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PERSONALITY AND THE DEFAULT MODE NETWORK: AN EEG STUDY

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ABSTRACT

Recent research in neuroscience and psychology has emphasized how the brain is organized in terms of networks. One interesting question is how fairly stable traits like personality style are related to cortical networks, and there has been little prior research in this area. We will look at individuals who are exemplars of various personality styles, namely introverts and extroverts. We are interested in the activity of these cortical networks during periods of no input (the default mode network). Furthermore, we are investigating whether there are significant differences in the activity of the Default Mode Network between introverts and extroverts. This will provide insight into the correlation between neural structure and activity and observed behavior. Using surveys to determine personality type, participants were recruited and EEG was performed during resting states. Participants were classified according to their introversion and extroversion scores, and data was processed in EEGLAB using fourier transform, and average power for frequency bands as well as coherence between brain regions was calculated. Significant interactions between personality, region, and coherence were noted in the Delta and Theta Bands in ROIs 3, 4, and 7.

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Chapter 1

Introduction

The brain is made up of interconnected regions that can be thought of as structural and functional networks, as opposed to distinct regions that carry out independent functions. Some of the earliest work on brain networks comes from Wernicke and Pavlov in 1874 and 1949, respectively. These papers proposed that there is value to analyzing how different brain areas work together instead of attempting to map functions onto specific areas. More recent work has established the complexity of cortical systems like the primate visual system, which can be topographically mapped but has a highly complex system architecture (Young, 1992).

Cortical networks are defined by two major factors common to any system: nodes and edges. Nodes are sites of information processing, and edges are the connections between these nodes that bring them together into a cohesive network (Wig et al, 2011). Nodes are characterized by four factors: ctyoarchitectonics, local circuit connectivity, output projection target commonality, and input projection source commonality (Bressler and Menon, 2010). However, the exact number and location of these nodes can be difficult to pinpoint because of the brain's complexity, with existing work mostly provided by fMRI (Power et al, 2010). Edges bring these nodes together into networks, with important implications for both existing networks and "rewiring" of networks in the event of damage or change to the cortex (Nepusz et al, 2008).

To convey information throughout the system and generate a response, neuronal messages from nodes and their connecting edges must accomplish two tasks: they must be directed towards a specific function, and they must be designed to interact properly with the cells that the receiving neuron is connected to (Singer, 2009). Lastly, cortical networks must operate under certain constraints in order to maintain efficiency within the vast computing power of the brain. Cortical networks exhibit sparse but directed connectivity, energy efficient design, and layout designed to minimize noise and maximize output from constituent neurons (Laughlin and Sejnowski, 2003). These networking principles insure that the system, whether feeding back into itself or providing information for other systems, can integrate information correctly.

Chapter 2

The Three Cortical Networks

Beyond the visual network and other sensory networks, there are three cortical networks involved in the process of cognition: the central executive network (CEN), the salience network (SN) and the default mode network (DMN) (Bressler and Menon, 2010). The SN and CEN are associated with active engagement in tasks, while the DMN is associated with a lack of external engagement. The salience network seems to be designed to integrate external sensory information with visceral and hedonic markers, in order to direct an organism's action based on these stimuli (Seeley et al, 2007). This network is built from primarily paralimbic structures, and responds to external factors as varied as pain, stress, hunger, pleasurable touch, faces of loved ones, and social rejection (2007). Abnormalities in the salience network have been linked to neuropathies such as schizophrenia (Palaniyappan and Liddle, 2012).

The CEN works in concert with the salience network, but with a directed focus. The CEN identifies and directs attention towards external stimuli based on neural demands and the drive to maintain homeostasis in the brain (Seeley et al, 2007). Activation of working memory is required in order to balance incoming external information with internal demands. In order to accomplish this, the CEN encompasses regions of the brain involved in attention and memory, such as the lateral parietal cortex and dorsomedial frontal cortex (2007). Like the salience network, deficits and abnormalities in the CEN have been linked to schizophrenia (Wang et al, 2005). Lastly, the CEN works in concert with the orienting and alerting networks to control the human attentional system (Callejas et al, 2005).

In the study of any cortical network, there has always been interest in establishing a baseline. Past work on cortical networks has concentrated on the reception of external stimuli, and the state of the brain during periods lacking in stimulation was referred to as the “resting state.” However, the brain is actually quite active during these periods of low external stimulation, and a network has been identified that is associated with these events. It was first understood during attempts to establish a baseline for the brain, but instead was recognized as a unique form of neural excitation distinct from the stimui-associated cortical networks (Raichle et al, 2001). This network has been dubbed the “Default Mode Network” (DMN). The DMN has been linked to activity to in the posterior cingulate cortex (PCC) and ventral anterior cingulate cortex (vACC) during rest, which correlates with decreased activity in regions that are activated during tasks (Greicius, 2003). Since the DMN is a resting state, some critics have claimed that it is merely a collection of neural artifacts, but a strong correlation has been established between functionality and structure in the processes that occur during rest, indicating that the DMN does exist (Greicius et al, 2008).

As a discrete cortical network, the DMN has important implications for the study of cognition and disease. Decreased activity in the DMN has been associated with Alzheimer’s Disease compared to healthy aging, which indicates that the DMN is most likely associated with episodic memory processing and could serve as a biomarker for Alzheimer’s (Greicius et al, 2004.) Furthermore, dysfunction in the DMN has been associated with neuropathic pain (Seifert and Maihofner, 2008) and Parkinson’s Disease

(Eimeren et al, 2009). In addition to its importance in human disease, the DMN is important in the exercise of cognition and interaction with the other cortical networks. The switch that occurs when external stimuli is applied or removed is critical to the interplay of these networks, and is mediated by the right-insular cortex (Sridharan et al, 2008). This switch between networks is critical, and dysfunction in the suppression of the DMN during goal-directed tasks can manifest itself as behavioral disorders (Kelly et al, 2008). Therefore, the proper functioning of the DMN is critical in the maintenance of normal function and health.

