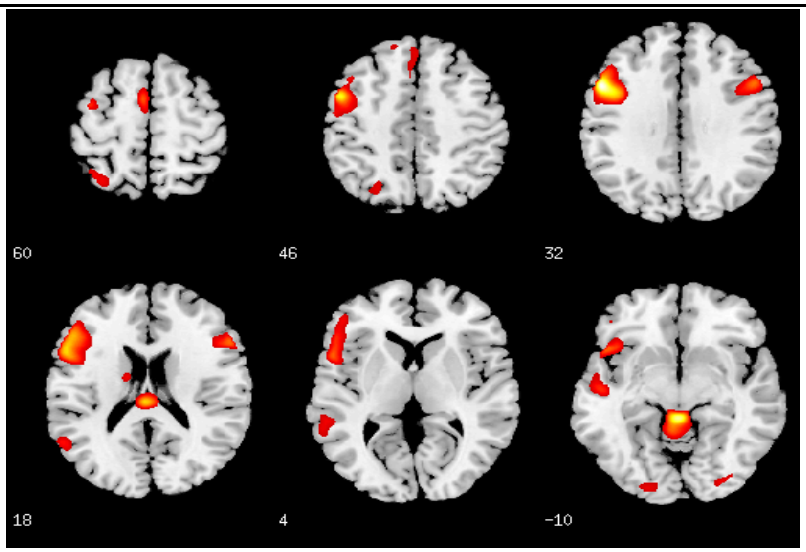
Bar Dancer



Teacher



No Profile



General Empathy

Figure 4.6: Activation maps for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-3 for when the participants read the narratives inside the fMRI scanner. The areas and other details have been listed in Table 4.5 and

have also been discussed in detail in the following text (Ref: Selected IC Network - 3). Primarily, activations (in areas belonging to selected IC network-3) were noted in Superior and Inferior frontal gyri with small clusters in Anterior and Middle parts of the cingulate cortex.

Selected IC Network - 4

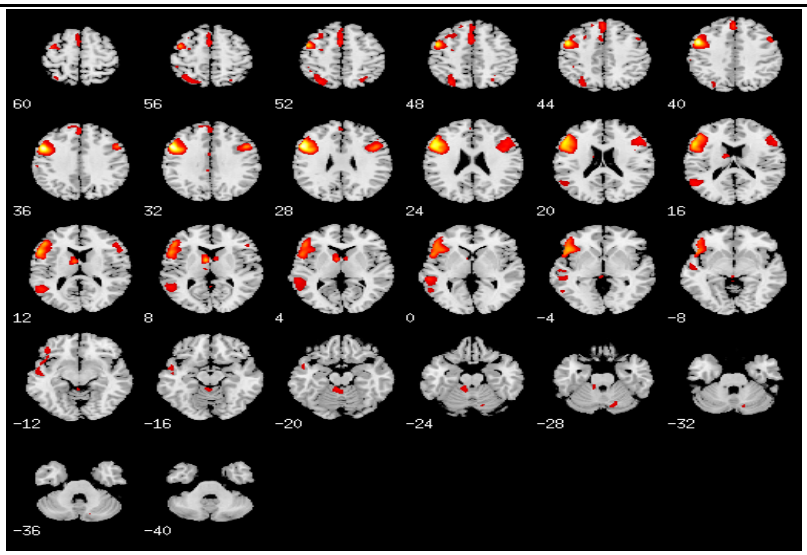
[Table – 4.6, Figure – 4.7] Simultaneous activations in a rather spatially distributed set of areas were observed in the selected IC network 4. It can be seen from all the sessions that the areas showing predominant activations were inferior frontal gyrus and posterior-medial frontal with small clusters in middle frontal gyrus and superior frontal gyrus. In literature, superior frontal gyrus and inferior frontal gyrus have been identified as areas pertaining to cognitive empathy network while the network of areas covering inferior frontal gyrus and posterior-medial frontal have been a crucial part of motor empathy network. The activity in superior medial gyrus have been observed. In literature, activity in superior medial gyrus along with anterior part of cingulate cortex have been reported to play an important role in mediating human empathy [Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005); Singer et al. (2004)]. These areas have been identified to be involved in cognitive empathy networks [Shamay-Tsoory, S. G., Aharon-Peretz, J., & Perry, D. (2009)]. Activations in the inferior parietal cortex have been noted that is one of the key neural substrates involved in the “mirroring” of emotional expressions. This also include motor-related cortex, such as the precentral gyrus and inferior frontal gyrus (IFG) [Carr et al., 2003; Pfeifer et al., 2008] and somatosensory-related cortex (SRC), such as the postcentral gyrus and the supramarginal gyrus in the inferior parietal lobe [Adolphs et al., 2000; Gazzola et al., 2006].

Table 4.6: Independent component analysis results for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-3. The session column also indicates the FWE threshold applied over activations belonging to that session. The Hemispherical side of the brain, Region of brain, voxel cluster size, MNI *x, y, z* coordinates, peak activation and Z values showing activation in the areas that form part of the empathy networks.

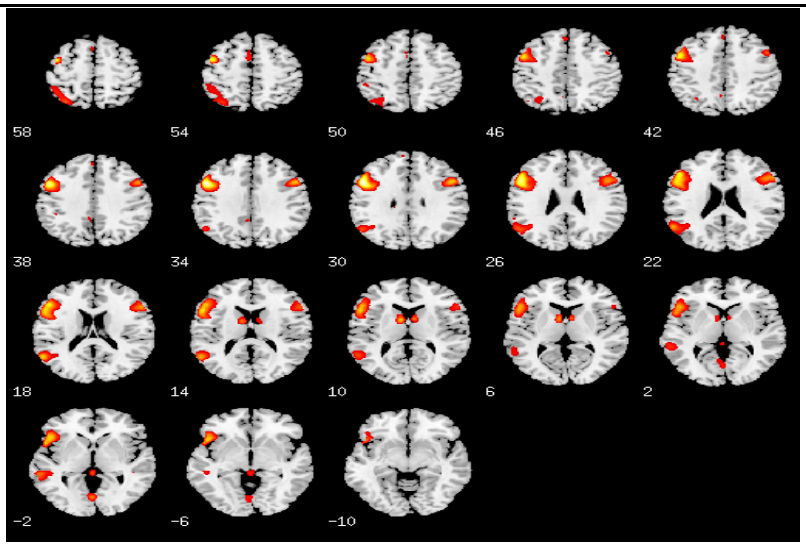
Session (applied correction)	***Hemisphere***	***Region***	***cluster K***	**Peak T**	***Z score***	***x y z {mm}***
Bar (FWE-0.05)						
	L	IFG (p. Triangularis)	1768	12.88	6.5	-52 26 16
	L	IFG (p. Orbitalis)	1768	12.23	6.37	-44 30 -6
	R	IFG (p. Triangularis)	103	9.34	5.66	48 14 26
	L	Posterior-Medial Frontal	125	11.81	6.28	-4 12 50
	L	Superior Medial Gyrus	125	10.04	5.85	-2 30 50
	L	Middle Temporal Gyrus	79	11.27	6.16	-54 -38 0
	L	Inferior Parietal Lobule	19	9.29	5.64	-38 -50 52
	L	Superior Parietal Lobule	12	8.6	5.43	-26 -68 54
Teacher (FWE-0.05)						
	L	IFG (p. Triangularis)	937	13.58	6.64	-54 16 18
	R	IFG (p. Triangularis)	11	8.9	5.52	60 26 14
	R	IFG (p. Opercularis)	11	8.63	5.44	46 16 22

	L	Superior Parietal Lobule	17	10.2	5.89	-28 -72 54
	L	Middle Temporal Gyrus	124	9.87	5.8	-54 -58 12
	L	Precentral Gyrus	18	8.63	5.44	-42 2 56
	L	Cerebellum (VII)	16	8.41	5.37	-18 -76 -36
	R	Cerebellum (Crus 1)	13	9.57	5.72	28 -72 -32
No Profile (FWE-0.05)						
	L	IFG (p. Triangularis)	1691	17.36	7.25	-50 16 28
	L	IFG (p. Opercularis)	1691	15.06	6.9	-38 14 26
	R	IFG (p. Triangularis)	162	12.98	6.53	46 10 28
	L	Posterior-Medial Frontal	268	13.61	6.65	0 20 58
	L	Superior Medial Gyrus	268	9.57	5.72	0 40 48
	L	Middle Frontal Gyrus	20	8.22	5.31	-24 22 54
	L	Superior Parietal Lobule	41	12.38	6.4	-26 -68 52
	L	Middle Temporal Gyrus	89	11.44	6.2	-56 -58 18
	R	Cerebellum (Crus 2)	15	8.4	5.37	12 -78 -30
General Empathy (FWE-0.05)						
	R	Insula Lobe	1577	19.07	7.48	40 14 -2
	L	Insula Lobe	885	12.77	6.48	-38 16 2
	L	ACC	1646	17.78	7.31	0 28 26
	R	ACC	1646	17.21	7.23	6 32 32
	L	Superior Medial Gyrus	1646	15.6	6.99	-2 30 42
	R	Middle Frontal Gyrus	605	16.56	7.14	30 46 18