Chapter 3

EEG and Personality

The DMN and other cortical networks can be studied using a variety of techniques, such as fMRI and EEG studies. EEG studies in particular allow researchers to focus on discrete frequency bands, named after Greek letters: alpha (8-12 Hz), beta (18-30 Hz), delta (.5-4 Hz), and theta (4-8 Hz) (Stern et al, 2001). These oscillations are commonly correlated with different types of activity in the brain. For example, alpha waves are often associated with wakeful rest and inactivity and start to appear in the human EEG at around 3 years of age (Kolev et al, 1994). Beta waves, on the other hand, are associated with attentive wakeful consciousness and can be used to study excitation imbalance in alcoholics (Rangaswamy et al, 2002). On the other hand, delta waves are often observed during the deepest stages of sleep and theta waves are associated with drowsiness and the early stages of sleep (Steriade et al, 1991)(Cantero et al, 2003). Analysis of these frequency bands can be tied to a number of different psychological variables to find meaningful correlations. Furthermore, participants can be given different tasks, or merely keep eyes open or closed to search for correlations with different variables. Some prior studies have correlated neural oscillations with personality traits using both eyes open and eyes closed conditions (Chi et al, 2005). Personality is a particularly well-studied area of EEG research, and has implications in the study of cortical networks as well.

One particular area of DMN research that is growing in popularity is its relationship with personality. Personality is a complex concept that encompasses many aspects of cognition, and so it is best to consider distinct aspects of personality when attempting to study its relationship with other neural features. In particular, the extraversion/introversion trait may hold interesting prospects for further research. Extraversion, along with neuroticism, openness, conscientiousness, and agreeableness, are the traits of the Five-Factor Model (FFM) of personality (Digman, 1990). Prior research into the extraversion trait has explored its relationship with baseline arousal and brain circuits, such as the reticulo-cortical and reticulo-limbic circuits (Matthews and Gilliland, 1997). A lower level of brain activity is usually expected in extraverts, while introvert tend to have higher activity (Jausovec and Jausovec, 2007). However, this difference is not as marked as observed in other personality traits, such as neuroticism (2007). Recent work has determined that brain activation during tasks among extraverts and introverts also varies by other variables, such as complexity of task (Fink and Neubauer, 2002). Furthermore, other work has indicated that correlation between brain activity during specific tasks, such as creative idea generation, and personality traits like extraversion can be variable, indicating a more complex interrelation (Fink and Neubauer, 2007). In these studies and others, the differences in brain activity between individuals with different personality types are often measured with EEG.

Developing studies on the DMN and extraversion/introversion indicate a multiple of different correlations. DMN activity may positively correlate with both extraversion and introversion in the posterior and anterior DMN regions, respectively (Knyazev, 2012). This may indicate an intricate interplay between neural oscillations in this network and personality type. Furthermore, specific EEG frequency bands in stable portions of the DMN may be able to predict personality types. Specific theta activity in the posterior hub of the DMN and the orbitofrontal cortex has been strongly correlated with extraversion, allowing researchers to differentiate between the two personality types based off of these oscillations (Knyazev et al, 2012). Since the DMN is associated with lack of external stimulation, baseline studies are particularly important for establishing its synchronicity and thus relationship to other variables.

Discerning the relationship between extraversion/introversion and the default mode network could lead to a better understanding of the cortex's role in modulating basal arousal levels. Furthermore, establishing a physiological basis for personality type could aid in the diagnosis of different personality disorders and treatment. The aim of this study is to further test the relationship between personality and brain frequency oscillations, focusing on the Default Mode Network and the extraversion/introversion personality traits.

Chapter 4

Materials and Methods

Subjects

Resting EEG data was collected from 17 healthy volunteers, (12 Men and 5 Women, Age 18-27) all of which were university students. Participants completed a NEO-FFI questionnaire to determine their extraversion-introversion score (Appendix A) and were grouped as one or the other if they scored in the top 10% for either group (11 Extraverts and 6 introverts). All participants gave informed consent and were treated consistent with IRB guidelines.

Experimental Procedure and Instrumentation

EEG was run in a closed room free of distractions. EEG equipment was 128 channel, high density, and high impedance HydroCel Geodesic Sensor Net (HCGSN). Subjects were required to keep their eyes open for 1 minute at the beginning of the EEG run, providing the information for this study, while other conditions (such as eyes closed) were measured later in the EEG run. Participants were given specific directions for each phase of the baseline (Appendix B).

EEG data analysis

EEG data for the beginning baseline was analyzed for this experiment. This included all of the participants, and two different conditions: beginning baseline eyes open (BBLO) and beginning baseline eyes closed (BBLC). EEG from each of these 1 minute segments was analyzed for each participant. EEG data was processed in EEGLAB to notch filter (60 Hz line noise) remove artifacts, remove and average bad channels, and be cleaned for further processing. Channels that were removed, by participant: P07, 110; P08, 37; P10, 48; P14, 25; P15, 113 and 119; P17 9 and 56; P22, 110 and 127; P31, 56. Channels that were removed were judged from raw EEG data as deviating far enough from baseline to obviously obscure other channels, and averaging gave a good approximation because of the 127 other available channels.

Using MATLAB, EEG data was partitioned into 8 Regions of Interest (ROIs), 6 of which were paired off: 1 and 2, 3 and 4, and 5 and 6. Regions 1 and 2 refer to the left and right dorsolateral prefrontal cortex, respectively. Regions 3 and 4 refer to the left and right lateral parietal cortex. Regions 5 and 6 refer to the left and right occipital lobes, Region 7 refers to the medial prefrontal cortex, and Region 8 refers to the posterior cingulate cortex. EEG data from each of these ROI sets was grouped according to frequency band (alpha, beta, delta, and theta) and coherence values between different regions were also calculated. ROIs 3, 4, 7, and 8 refer to regions that are within the DMN.

Statistical analysis

Statistics were performed within SPSS. ANOVA was run for each frequency band comparing personality type with power in each ROI set, as well as checking for interactions between the regions themselves. In the Delta and Theta bands, ANOVA was performed to compare average spectral power within the DMN ROIs with the non-DMN ROIs. Last, coherence between different ROIS and within each individual ROI was compared between the personality conditions in each frequency band using ANOVA.

Chapter 5

Results

To analyze differences in activity between different groups and brain regions, it is helpful to separate EEG data into the different frequency bands and analyze them separately.

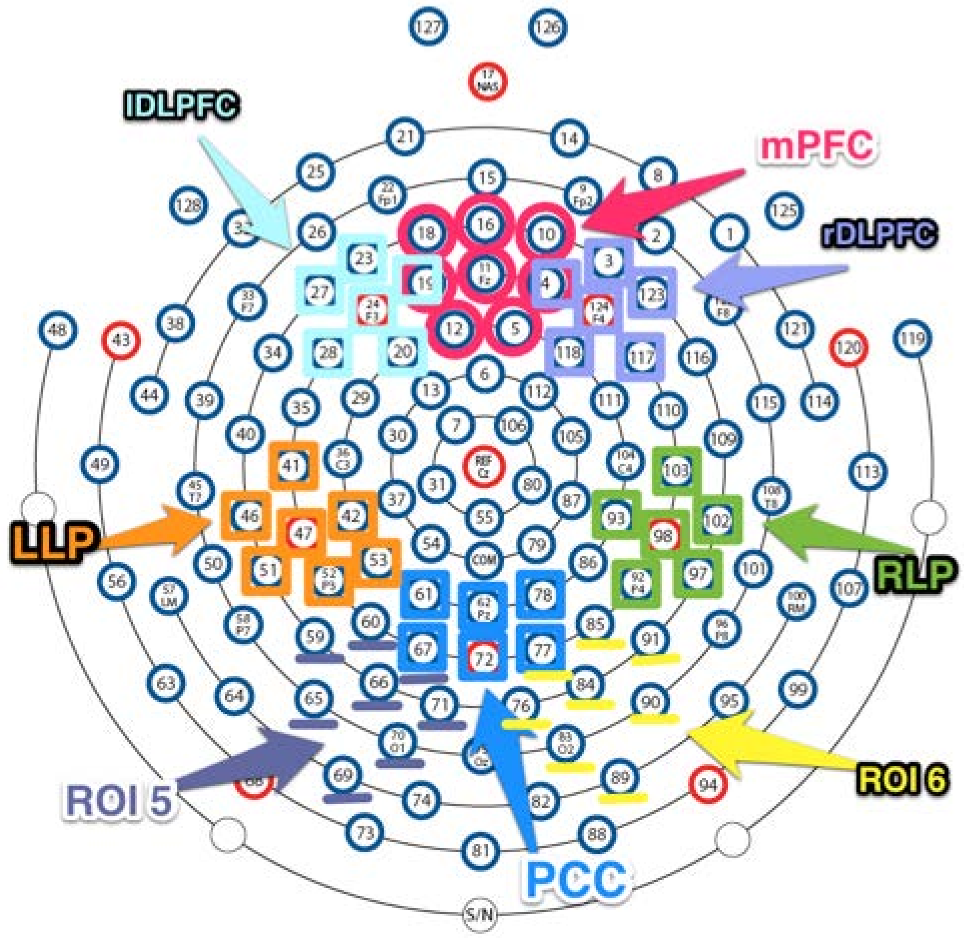

Figure 1: Map of EEG electrodes with ROI labels. mPFC: medial prefrontal cortex; lDLPFC and rDLPFC: left and right dorsolateral prefrontal cortex; LLP and RLP: left and right lateral parietal; ROI 5 and 6: left and right occipital; PCC: posterior cingulate cortex

Table 1: Key to ROI labels

ROI 1	Left Dorsolateral Prefrontal
ROI 2	Right Dorsolateral Prefrontal
ROI 3	Left Lateral Parietal
ROI 4	Right Lateral Parietal
ROI 5	Left Occipital
ROI 6	Right Occipital
ROI 7	Medial Prefrontal
ROI 8	Posterior Cingulate

Alpha Power, Eyes Closed

Power in the alpha frequency for the eyes closed condition was compared between the two personality types (Extraversion/Introversion) and each ROI. Means of Alpha power between groups and Regions were calculated. One way ANOVA of personality type and brain region did not yield any significance in this band (all $p>.05$) but power in ROI 8 had the most significance ($p \leq .237$).