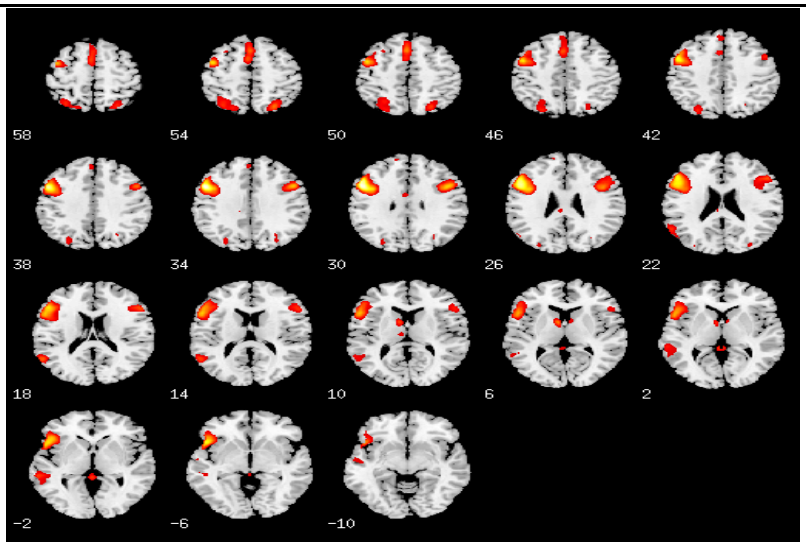
	L	Middle Frontal Gyrus	537	13.49	6.62	-28 46 28
	R	IFG (p. Orbitalis)	1577	15.69	7	38 26 -8
	L	IFG (p. Orbitalis)	24	10.45	5.96	-46 42 0
	R	Superior Frontal Gyrus	13	8.86	5.51	14 16 58
	R	Precuneus	18	8.4	5.36	12 -72 48
	R	Cerebellum (Crus 2)	33	7.97	5.22	42 -58 -34
	R	SupraMarginal Gyrus	151	9.84	5.8	62 -32 34
	R	Superior Temporal Gyrus	151	9.61	5.73	56 -34 26
	L	Temporal Pole	885	14.21	6.76	-44 12 -10



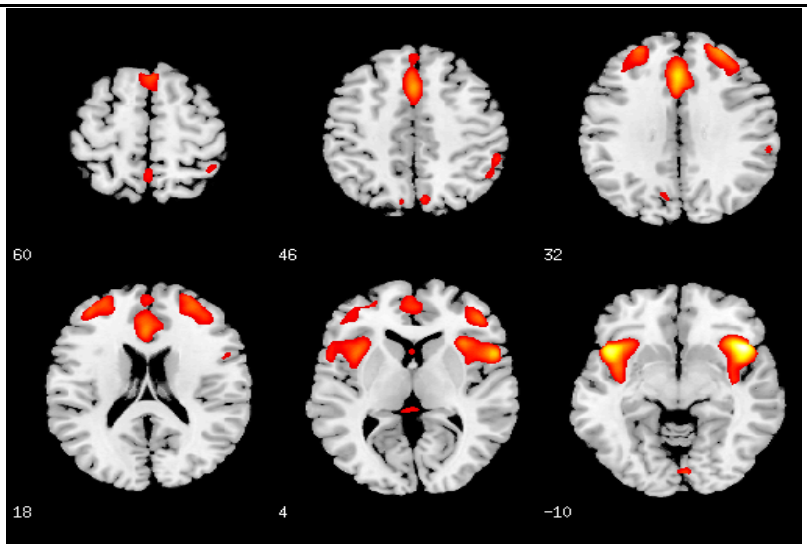
Bar Dancer



Teacher



No Profile



General Empathy

Figure 4.7: Activation maps for all the 4 sessions (Bar Dancer, Teacher, No Profile, General Empathy) for selected IC network-4 for when the participants read the narratives inside the fMRI scanner. The areas and other details have been listed in Table 4.6 and have also been discussed in detail in the following text (Ref: Selected IC Network - 4). Primarily, distributed and sparse network of activations were noted in areas belonging to Frontal as well as Parietal cortices.

4.2.2.2 Comparative Analysis Results

The whole-brain contrasts corresponding to second-level analysis (a > b; a, b are sessions) were also prepared. The activations corresponding to these contrasts were thresholded using FWE and FDR corrections but none of the activations crossed the barrier.

4.2.3 Post Experiment Survey Results

4.2.3.1 Davis IRI empathy Index and RMA survey results

The updated Illinois rape myth acceptance questionnaire was considered. The internal consistency for the current study data was good (Cronbach's α = 0.80). Higher RMA values implies rejection of the rape myths. Since each subscale of RMA had different number of questions, the total score per subscale per participant was not balanced (max score of 30 for subscales with 6 questions and max score of 25 for subscales with 5 questions) hence the scores from each subscale were normalised to a score of 10. Interestingly, box plots for sub-scales of RMA are shorter compared to sub-scales of IRI index. Also, we can see the box-plot for PD subscale of IRI index is the largest.

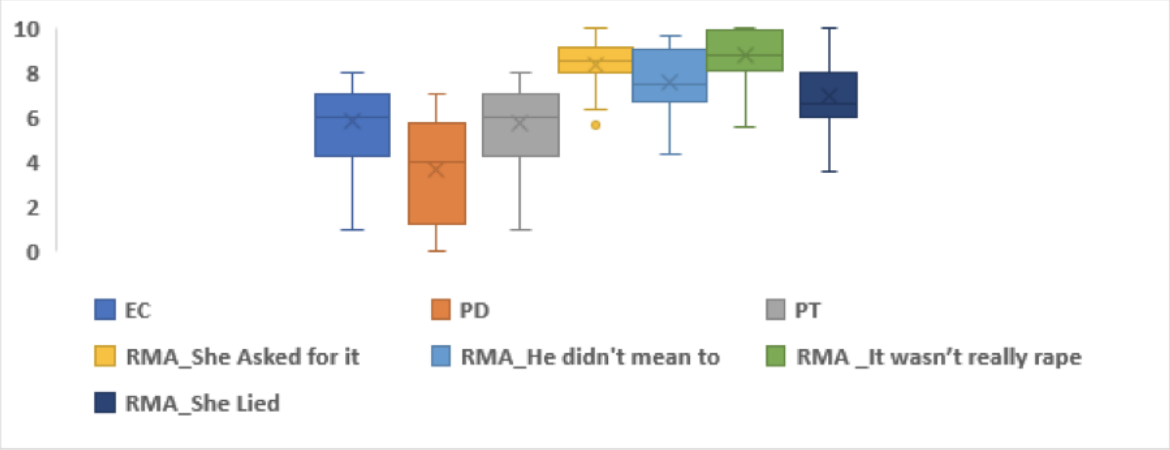


Figure 4.8: Box-plot for average scores of all selected sub-scales of RMA and IRI indices.

The average for the subscale *she-lied* was lower and hence marginally more accepted followed by *he-didn't-mean-to* subscale (compared to *it-wasn't-really-rape* and *she-asked-for-it* subscales) [Figure – 4.8]. In the correlation analysis [Table – 4.8], it is interesting to notice +ve correlation value for Bar Dancer/*RMA_she-lied* and *RMA_she-asked-for-it* across all the narratives. If we analyse these independently, and only the *RMA_she-asked-for-it*, the more they reject the myth (as the higher average scores indicate) the emotional response factors also increase across all the narratives, with Bar Dancer being higher than Teacher followed by No Profile. But, of relevance is the correlation between

the IRI indexes and the RMA. In principle, higher EC and PT means greater rejection of RMA (higher scores) but most of the correlations are low and near zero, except for the PD index and the *RMA_she-asked-for-it* subscale. This is interesting because the average PD score was lower than EC and PT. The scores from the IRI index clearly indicates higher EC and PT, but lower PD, the RMA scores show rejection of the rape myths except a slightly lower rejection for the subscale *she-lied* and the emotional response is nearly the same for all the three narratives. The correlation estimates are ambiguous at certain cells leading us to theorise that it might be because participants wanted to be socially acceptable when answering the questionnaires.

4.2.3.2 Narrative Based Survey Results

Participants gave rating on a scale of 1-5 for pity, compassion, sympathy and empathy post-scanning as they re-read the three rape narratives. Since the aim of the experiment was to compare differences in emotional responses towards the pain of others with respect to the profession they represent the general empathy narrative wasn't considered for this survey. The ratings for the four responses did not show significant within-narrative difference.

Table 4.7: Mean scores for all 4 scales, including, pity, compassion, sympathy and empathy for all the narratives.

	Bar Dancer		**No Profile**		**Teacher**	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Pity	4.15	0.67	4.25	0.55	4.25	0.71
Compassion	4.3	0.92	4.3	0.86	4.2	1.19
Sympathy	4.3	0.92	4.2	0.76	4.3	0.8

Empathy	4.05	0.88	4.15	0.78	4.15	0.96

Interestingly, the mean rating for each response across all the narratives was nearly the same, with mean value for empathy slightly less than pity, sympathy and compassion (empathy = 4.08; pity = 4.21; sympathy = compassion = 4.26).

A pair-wise cross Pearson correlation shows the Bar Dancer and Teacher ratings having lower correlation values or partial dissociation while No Profile and Bar Dancer/Teacher had higher correlation.

Table 4.8: Cross correlation scores for all 4 scales combined (including, pity, compassion, sympathy and empathy) for each of the narratives, individual sub-scales of RMA and sub-scales of IRI index.