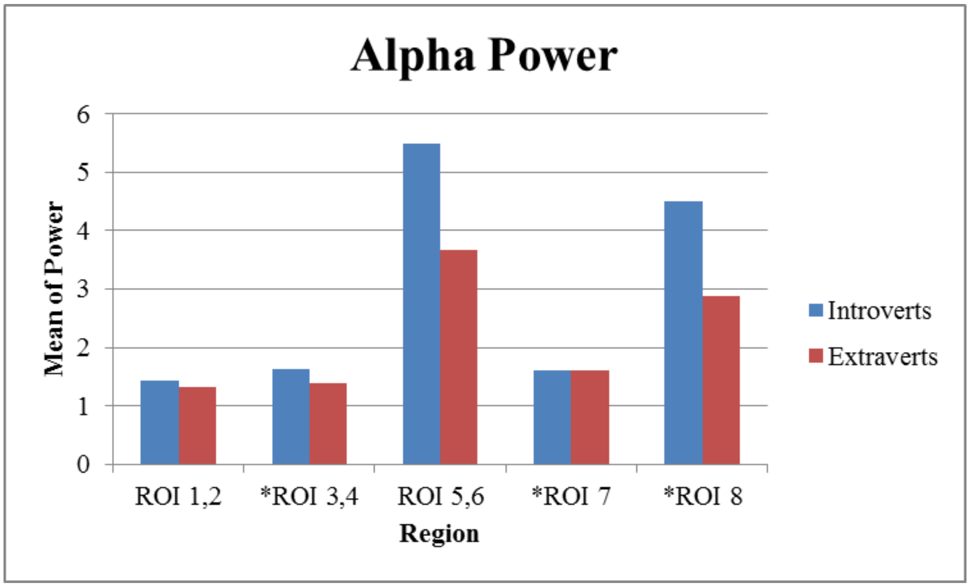

Figure 2: Alpha Power by Brain Region, Introverts and Extraverts, Eyes Closed

Table 2: ANOVA Results, Region by Personality in Alpha Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Alpha Power - DLPFC	Between Groups	.035	1	.035	.039	.846
	Within Groups	13.460	15	.897		
	Total	13.495	16			
Alpha Power - Lateral Parietal Cortex	Between Groups	.226	1	.226	.217	.648
	Within Groups	15.599	15	1.040		
	Total	15.824	16			
Alpha Power - roi 5 and 6	Between Groups	12.901	1	12.901	1.220	.287
	Within Groups	158.666	15	10.578		
	Total	171.567	16			
Alpha Power - MPFC	Between Groups	.000	1	.000	.000	.990
	Within Groups	16.021	15	1.068		
	Total	16.021	16			
Alpha Power - PCC	Between Groups	10.148	1	10.148	1.515	.237
	Within Groups	100.496	15	6.700		
	Total	110.644	16			

Alpha Power, Eyes Open

In addition to the eyes closed condition, power in the Alpha frequency band was compared for the beginning baseline line eyes open condition between personality and ROI. One way ANOVA of these variables did not yield any significance (all p>.05) and no interactions were near significance.

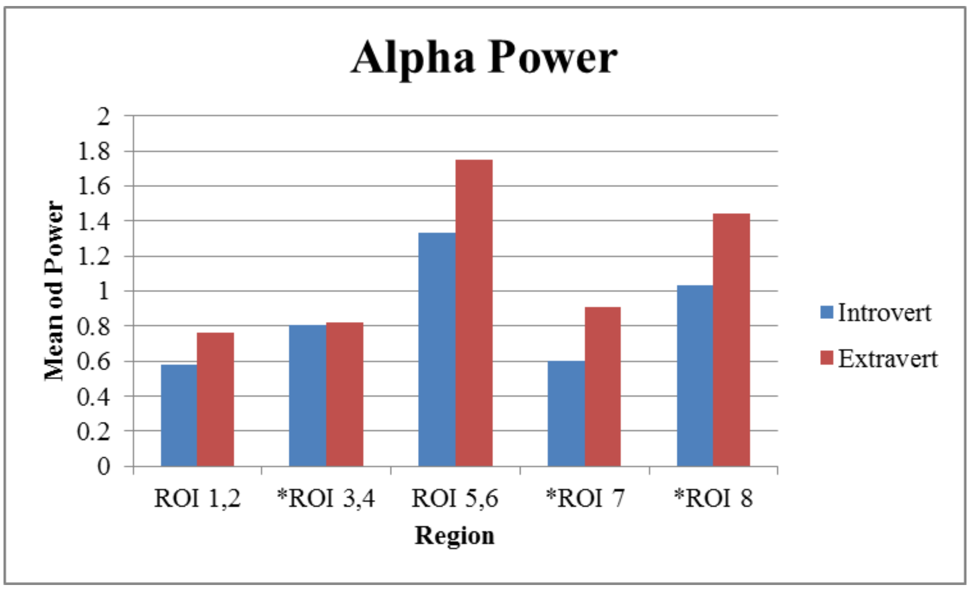

Figure 3: Alpha Power by Brain Region, Introverts and Extraverts, Eyes Open

Table 3: ANOVA Results, Region by Personality in Alpha Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	.135	1	.135	.259	.618
Alpha Power – DLPFC	Within Groups	7.839	15	.523		
	Total	7.974	16			
Alpha Power – Lateral Parietal	Between Groups	.001	1	.001	.001	.981
Cortex	Within Groups	12.665	15	.844		

	Total	12.665	16			
Alpha Power – roi 5 and 6	Between Groups	.673	1	.673	.115	.739
	Within Groups	87.684	15	5.846		
	Total	88.357	16			
Alpha Power – MPFC	Between Groups	.371	1	.371	.626	.441
	Within Groups	8.893	15	.593		
	Total	9.264	16			
Alpha Power – PCC	Between Groups	.653	1	.653	.238	.633
	Within Groups	41.176	15	2.745		
	Total	41.830	16			

Beta Power, Eyes Closed

Power in the Beta band for the eyes closed condition was compared in the same manner, between personality and ROI. Means of Beta Power between groups and Regions were calculated. One way ANOVA of personality type did not yield any significance in the Beta band (all $p>.05$) but power in ROI 3,4 had the most significance ($p\leq.184$)

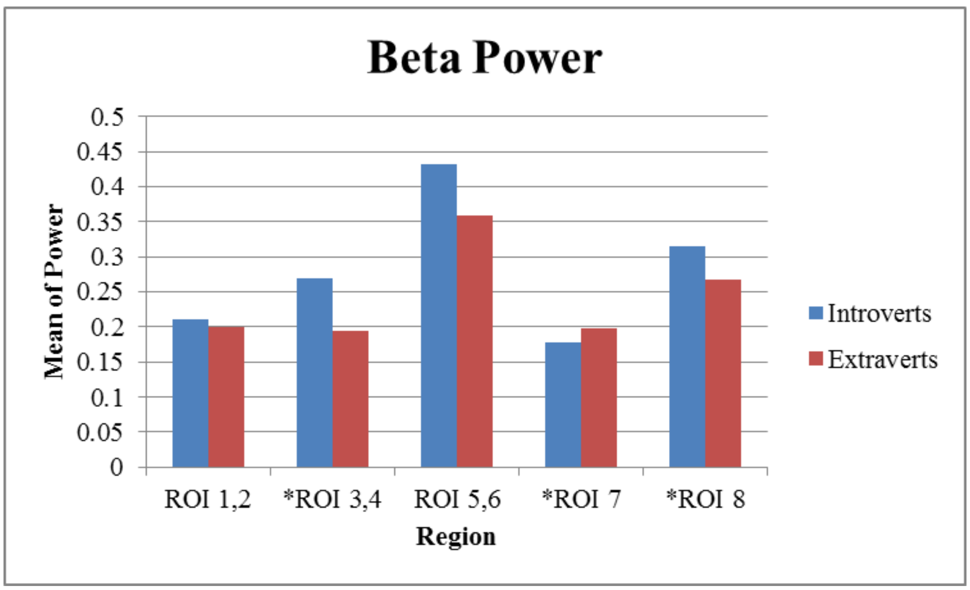

Figure 4: Beta Power by Brain Region, Introverts and Extraverts, Eyes Closed

Table 4: ANOVA Results, Region by Personality in Beta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Beta Power – DLPFC	Between Groups	.000	1	.000	.072	.792
	Within Groups	.099	15	.007		
	Total	.100	16			
Beta Power – Lateral Parietal Cortex	Between Groups	.021	1	.021	1.935	.184
	Within Groups	.165	15	.011		
	Total	.187	16			
Beta Power – roi 5 and 6	Between Groups	.021	1	.021	.563	.464
	Within Groups	.550	15	.037		
	Total	.570	16			
Beta Power – MPFC	Between Groups	.001	1	.001	.376	.549
	Within Groups	.056	15	.004		
	Total	.057	16			
Beta Power – PCC	Between Groups	.009	1	.009	.419	.527
	Within Groups	.311	15	.021		
	Total	.320	16			

Beta Power, Eyes Open

Power in the Beta band for the eyes open condition was compared in the same manner, between personality and ROI using one-way ANOVA. No significant interactions were noted in this frequency band (all $p>.05$).

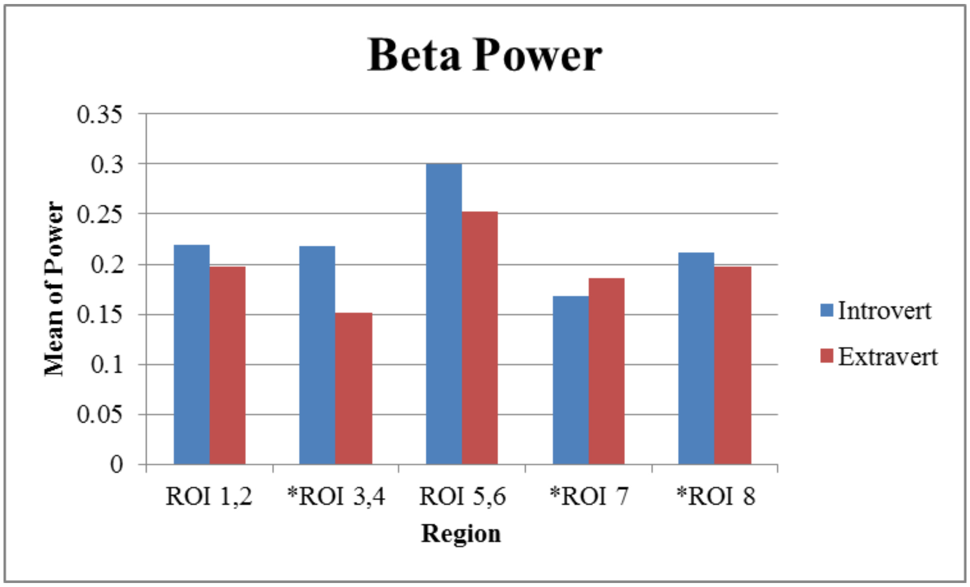

Figure 5: Beta Power by Brain Region, Introverts and Extraverts, Eyes Open

Table 5: ANOVA Results, Region by Personality in Beta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
Beta Power - DLPFC	Between Groups	.002	1	.002	.125	.728
	Within Groups	.214	15	.014		
	Total	.216	16			
Beta Power - Lateral Parietal Cortex	Between Groups	.017	1	.017	1.381	.258
	Within Groups	.187	15	.012		
	Total	.204	16			
Beta Power - roi 5 and 6	Between Groups	.009	1	.009	.226	.641
	Within Groups	.586	15	.039		
	Total	.595	16			
Beta Power - MPFC	Between Groups	.001	1	.001	.148	.706
	Within Groups	.122	15	.008		
	Total	.124	16			
Beta Power - PCC	Between Groups	.001	1	.001	.042	.841
	Within Groups	.285	15	.019		
	Total	.286	16			

Delta Power, Eyes Closed

Power in the Delta Band for the eyes closed condition was compared similarly, between personality and ROI. Means of Delta Power between groups and Regions were calculated. One way ANOVA of personality type did not yield any significance in the Delta band (all p>.05) with no noteworthy interactions at unacceptable significance.