	Bar Dancer	***Teacher***	***No Profile***	***RMA_she-lied***	***RMA_It-wasn't-really-rape***	***RMA_he-didn't-mean-to***	***RMA_she-asked-for-it***	***EC***	***PD***	***PT***
Bar Dancer	1									
Teacher	0.724458	1								
No Profile	0.880959	0.82879	1							
RMA_she-lied	0.174615	0.02286	0.007729	1						
RMA _It-wasn't-really-rape	0.055731	-0.08378	-0.08721	0.680771	1					
RMA_he-didn't-mean-to	0.025301	0.156762	-0.07535	0.493533	0.548451	1				
RMA_she-asked-for-it	0.365454	0.239774	0.146089	0.502883	0.592257	0.437256	1			
EC	-0.24428	-0.2001	-0.21604	0.012144	-0.18294	-0.09677	-0.00165	1		
PD	0.219787	0.148093	0.240413	-0.05279	0.102346	-0.17087	0.388322	-0.12125	1	

PT	-0.16408	-0.0401	-0.21902	0.083549	-0.06142	0.124278	0.137213	0.499995	-0.40856	1

From Table – 4.8, first and foremost we notice comparatively lower inter-scale correlation values. However, the correlations estimate of Rape Myth Acceptance scores and the empathy, sympathy, pity, compassion combined scores show positive and slightly higher correlation values for Bar Dancer for the *RMA_she-lied*/ *RMA_she-asked-for-it*/ *RMA_it-wasn't-really-rape* categories compared to the corresponding values for Teacher and No Profile. Interestingly, for No Profile, the values were the least for the 4 RMA categories. In case of No Profile, an observation of negative correlation values was made for two of the sub-scales of RMA (including *RMA_it-wasn't-really-rape* and *RMA_he-didn't-mean-to*). Interestingly, EC and PT subscales of empathy showed negative correlation with all the three profiles. In case of PD subscale, the values were observed to lie towards the positive side of the scale and interestingly the correlation score for the Teacher profession was observed to be slightly lower compared to the other two.

4.3 Discussion

Empathy, being critical for prosocial behaviour and social interactions among individuals, has been researched (and is still an ongoing topic of interest to many) in detail and is established to be modulated by many factors. The aim of the first of its kind study was to probe into neural networks associated with rape victim empathy and investigate its modulation with the knowledge of profession of victim. The two pre-fMRI study surveys (Chapter-3), established that respect is a function of the profession and that there is difference in the empathic responses to rape victim narratives again as a function of profession. We started off this study with the hypothesis that the knowledge of profession does affect the empathic responses of individuals towards rape victims. We hypothesized that the lower the respect accorded to the profession, the lower will be the empathy for the victim who chose to pursue their respective profession as a career. First person narration of fictional rape incidents were presented to people to achieve this. The recorded fMRI data was analyzed using general linear model (in SPM) and independent component analysis (in GIFT) approaches and some very interesting observations were made.

To get task related significant brain activity, the activations from the GLM and ICA methods were subjected to stringent thresholds (FDR & FWE) to remove Type-I errors (false positives) though signal strength was compromised. The first level analysis in SPM revealed significant activations in areas investigated to be part of the empathy network (emotional and cognitive). Clusters of voxels showing activities in the middle (superior in the case of the Bar Dancer) prefrontal area were noted. These activations along with activations in areas from the cingulate cortex (anterior and middle) confirmed the activation of cognitive empathy network. Simultaneous but distributed activations in the insular region (except for the case of No Profile at the respective harsh threshold applied for this session) and rolandic operculum along with ACC/MCC confirmed the activation of emotional empathy network. We noticed that for Bar Dancer, Teacher and even General Empathy insula was observed whereas for No Profile it was not. A possible reason for this could be that by providing information about the victim, like, profession - about the victim, a certain bonding is established irrespective of the profession. So a social status modulates empathy. It is an interesting observation that while a profession with lower social respect would evoke less empathic response, absence of information also shows similar activation, a finding which requires further exploration. Another very interesting observation made from first level results was of brain activity from Bar Dancer session being of lower signal strength and not showing activations for a more stringent thresholds ($p < 0.01$) compared to other sessions (indicating lower signal strength for narrative with Bar Dancer session compared to other narratives), thereby, maybe confirming the hypothesis made during the start of study that knowledge of profession does affect the intensity of empathic response for the victim. Another interesting observation made from the results was that the activations for the No Profile session survived a harsh threshold ($p < 0.001$).

The uncorrected results from the second level analysis during GLM were very interesting. The activations for contrasts, Bar Dancer > Teacher and Bar Dancer > Gen Empathy, did not survive the applied threshold suggesting Bar Dancer session has comparatively lower strength activation clusters for respective voxels compared to other (Teacher and General Empathy) sessions. This again is a confirmatory result towards the hypothesis for this research. The contrast for No Profile > Bar Dancer showed significant activations in rolandic operculum and cingulate areas of the brain both of which play crucial roles in the emotional empathy network, though the crucial area of insula was not observed. A

possible reason for this can be attributed to the imaginative connection felt by the participants towards the character for No Profile session compared to Bar Dancer session. Also, for contrasts Teacher > Bar Dancer, Teacher > General Empathy, Teacher > No Profile, General Empathy > Bar Dancer, General Empathy > Teacher and General Empathy > No Profile we noticed the activations in areas belonging to cognitive as well as affective components of empathy but in the case of last 3 contrasts (i.e. with General Empathy > 'other' sessions) we observed empathic responses with greater signal strength compared to rape narratives. A possible reason for the later might be that in general people have empathy but this is lowered for a rape victim.

As we know, fMRI data is composed of physiological activity from different sources of fluctuations (task-related neural signal and noise). ICA framework, when applied on this data, results in segregation of these temporally correlated intrinsic networks. Post estimation of these selected networks of neural activity, using the knowledge from the available literature [Griffanti et al. (2017); Kelly Jr et al. (2010)] and after careful visual inspection, 4 networks were selected. A network contrasts comparison between sessions did not yield any differential activation. This constraints us from making any strong inference of the professions influence on empathy response from the ICA data. But, through ICA we observe functional connectivity in areas attributed to empathy performing the task of reading the empathic rape incident narratives.

Through selected IC network 1 of all the sessions we observed predominant activations in insular lobe and anterior and middle parts of cingulate cortex, areas reported to play prominent roles in the affective component of empathy network, areas also reported for the pain of a conspecific. Also, it has been noted that increased activity in these regions has been implicated in response to distasteful stimuli [Kinomura et al. (1994)], perspective taking and have also been known to modulate ethics, emotions and morality [Sevinc, G., Gurvit, H., & Spreng, R. N. (2017); Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006)]. Simultaneously, increased activations in precuneus and rolandic operculum suggest participants might be recalling instances (possibly of similar nature) from their past memories [Fletcher et al. (1995)] and feeling empathy for pain, especially and possibly, towards social exclusion [Novembre, G., Zanon, M., & Silani, G. (2014)], as the victims in the narratives presented report. These results through preliminary and exploring

rape victim empathy using a single factor (of profession/respect), support the motive of this study and set the basic understanding for further studies.

Selected IC network 2 noted the presence of a distributed network of activations in angular gyrus, posterior cingulate cortex extending up to middle temporal gyrus. Activities in this network of areas have been attributed with forming a syntactic representation of words (from the presented narratives) and processing the semantic meaning out of those words [Horwitz, B., Rumsey, J. M., & Donohue, B. C. (1998); Acheson, D. J., & Hagoort, P. (2013)]. This network of activations segregates the physiological activity in the network of areas attributed to language processing (corresponding to the presented stimuli) as compared to emotion processing.

Interestingly, in selected IC network 3, we noticed distributed activity in the network of areas belonging to both cognitive as well as affective components of empathy. Increased activations in superior and inferior frontal gyri have been previously reported to be involved in understanding and reacting to the feelings of others. A network of activations was observed in areas covering the inferior parietal lobule, supramarginal gyrus, superior medial gyrus with small activations in angular gyrus, all being reported to be crucial for modulating cognitive empathy network. Simultaneously, synchronized increase in activity between frontal lobe and cingulate cortex has been implicated to be crucial in empathising to the pain of others pertaining to emotional empathy. Activations observed in this network reiterate the complexity of empathy as a construct with separate but inter-dependence of cognitive and emotional processing.

Finally, in the last selected IC network (network 4), activities in clusters of voxels belonging to parts of prefrontal gyrus (predominantly inferior), posterior-medial frontal, superior medial gyrus were noticed. Activations in the anterior part of the cingulate cortex, parts of temporal gyrus (temporal pole) extending up to precuneus in the parietal lobule were also noticed. This signifies the presence of areas from cognitive empathy network while reading the rape victim narratives. These areas have been investigated for social context identification, memory encoding and retrieval, recalling of episodic memories [Fletcher et al. (1995); Nyberg, L. et al. (1996)], self-processing [Kjaer, T. W., Nowak, M., & Lou, H. C. (2002); Lou, H. C. et al. (2004)] and cognitive processing. The activations in

this network of areas might be due to participants processing the information from the narratives and trying to relate with it keeping a distinction of self vs the other.

The second level analysis from both the toolboxes did not give any significant results as none of the activations were able to pass the threshold. However, the uncorrected results from the GLM method have been reported and discussed briefly in the previous and current sections of this thesis.

From the post experiment survey we observed greater rape myth rejection indicated by the higher mean values for subscales of RMA. The differences of the mean values for RMA scales were observed to be not so significant compared to those for sub-scales of IRI index indicating high level of agreement among the participants regarding rape myths. One of the possibilities for such high scores at the RMA scale could be because of the psychological need of a person to project oneself at ethical/moral high ground and social acceptance Also, the participants were college graduates and hence understood the trauma of a rape victim. Another very interesting observation is from the box plot of PD sub-scale of empathy. It is comparatively the largest in size suggesting sparse data and correspondingly difference among participants. This might be because every person has a different way and intensity of stress one feels for the pain of others. The personal distress one feels varies has high inter-person variability.

The inferences made from analysis of survey data are also a great source of confirmatory correlations between neural activity and behavioral scoring by the participant for the task. The survey ratings data indicate that the participants a) have either not differentiated the four responses of empathy, sympathy, pity and compassion strictly or response to a rape victim is a complex combination of all these responses and b) partial dissociation between the Bar Dancer and Teacher in general, which supports the findings from the profession and respectability ratings (presented in Chapter 3). and c) correlation between rape myth acceptance wherein the blame lies on the victim and the emotional response factors is higher for Bar Dancer than other two professions.

4.4 Conclusion

This experimental study was undertaken with the objective of exploring the influence of the knowledge of social status/standing of a female rape victim on empathy response at the neural activations. An extensive literature review was performed to pre-identify neural correlates of empathy for targeted focus on regions of interest. Also, the collected empathy rating scores provided by participants of undertaken surveys before performing this study confirmed that the text narratives were capable of evoking empathy.

Although a variable threshold was applied, the presented narratives were able to evoke neural activation in the regions of interest (belonging to both cognitive as well as emotional components of empathy) in the brain. The empirical evidence provided by the results of conditional lower signal strength of neural emotion/empathy activation responses to the Bar Dancer session compared to other sessions is the most important finding of the study. This finding is in accordance to our premise for the study and the findings from the initial surveys conducted. Though, the empirical evidence is not strong, we make the conjecture that the high imaginative power of the participants in the No Profile session could have led to relatively higher activation response values compared to other sessions. This could be the result of a subconsciously deep connection felt by the participant towards the imaginary character in the narrative. From the second level analysis we have also observed significant activations for the contrasts General Empathy > Bar Dancer, General Empathy > Teacher and General Empathy > No Profile suggesting the presence of in general empathy in the participants which is subsequently reduced for rape victim crimes, probably an outcome of the social stereotypes/myths/beliefs relating to rape victims.

The application of ICA analysis on the data revealed significant functionally connected empathy supporting areas as a network. The ICA approach grouped the brain activity into regions with temporal coherence but segregated areas attributed to cognitive and emotional sub-components of empathy. Comparison analysis from ICA did not reveal any significant differences between the sessions but these identified networks cross-referenced with literature review will be of great help to us in forming base activity models which can further be applied to compare data from convicted rapists or sexual offenders.

The post-experiment surveys indicated higher rejection of rape myths (as indicated by high RMA scores) as well as high agreement among the participants towards the

rejection. On the IRI scale as well, participants seemed to have high empathy scores. An important observation was the relatively lower average score for PD subscale of empathy compared to the other two indexes, indicating participants experienced higher self-oriented feelings while being unable to make the self-other distinction. The sparse data distribution for PD subscale of empathy indicated differential self-oriented feelings experienced by the participants.

In conclusion, the results provide the basic networks of empathy in response to rape incident narratives and the differential activation modulated by information about the profession pursued by the victim. The findings have great social implications, as these biases lead to victims not having access to an unbiased judicial system and societal support – a core requirement for recovery from the trauma. Via these results we have come one step closer to identifying deeper representations of social biases and beliefs at the neural correlates level as a function of the profession opted by women and what causes differential victim empathy responses.

Chapter- 5

Conclusion

Lucas, B. J., & Kteily, N. S. (2018) performed a survey to explore the relationship between group-based egalitarianism and perceived empathy for members of different groups (based on the target's socio-economic position in society) subjected to harmful situations. They found that a person's high- or low-ranking position in society has a huge impact on the level of empathy egalitarians and anti-egalitarians express towards them. Social stereotypes, cultural and moral myth beliefs that exist in society are major contributors of ignorance surrounding the reality of sexual violence and its devastating effects. These types of myths cause real harm and have to be constantly questioned to bring real change at a fundamental socio-cultural level.

The present study focused primarily on providing two major contributions. First, by confirming and establishing the existence of social biases and myth beliefs among individuals of society towards different career options opted by women. This was further extended to explore the differential empathic responses towards the perceived pain of women, belonging to different professions and social standing in society, who faced sexual assault. Second, we prepared an experimental paradigm to explore the underlying neural bases for observed difference in perceived empathic responses towards the pain of character in the narratives. Towards these, a set of questionnaires were prepared and presented to participants to analyse the indoctrinated behavioural notions and beliefs among individuals and a functional magnetic resonance imaging (fMRI) experiment was conducted using text narratives describing the first hand experience of female victims of the incident and its post-traumatic effects.

Through this research we aimed at increasing awareness among everybody towards the existing negative norms and beliefs which degrades the reality of traumatic incident like rape, through victim-blaming, and its after effects on the victim’s mental health. We wished to establish a neural basis representative of differential empathic responses given the knowledge of different career paths/socio-economic standing of the victim. We hoped to

use this representative network as a base model for evaluating people showing aberrant behaviour and pre-profiling them for potential criminal behaviour.

In **Chapter-3**, this study found the existence of social bias, associated with professions considered less respectable according to stereotypic society norms, both through significant variations in self-reported empathy levels of participants towards an alleged rape victim and the empirical evidence provided by the results of fMRI study undertaken (in **Chapter-4**). From the survey on respect accorded to professions opted by women, we found that people believe teacher and doctor professions to be more esteemed compared to professions like secretary and bar manager. Now, how does respect for any profession in other people's minds can harm someone? A belief like this and many others shape people's perception about a person's (who has opted such profession as a career option) character in general disregarding all the hard effort each person is putting in the profession or the trauma one is going through. As observed through reported differential empathy scores, the myth beliefs clouds the observer's judgement and they make biased/different opinions about the same reported crimes by two different women belonging to different professions. We observed participants to have relatively lower other-oriented empathy scores compared to self-oriented empathy scores. Further, our study confirms the previously reported display of relatively lower empathy response by police personnel compared to the general civilian population probably as part of a mechanism to protect self from personal distress to make better unbiased judgments.

Through this thesis we tried to explore whether the propagation of these myths affects only the behaviour of the participant or has any neural representation in the brain as well. Researching this complex rape victim empathy requires a lot of different combinations of situations which is not possible for any single study to cover. With a particular focus on the use of one of the rape myths (respect accorded to different professions opted by women as career option) in narratives about sexual violence we prepared a fMRI study with the hope of finding a representational neural bases for how this myth affects participants empathy towards the victims.

In **Chapter-4** of this study, through a combination of GLM and ICA approaches we were able to extract out functionally connected brain regions with similar activity patterns giving us the neural network of areas involved with sub-component of empathy responses.

Further, we observed differential activations corresponding to different professions used in the narratives. The narrative with ‘Bar’ session showed relatively lower activation responses compared to other narratives whereas the one with ‘No profile’ showed relatively the highest. Another interesting thing to notice was the presence of in-general empathy in the participants which got relatively lowered for rape narratives. These results are of great help in deducing the existence of social biases deep inside our brain affecting the victim empathy responses.

Through this study, we provide the confirmation for propagation of myth believes within the society and prepared a foundation with base neural activations in the networks attributed to cognitive as well as emotional components of empathy (in general civilians of society) which can be compared with data from convicted rapists to identify the causes for their abrupt behaviour and prepare counter-measures to deal with them.

5.1 Limitations

Due to availability of limited financial resources we were only able to perform this study with a small and similar (tight age range) set of participants. Since majority of women rape crimes are commited by men we limited ourselves to involve only male participants who were also not culturally much diverse. Another limitation to our study was experimental control. Text narratives are proven to be very immersive but we had no control on the imaginative power of the participants during the experiment.

5.2 Future scope and studies

The findings from this study, to the best of our knowledge the first of its kind in the country, have confirmed our hypothesis about the existence of social biases and myth beliefs in the general population (non-convicts) concerning women belonging to different professions. Another team of ours have started looking (in parallel to this study) into how attributes like skin color, traditionality and place of residence effect the empathy responses towards purported rape victims. The purpose of these studies was to identify and establish the

influence of different factors on social perceptions eventually influencing rape victim empathy.

In future, an extensive and systematic research needs to be conducted on sexual offenders and rape convicts. Using above research as foundation one can compare results to build neural models as well as behavioural paradigms on how these perpetrators are different from the general population. This research can help generate models to prepare profiles for people showing sexually violent or any possible abnormal behaviour. Another effort can be made to perform research with a more diverse set of participants belonging to different gender or wider age ranges to gather more statistically conclusive results.