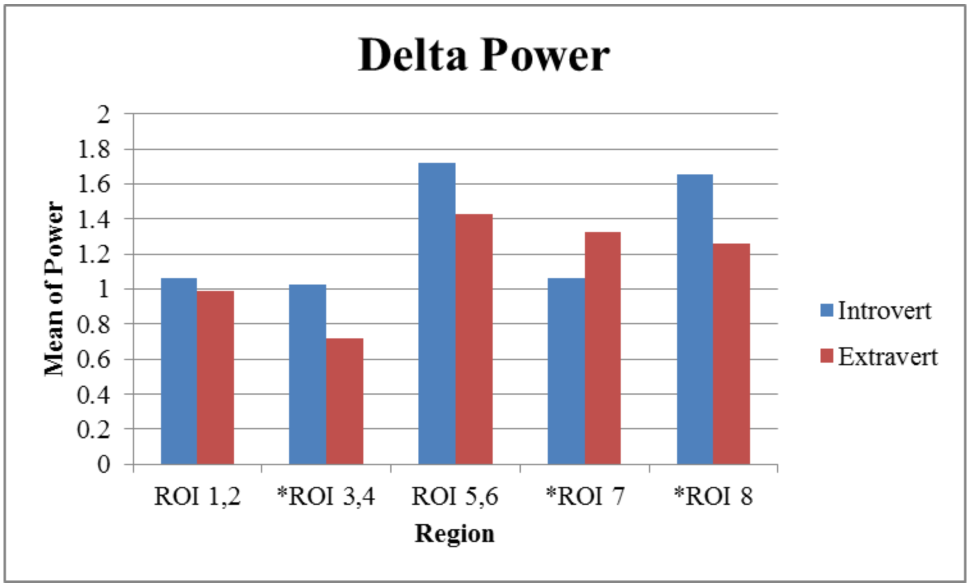

Figure 6: Delta Power by Brain Region, Introverts and Extraverts, Eyes Closed

Table 6: ANOVA Results, Region by Personality in Delta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Delta Power - DLPFC	Between Groups	.021	1	.021	.071	.793
	Within Groups	4.396	15	.293		
	Total	4.417	16			
Delta Power - Lateral Parietal Cortex	Between Groups	.382	1	.382	1.080	.315
	Within Groups	5.305	15	.354		
	Total	5.687	16			
Delta Power - roi 5 and 6	Between Groups	.338	1	.338	.316	.582
	Within Groups	16.064	15	1.071		
	Total	16.402	16			
Delta Power - MPFC	Between Groups	.267	1	.267	.377	.548
	Within Groups	10.596	15	.706		

	Total	10.862	16			
Delta Power - PCC	Between Groups	.603	1	.603	.645	.434
	Within Groups	14.015	15	.934		
	Total	14.618	16			

To directly compare ROIs within the DMN and those outside of it, ROIs within the DMN were averaged together for each participant, and compared with the averages of the non-DMN regions. This was compared via ANOVA with personality type. In this band, no significant interactions were observed

Table 7: ANOVA Results, DMN vs. Non-DMN in Delta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
DMN	Between Groups	.084	1	.084	.183	.674
	Within Groups	6.899	15	.460		
	Total	6.983	16			
NON-DMN	Between Groups	.134	1	.134	.232	.637
	Within Groups	8.685	15	.579		
	Total	8.820	16			

Delta Power, Eyes Open

Delta power was also compared with personality for the eyes open condition in the same manner. One-way ANOVA did not yield any statistically significant interactions between personality and ROI, and comparison of average DMN power with power outside the DMN by personality type also did not yield significant interactions.

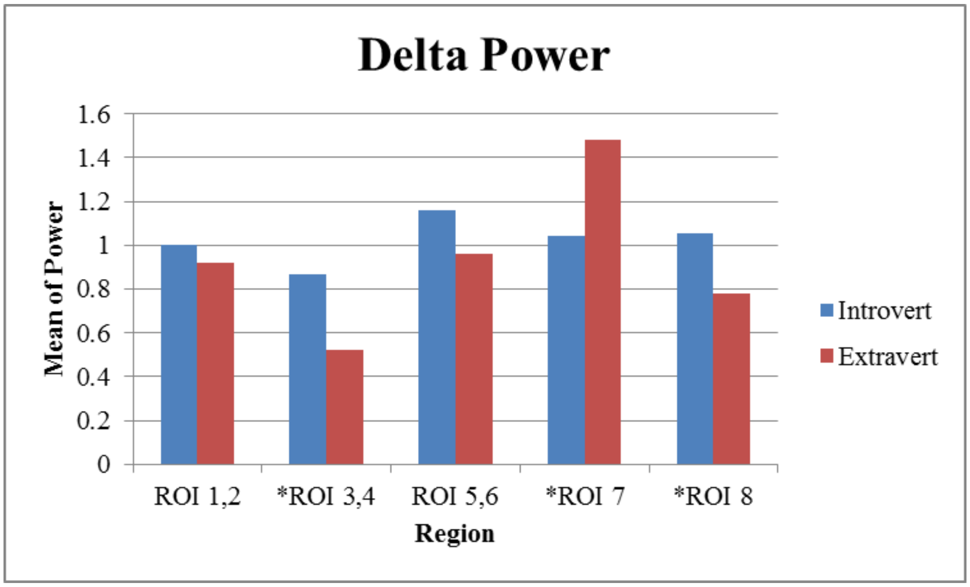

Figure 7: Delta Power by Brain Region, Introverts and Extraverts, Eyes Open

Table 8: ANOVA Results, Region by Personality in Delta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
Delta Power - DLPFC	Between Groups	.025	1	.025	.049	.828
	Within Groups	7.815	15	.521		
	Total	7.840	16			
Delta Power - Lateral Parietal Cortex	Between Groups	.458	1	.458	1.140	.303
	Within Groups	6.033	15	.402		
	Total	6.491	16			
Delta Power - roi 5 and 6	Between Groups	.162	1	.162	.149	.704
	Within Groups	16.250	15	1.083		
	Total	16.412	16			
Delta Power - MPFC	Between Groups	.749	1	.749	.338	.570
	Within Groups	33.254	15	2.217		
	Total	34.003	16			
Delta Power - PCC	Between Groups	.291	1	.291	.389	.542
	Within Groups	11.205	15	.747		
	Total	11.496	16			

Table 9: ANOVA Results, DMN vs. Non-DMN in Delta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	.014	1	.014	.019	.891
DMN	Within Groups	10.566	15	.704		
	Total	10.580	16			
	Between Groups	.079	1	.079	.118	.736
non_DMN	Within Groups	10.030	15	.669		
	Total	10.109	16			

Theta Power, Eyes Closed

Power in the Theta frequency band for the eyes closed condition was compared in the same manner once again, between personality and ROI. Means of Beta Power between groups and Regions were calculated. One way ANOVA of personality type did not yield any significance in the Theta band (all p>.05) nor any noteworthy non-significant interactions.