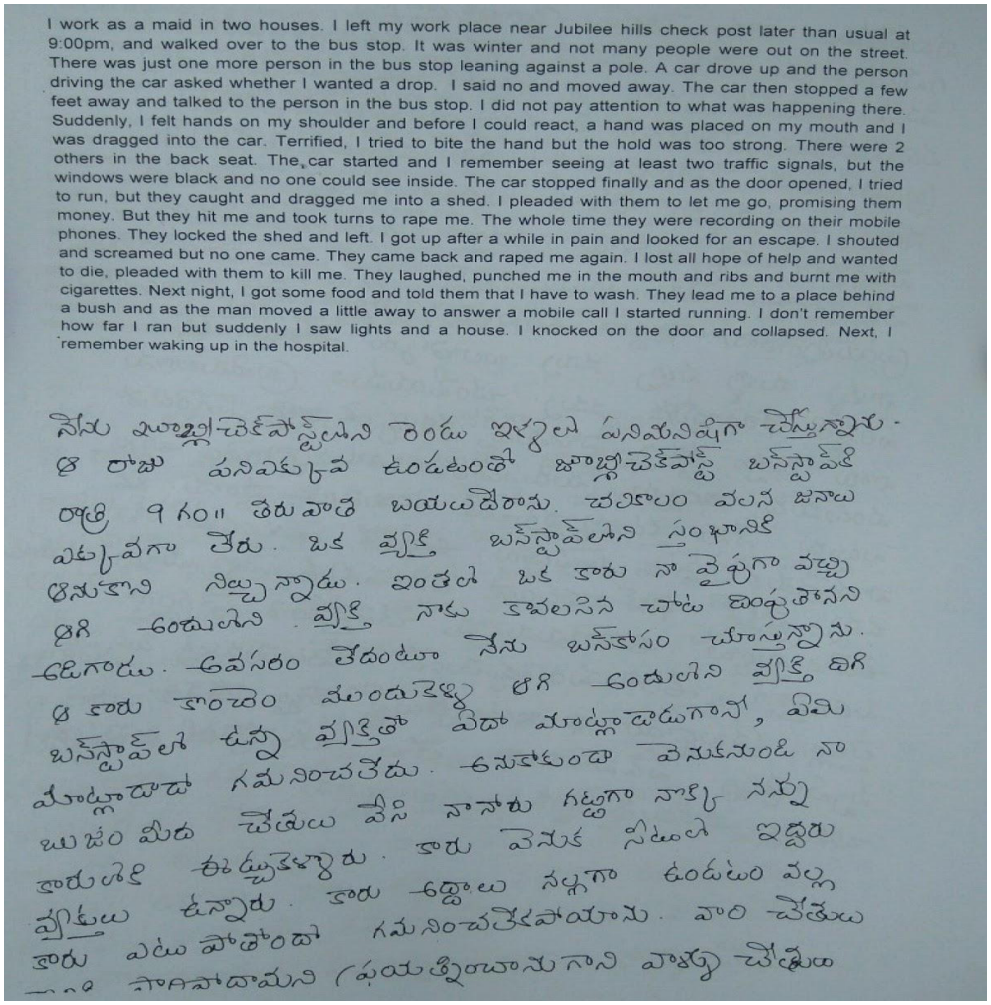
5.3 Related Publications

- Working Journal: Goel M., Sharma N., Vemuri K.(2020). " Empathy-related response towards professions of female rape victims - An fMRI study".
- Sharma N., Goel M., Vemuri K.(2018). " Empathy-related response towards faces of female rape victims - An fMRI study". Organization for Human Brain Mapping (OHBM-18).

Appendix

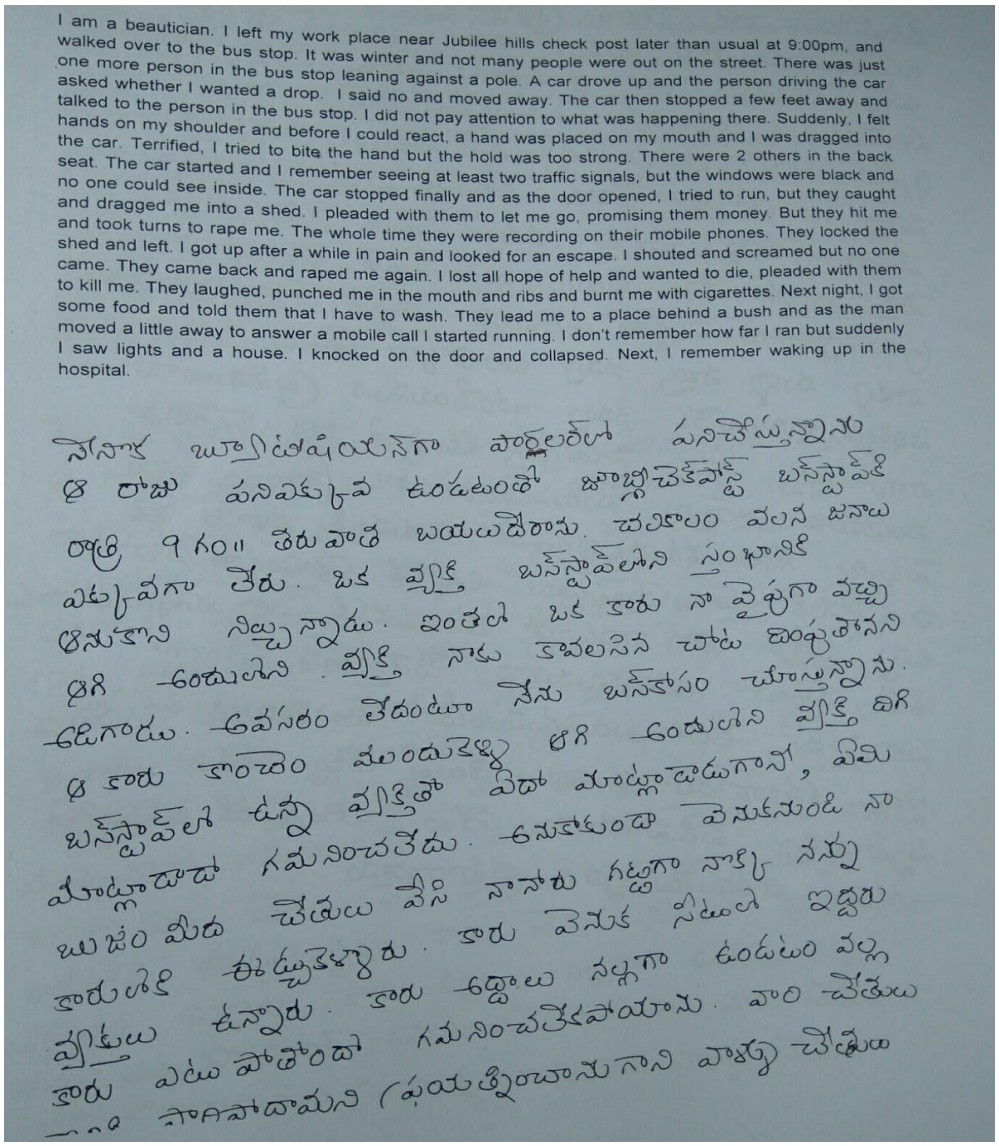
Narratives used in fMRI experiment

Narrative – 1



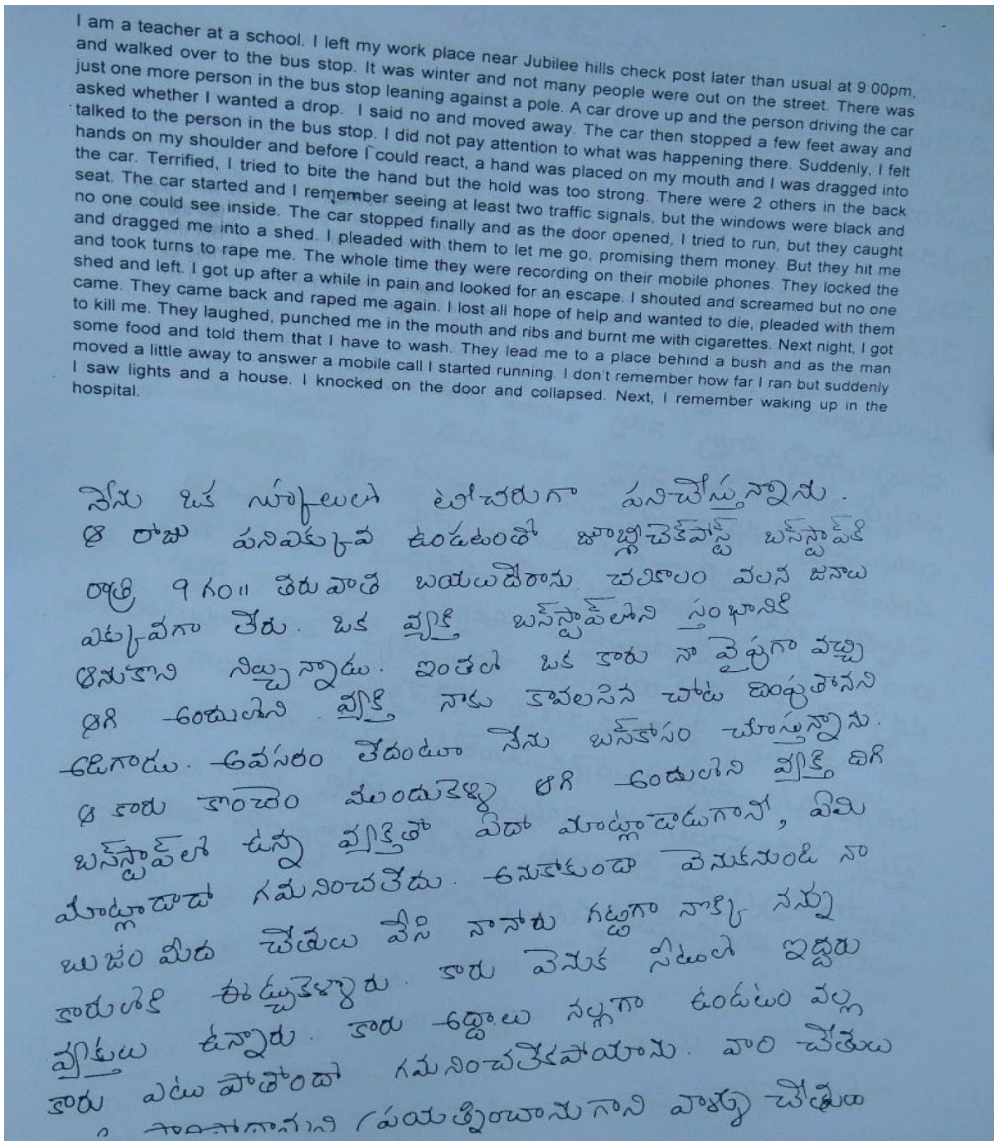
I work as a maid in two houses. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

Narrative - 2



I am a beautician. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

Narrative - 3

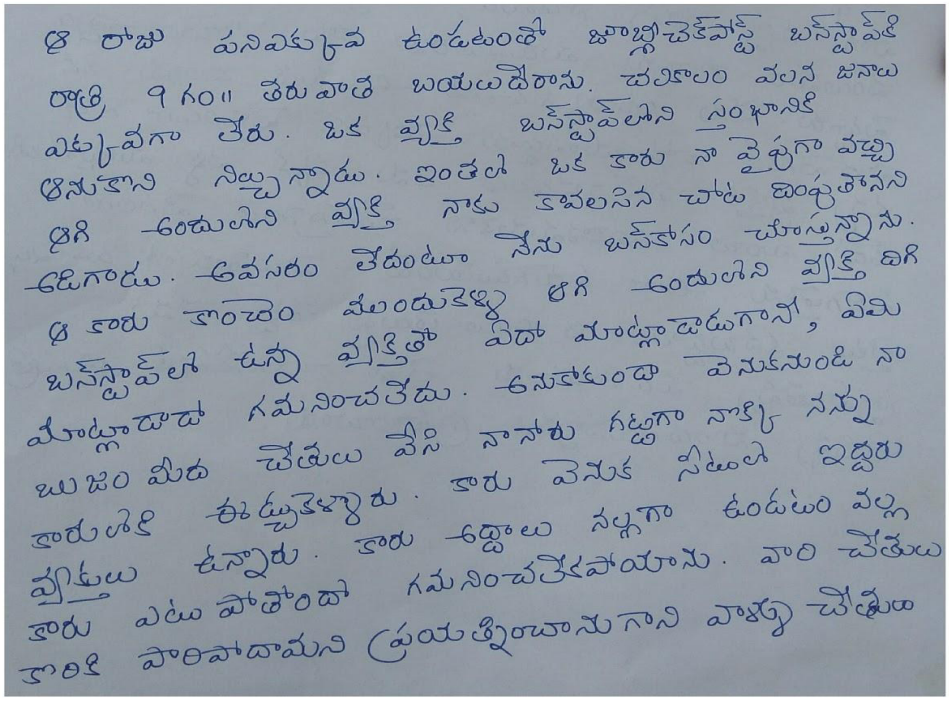


I am a teacher at a school. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

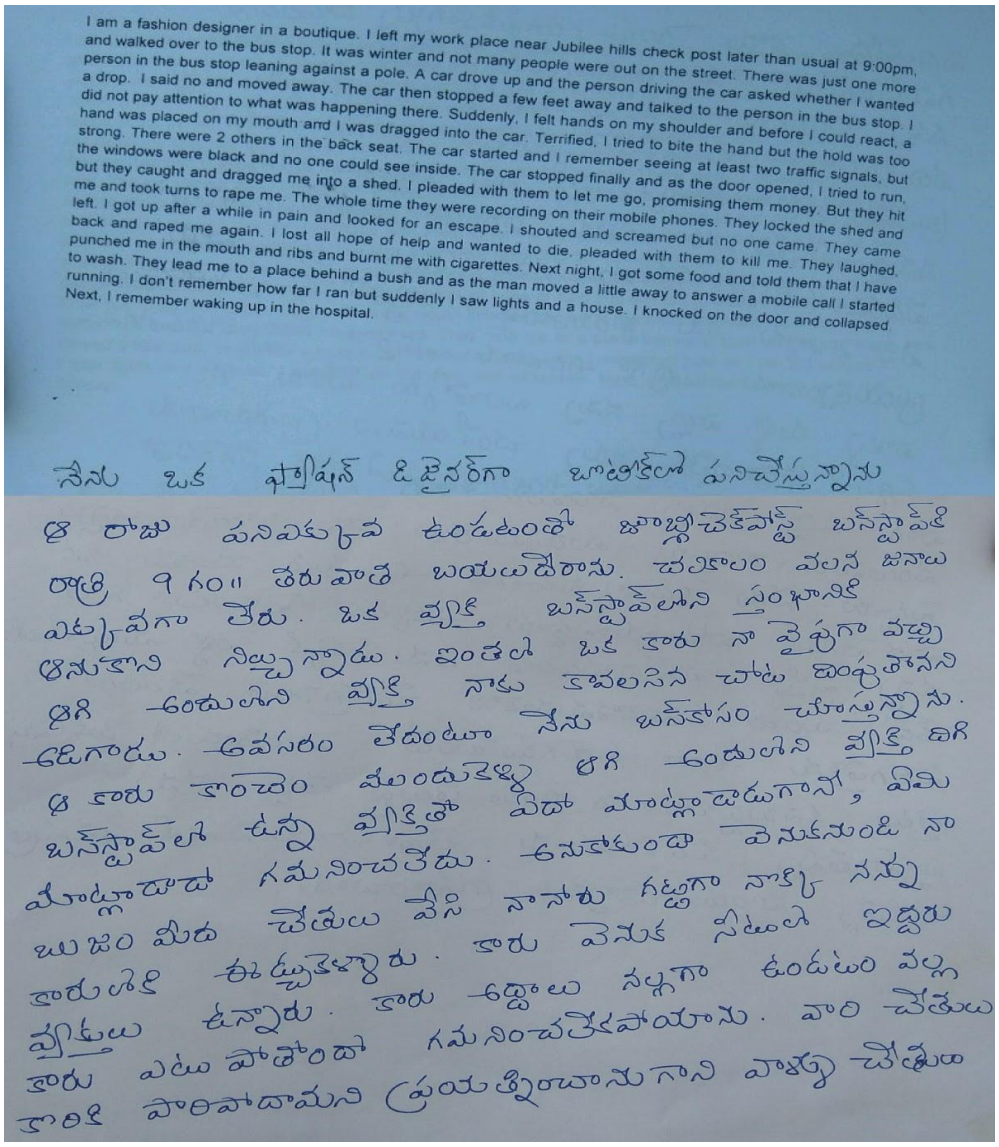
నేను ఒక స్కూల్‌లో టీచరుగా పనిచేస్తున్నాను.
ఆ రోజు పనివత్తిడి ఉండటంతో జూబ్లీచెక్‌పోస్ట్ బస్‌స్టాప్‌కి
రాత్రి 9 గం॥ తరువాతి బయలుదేరాను. చలికాలం వలన జనాలు
ఎక్కువగా లేరు. ఒక వ్యక్తి బస్‌స్టాప్‌లోని స్తంభానికి
ఆనుకొని నిల్చున్నాడు. ఇంతలో ఒక కారు నా వైపుగా వచ్చి
ఆగి ఎందుకని వ్యక్తి నాకు కబలసేన చోటు దొరుకుతానని
అడిగాడు. ఉపసరం లేదండూ నేను బస్‌కోసం చూస్తున్నాను.
ఆ కారు కాంచెం ముందుకెళ్ళి ఆగి ఉండులని వ్యక్తి దిగి
బస్‌స్టాప్‌లో ఉన్న వ్యక్తితో ఏదో మాట్లాడుగానో, ఏమి
మాట్లాడాడో గమనించలేదు. ఉనుకుండా వెనుకనుండి నా
భుజం మీద చేతులు వేసి నానోరు గట్టిగా నొక్కి నన్ను
కారుదగ్గరికి ఈడ్చుకెళ్ళారు. కారు వెనుక సీటులో ఇద్దరు
వ్యక్తులు ఉన్నారు. కారు తలుపులు వేసుగా ఉండటం వల్ల
కారు ఎటు పోతోందో గమనించలేకపోయాను. వారి చేతులు
[illegible] గమనించాను గాని వారు చేతులు

Narrative - 4

I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.