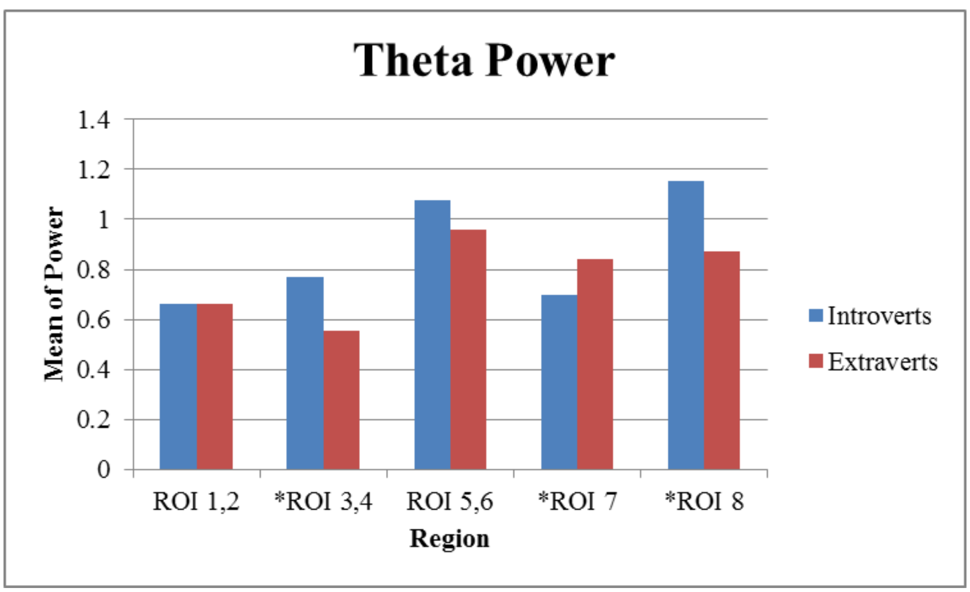

Figure 8: Theta Power by Brain Region, Introverts and Extraverts, Eyes Closed

Table 10: ANOVA Results, Region by Personality in Theta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Theta Power - DLPFC	Between Groups	.000	1	.000	.000	.992
	Within Groups	1.218	15	.081		
	Total	1.218	16			
Theta Power - Lateral Parietal Cortex	Between Groups	.186	1	.186	.917	.353
	Within Groups	3.039	15	.203		
	Total	3.225	16			
Theta Power - roi 5 and 6	Between Groups	.052	1	.052	.127	.726
	Within Groups	6.080	15	.405		
	Total	6.132	16			
Theta Power - MPFC	Between Groups	.078	1	.078	.659	.430
	Within Groups	1.771	15	.118		
	Total	1.849	16			
Theta Power - PCC	Between Groups	.317	1	.317	.644	.435
	Within Groups	7.389	15	.493		
	Total	7.706	16			

Table 11: ANOVA Results, DMN vs. Non-DMN in Theta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
DMN	Between Groups	.058	1	.058	.274	.609
	Within Groups	3.174	15	.212		
	Total	3.232	16			
NON-DMN	Between Groups	.011	1	.011	.054	.819
	Within Groups	3.047	15	.203		
	Total	3.058	16			

As in the Delta band, to directly compare ROIs within the DMN and those outside of it, ROIs within the DMN were averaged together for each participant, and compared with the averages of the non-DMN regions. This was compared via ANOVA with personality type. In this band, no significant interactions were observed

Theta Power, Eyes Open

Power was compared in the same manner for the eyes open condition in the theta band, and one-way ANOVA did not indicate any significant interactions between personality and ROI in this band, nor were there interactions between average DMN power and power outside the DMN by compared with personality.

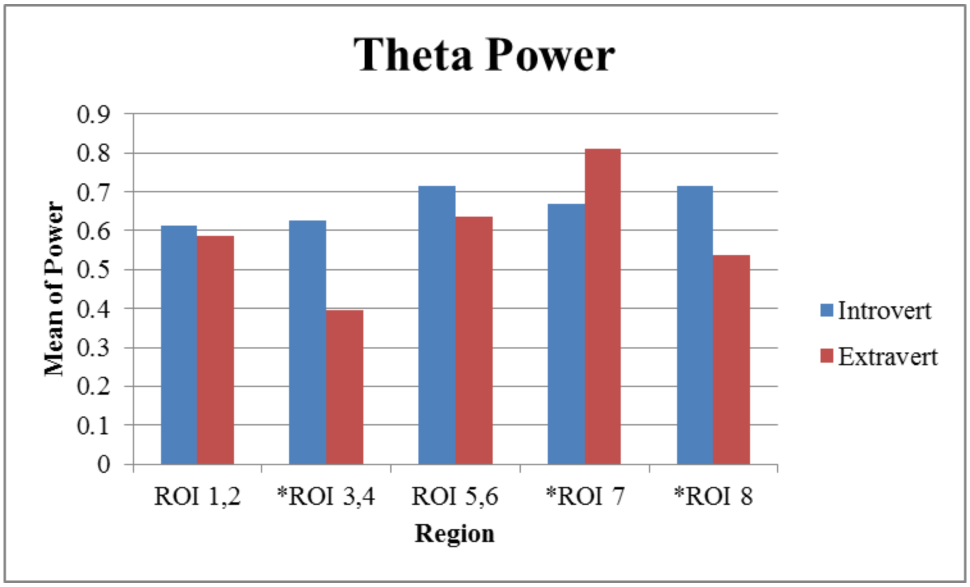

Figure 9: Theta Power by Brain Region, Introverts and Extraverts, Eyes Open

Table 12: ANOVA Results, Region by Personality in Theta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
Theta Power - DLPFC	Between Groups	.003	1	.003	.018	.895
	Within Groups	2.178	15	.145		
	Total	2.180	16			
Theta Power - Lateral Parietal Cortex	Between Groups	.202	1	.202	.955	.344
	Within Groups	3.169	15	.211		
	Total	3.371	16			
Theta Power - roi 5 and 6	Between Groups	.025	1	.025	.065	.803
	Within Groups	5.905	15	.394		
	Total	5.931	16			
Theta Power - MPFC	Between Groups	.078	1	.078	.236	.634
	Within Groups	4.951	15	.330		

		Sum of Squares	df	Mean Square	F	Sig.
	Total	5.029	16			
Theta Power - PCC	Between Groups	.125	1	.125	.371	.551
	Within Groups	5.059	15	.337		
	Total	5.184	16			

Table 13: ANOVA Results, DMN vs. Non-DMN in Theta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
DMN_THETA	Between Groups	.030	1	.030	.140	.713
	Within Groups	3.260	15	.217		
	Total	3.291	16			
NONDMN_THETA	Between Groups	.011	1	.011	.050	.827
	Within Groups	3.347	15	.223		
	Total	3.358	16			

Alpha Coherence, Eyes Closed

Coherence between the different DMN regions was compared with personality type using ANOVA for the Alpha frequency band, eyes closed condition. Coherence between any region of the DMN and a non-DMN ROI was not considered, nor was coherence between non-DMN regions. No statistically significant interactions were observed.