Narrative - 5



I am a fashion designer in a boutique. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die. pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

నేను ఒక ఫ్యాషన్ డిజైనర్‌గా బూటిక్‌లో పనిచేస్తున్నాను
ఆ రోజు పనివుర్వ ఉండటంతో జూబ్లీచెక్‌పోస్ట్ బస్‌స్టాప్‌కి
రాత్రి 9 గం॥ తరువాతి బయలుదేరాను. చలికాలం వలన జనాలు
ఎక్కువగా లేరు. ఒక వ్యక్తి బస్‌స్టాప్‌లోని స్తంభానికి
ఆనుకొని నిల్చున్నాడు. ఇంతలో ఒక కారు నా వైపుగా వచ్చి
ఆగి ఉండులోని వ్యక్తి నాకు కావలసిన చోటు దింపుతానని
అడిగాడు. ఉపసరం లేదండూ నేను బస్‌కోసం చూస్తున్నాను.
ఆ కారు కాంచెం ముందుకెళ్ళి ఆగి ఉండులోని వ్యక్తి దిగి
బస్‌స్టాప్‌లో ఉన్న వ్యక్తితో ఏదో మాట్లాడుతూనే, ఏమి
మాట్లాడుతు గమనించలేదు. ఉనుకోకుండా వెనుకనుండి నా
బుజం మీద చేతులు వేసి నానోరు గట్టిగా నొక్కి నన్ను
కారులోకి ఈడ్చుకెళ్ళారు. కారు వెనుక సీటులో ఇద్దరు
వ్యక్తులు ఉన్నారు. కారు అద్దాలు నల్లగా ఉండటం వల్ల
కారు ఎటు పోతోందో గమనించలేకపోయాను. వారి చేతులు
కాళ్ళకి పారిపోదామని ప్రయత్నించాను గాని వాళ్ళు చేతులు

Narrative - 6

I am a sales manager in a jewellery showroom. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

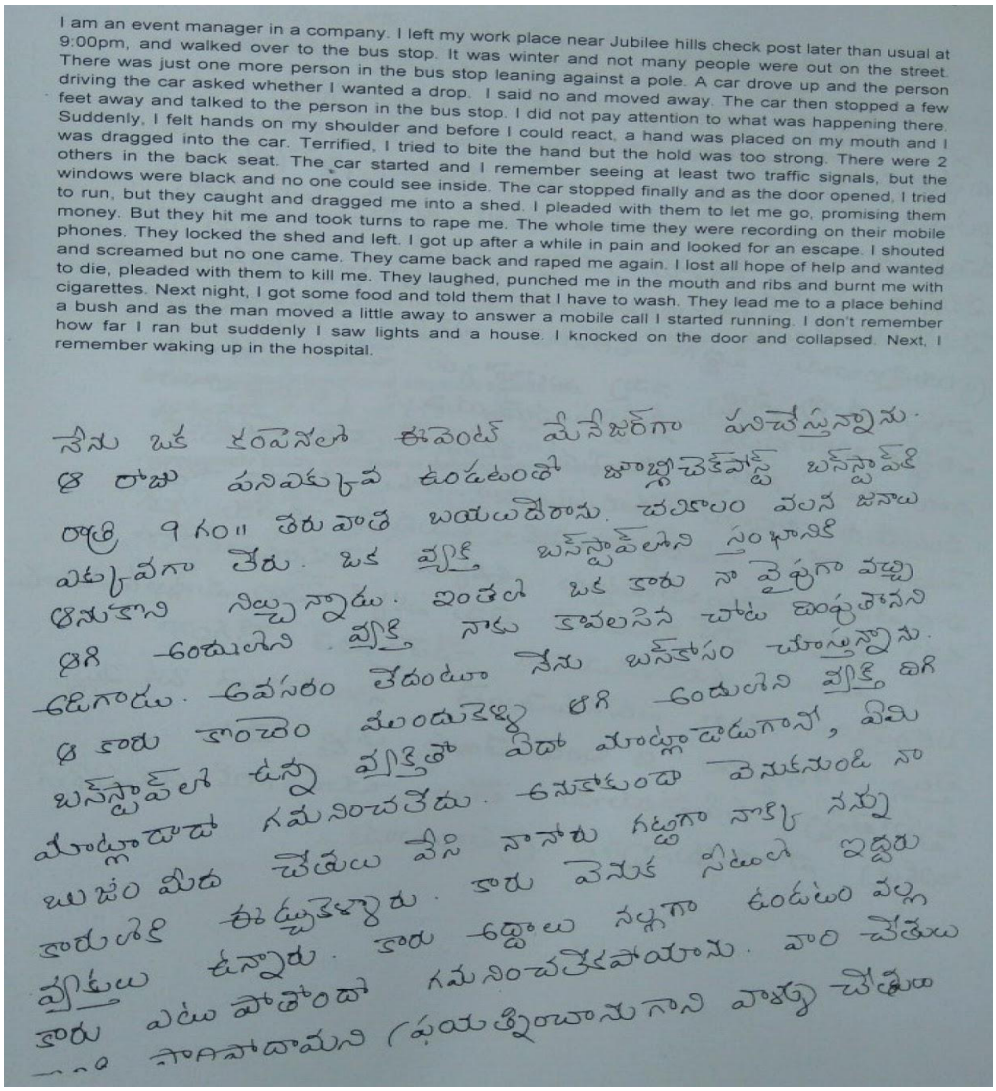
నేను బంగారునగల షాపులో సేల్స్‌మేనేజర్‌గా పనిచేస్తున్నాను.
ఆ రోజు పనివత్తిడి ఉండటంతో జూబ్లీచెక్‌పోస్ట్ బస్‌స్టాప్‌కి
రాత్రి 9 గం॥ తరువాత బయలుదేరాను. చలికాలం వలన జనాలు
ఎక్కువగా లేరు. ఒక వ్యక్తి బస్‌స్టాప్‌లోని స్తంభానికి
ఆనుకొని నిల్చున్నాడు. ఇంతలో ఒక కారు నా వైపుగా వచ్చి
ఆగి ఉండులోని వ్యక్తి నాకు కొలుసెన చూడు చెప్పుతానని
అడిగాడు. ఉపసరం లేదండూ నేను బస్‌కోసం చూస్తున్నాను.
ఆ కారు కాంచం ముందుకెళ్ళి లాగి ఉండులోని వ్యక్తి దిగి
బస్‌స్టాప్‌లో ఉన్న వ్యక్తితో ఏదో మాట్లాడుతుగానే, వేమి
మాట్లాడాడో గమనించలేదు. ఉనుకోకుండా వెనుకనుండి నా
బుజం మీద చేతులు వేసి నానోరు గట్టిగా నొక్కి నన్ను
కారులోకి ఈడ్చుకెళ్ళారు. కారు వెనుక సీటులో ఇద్దరు
వ్యక్తులు ఉన్నారు. కారు తలుపులు సరిగ్గా ఉండటం వల్ల
కారు ఎటు పోతోందో గమనించలేకపోయాను. వారి చేతులు
[illegible] పాడుచేదామని ప్రయత్నించాను గాని వారి చేతులు

Narrative - 7

I am a secretary in a real estate company. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

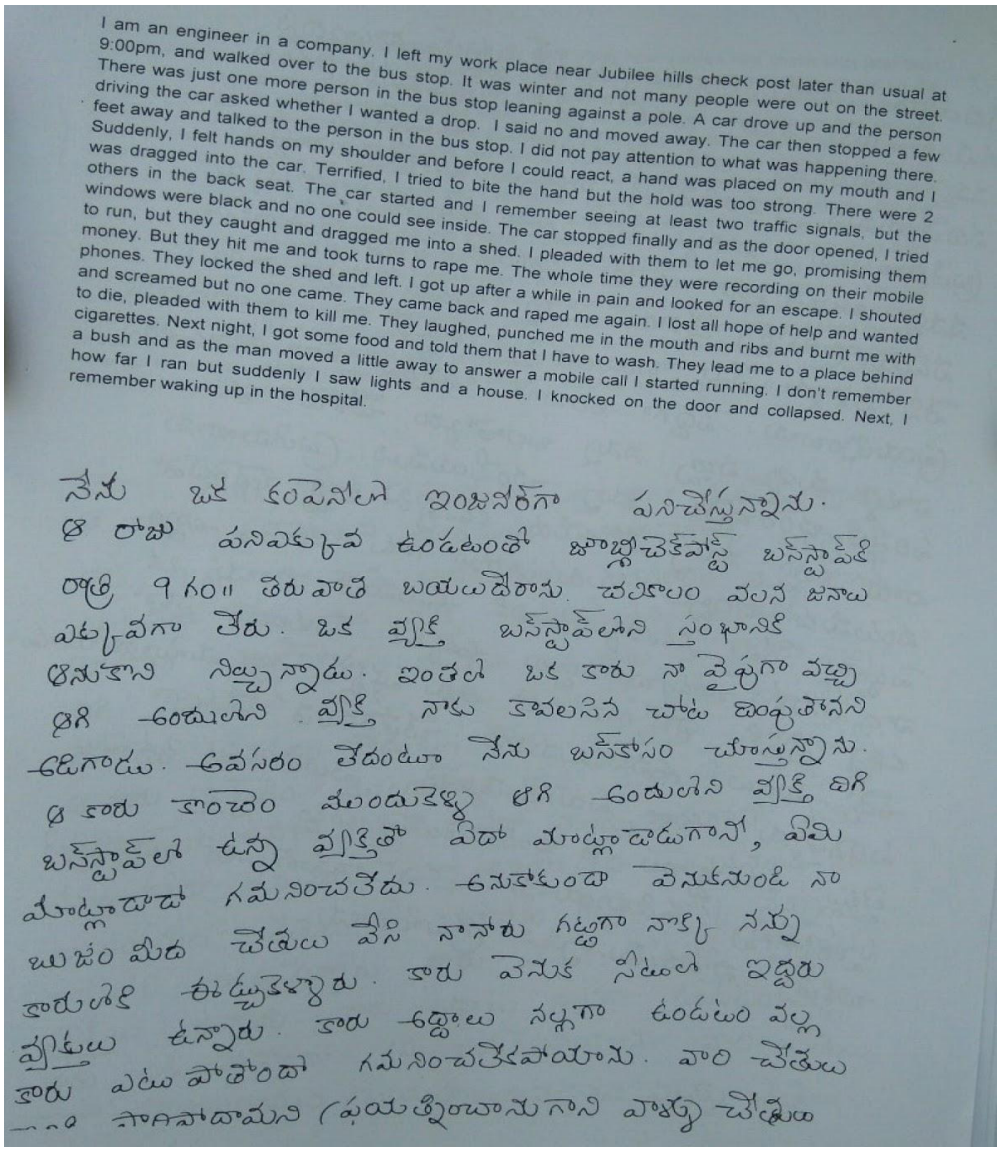
నేనొక రియల్ ఎస్టేట్ కంపెనిలో సెక్రటరిగా పనిచేస్తున్నాను. ఆ రోజు పనిఎక్కువ ఉండటంతో జూబ్లీచెక్‌పోస్ట్ బస్‌స్టాప్‌కి రాత్రి 9 గం॥ తరువాత బయలుదేరాను. చలికాలం వలన జనాలు ఎక్కువగా లేరు. ఒక వ్యక్తి బస్‌స్టాప్‌లోని స్తంభానికి ఆనుకొని నిల్చున్నాడు. ఇంతలో ఒక కారు నా వైపుగా వచ్చి ఆగి ఎందుకని. వ్యక్తి నాకు కావలసిన చోటు దింపుతానని అడిగాడు. ఉపసరం లేదండీ నేను బస్‌కోసం చూస్తున్నాను. ఆ కారు కాంచెం ముందుకెళ్ళి ఆగి ఎందుకని వ్యక్తి దిగి బస్‌స్టాప్‌లో ఉన్న వ్యక్తితో ఏదో మాట్లాడుతుంటే, ఏమి మాట్లాడాడో గమనించలేదు. ఉన్నట్టుండి వెనుకనుండి నా ముఖం మీద చేతులు వేసి నానోరు గట్టిగా నొక్కి నన్ను కారులోకి ఈడ్చుకెళ్ళారు. కారు వెనుక సీటులో ఇద్దరు వ్యక్తులు ఉన్నారు. కారు అద్దాలు నల్లగా ఉండటం వల్ల కారు ఎటు పోతోందో గమనించలేకపోయాను. వారి చేతులు [illegible] పారిపోదామని ప్రయత్నించాను కాని వాళ్ళ చేతులు

Narrative - 8



I am an event manager in a company. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

Narrative - 9



I am an engineer in a company. I left my work place near Jubilee hills check post later than usual at 9:00pm, and walked over to the bus stop. It was winter and not many people were out on the street. There was just one more person in the bus stop leaning against a pole. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away and talked to the person in the bus stop. I did not pay attention to what was happening there. Suddenly, I felt hands on my shoulder and before I could react, a hand was placed on my mouth and I was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. There were 2 others in the back seat. The car started and I remember seeing at least two traffic signals, but the windows were black and no one could see inside. The car stopped finally and as the door opened, I tried to run, but they caught and dragged me into a shed. I pleaded with them to let me go, promising them money. But they hit me and took turns to rape me. The whole time they were recording on their mobile phones. They locked the shed and left. I got up after a while in pain and looked for an escape. I shouted and screamed but no one came. They came back and raped me again. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs and burnt me with cigarettes. Next night, I got some food and told them that I have to wash. They lead me to a place behind a bush and as the man moved a little away to answer a mobile call I started running. I don't remember how far I ran but suddenly I saw lights and a house. I knocked on the door and collapsed. Next, I remember waking up in the hospital.

నేను ఒక కంపెనీలో ఇంజినీరుగా పనిచేస్తున్నాను.
ఆ రోజు పనివుక్కువ ఉండటంతో జూబ్లీచెక్‌పోస్ట్ బస్‌స్టాప్‌కి
రాత్రి 9 గం॥ తరువాత బయలుదేరాను. చలికాలం వలన జనాలు
ఎక్కువగా లేరు. ఒక వ్యక్తి బస్‌స్టాప్‌లోని స్తంభానికి
ఆనుకొని నిల్చున్నారు. ఇంతలో ఒక కారు నా వైపుగా వచ్చి
ఆగి ఎందుకని వ్యక్తి నాకు కావలసిన చోటు దింపుతానని
అడిగారు. ఉపసరం లేదంటూ నేను బస్‌కోసం చూస్తున్నాను.
ఆ కారు కాంచెం ముందుకెళ్ళి ఆగి ఉండుటని వ్యక్తి దిగి
బస్‌స్టాప్‌లో ఉన్న వ్యక్తితో ఏదో మాట్లాడుతున్నాడు, ఏమి
మాట్లాడాడు గమనించలేదు. ఉనుకోకుండా వెనుకనుండి నా
భుజం మీద చేతులు వేసి నానోరు గట్టిగా నొక్కి నన్ను
కారులోకి ఈడ్చుకెళ్ళారు. కారు వెనుక సీటులో ఇద్దరు
వ్యక్తులు ఉన్నారు. కారు లైట్లు సరిగా ఉండటం వల్ల
కారు ఎటు పోతోందో గమనించలేకపోయాను. వారి చేతులు
[illegible] పారిపోదామని ప్రయత్నించాను గాని వారి చేతులు

Narratives used in fMRI experiment

Narrative - 1

I work as bar dancer in local Bar. I left my work place near Jubilee hills check post later than usual at 11:00pm, and walked over to the bus stop. A car drove up and the person driving the car asked whether I wanted a drop. I said no and moved away. The car then stopped a few feet away. Before I could have realised what was happening there, I felt hands on my shoulder and mouth and was dragged into the car. Terrified, I tried to bite the hand but the hold was too strong. I was taken to a shed outside the city and as soon as the car stopped, I tried to run, but they caught and ragged me into a shed. I pleaded with them to let me go, but they hit me and took turns to rape me. I lost all hope of help and wanted to die, pleaded with them to kill me. They laughed, punched me in the mouth and ribs. Now, months later I feel too empty to continue to live, I don't talk, don't eat or sleep. I cannot interact with anyone. Many times, at work while dancing or at home I go to a quiet spot and scream. Sometimes I wish I had not gone out that night but then realise that it could have happened, just to somebody else. They took away my inner strength, my confidence and my body left to live the rest of my life as a dead person. I break down now when I watch any woman being harmed.

Narrative - 2

I am a school teacher. I was on my way back to home from school trip. It got late in the evening. School bus dropped me off on main road and I had to walk through few streets as big vehicles can't go there. Two men, who were present in the area, accosted me, started asking strange questions and called others to the spot. One of them then slapped me. I fell down and then he dragged me 15-20 feet away into a lonely dark alley and proceeded to brutalize me while others held me by hands and legs. I kept shouting for help. They all took turns to rape me. After the rape, they took photographs of me on their phones and told me to keep my mouth shut. They then left me there in pain. Even months later, I cannot sleep at night, I have nightmares of being touched. I feel ashamed to see my students in the eye and suddenly I leave the class to cry my heart out. I used to pride myself on my independence now I am afraid to step out of the house, attend social functions or even talk to my parents. My life has been distorted beyond recognition, the

quick smiles I used to exchange with the children in the class is gone. It is almost as if the rapists ripped away the bubble of joy and replaced it with only tears. I have lost so much weight and energy, that I can hardly walk a few feet. My hands and feet go cold whenever a news article of rape is reported.

Narrative - 3

I was heading home from market around 7 in evening. I took short route through the park as always. As I was walking two men stopped my way and dragged me to nearby bushes. They drugged me with chloroform. When I came into senses I found myself tied in a car parked in some secluded place. I started shouting for help but they stuffed my mouth with cloth. I was crying bitterly and pleading before them to leave me. They took turns to rape me. After a while, I fainted. When I woke up, it was complete dark and I was partially naked. The darkness terrifies me and I need to keep all the lights on inside the house at night even months later. The vulnerability, the fear and the helplessness I felt at that time haunts me. It was just another night of fun for them, but for me it is nightmare I re-live every second of the day. All clothes smell of chloroform now. I feel embarrassed on how feeble I feel, how timidly I move through life and how quick to anger to defend myself. The strong independent fun loving person is dead.

Narrative - 4

I am 30-year-old. A year and a half ago I started going blind in one eye and then the other. Now I'm almost completely blind. It feels terrible when you have to wait for somebody to help you in doing daily chores. I was passionate about reading. Adapting new methods of reading and writing at this age is very difficult. There is a constant darkness that becomes your whole world. I always live in fear of hitting something thus injuring myself while walking. I don't want food, I would even live in the streets. I just want to be able to see my 1 year old daughter growing up. I was re-collecting faded memories of her from past a year but now I know that I won't be able to see her again. There are no thoughts without content just like my life without sight.

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