Table 14: ANOVA, Average Coherence, Region by Personality in Alpha Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Ac_3_3	Between Groups	.025	1	.025	2.137	.164
	Within Groups	.179	15	.012		
	Total	.204	16			
Ac_4_3	Between Groups	.002	1	.002	.448	.514
	Within Groups	.068	15	.005		
	Total	.070	16			
Ac_4_4	Between Groups	.026	1	.026	2.919	.108
	Within Groups	.132	15	.009		

	Total	.157	16			
Ac_7_3	Between Groups	.000	1	.000	.000	.998
	Within Groups	.135	15	.009		
	Total	.135	16			
Ac_7_4	Between Groups	.001	1	.001	.185	.673
	Within Groups	.101	15	.007		
	Total	.102	16			
Ac_7_7	Between Groups	.001	1	.001	.217	.648
	Within Groups	.048	15	.003		
	Total	.049	16			
Ac_8_3	Between Groups	.006	1	.006	.426	.524
	Within Groups	.214	15	.014		
	Total	.220	16			
Ac_8_4	Between Groups	.000	1	.000	.082	.778
	Within Groups	.082	15	.005		
	Total	.082	16			
Ac_8_7	Between Groups	.005	1	.005	.438	.518
	Within Groups	.157	15	.010		
	Total	.162	16			
Ac_8_8	Between Groups	.002	1	.002	.199	.662
	Within Groups	.138	15	.009		
	Total	.140	16			

Alpha Coherence, Eyes Open

Coherence was similarly compared in the Alpha band for the eyes open condition, and no significant interactions were noted.

Table 15: ANOVA, Average Coherence, Region by Personality in Alpha Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
Ac_3_3	Between Groups	.027	1	.027	1.623	.222
	Within Groups	.251	15	.017		
	Total	.278	16			
Ac_4_3	Between Groups	.001	1	.001	.178	.679
	Within Groups	.046	15	.003		
	Total	.046	16			

	Between Groups	.038	1	.038	3.102	.099
Ac_4_4	Within Groups	.184	15	.012		
	Total	.222	16			
	Between Groups	.005	1	.005	1.758	.205
Ac_7_3	Within Groups	.042	15	.003		
	Total	.047	16			
	Between Groups	.004	1	.004	.708	.413
Ac_7_4	Within Groups	.074	15	.005		
	Total	.078	16			
	Between Groups	.006	1	.006	1.507	.239
Ac_7_7	Within Groups	.061	15	.004		
	Total	.067	16			
	Between Groups	.014	1	.014	2.729	.119
Ac_8_3	Within Groups	.079	15	.005		
	Total	.093	16			
	Between Groups	.000	1	.000	.002	.969
Ac_8_4	Within Groups	.071	15	.005		
	Total	.071	16			
	Between Groups	.009	1	.009	.943	.347
Ac_8_7	Within Groups	.148	15	.010		
	Total	.158	16			
	Between Groups	.000	1	.000	.022	.884
Ac_8_8	Within Groups	.227	15	.015		
	Total	.227	16			

Beta Coherence, Eyes Closed

Coherence in the beta band between DMN-regions was compared with personality type in the same manner, but no significant interactions were noted. However, difference in personality and coherence between ROIs 3 and 4 approached significance ($p<.061$)

Table 16: ANOVA, Average Coherence, Region by Personality in Beta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Bc_3_3	Between Groups	.041	1	.041	2.691	.122

	Within Groups	.227	15	.015		
	Total	.268	16			
	Between Groups	.012	1	.012	4.096	.061
Bc_4_3	Within Groups	.045	15	.003		
	Total	.057	16			
	Between Groups	.039	1	.039	2.939	.107
Bc_4_4	Within Groups	.197	15	.013		
	Total	.236	16			
	Between Groups	.004	1	.004	1.181	.294
Bc_7_3	Within Groups	.046	15	.003		
	Total	.049	16			
	Between Groups	.001	1	.001	.636	.438
Bc_7_4	Within Groups	.024	15	.002		
	Total	.025	16			
	Between Groups	.016	1	.016	1.766	.204
Bc_7_7	Within Groups	.134	15	.009		
	Total	.149	16			
	Between Groups	.012	1	.012	1.435	.250
Bc_8_3	Within Groups	.122	15	.008		
	Total	.134	16			
	Between Groups	.001	1	.001	.150	.704
Bc_8_4	Within Groups	.063	15	.004		
	Total	.064	16			
	Between Groups	.021	1	.021	2.654	.124
Bc_8_7	Within Groups	.120	15	.008		
	Total	.142	16			
	Between Groups	.000	1	.000	.023	.883
Bc_8_8	Within Groups	.205	15	.014		
	Total	.205	16			

Beta Coherence, Eyes Open

Coherence was compared with personality type and ROI in the same manner in the Beta frequency band for the eyes open condition. No significant interactions were noted, but as with the eyes closed condition in this band, difference in personality type and coherence between ROIs 4 and 3 approached significance ($p<.066$).

Table 17: ANOVA, Average Coherence, Region by Personality in Beta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	.036	1	.036	2.230	.156
Bc_3_3	Within Groups	.244	15	.016		
	Total	.280	16			
	Between Groups	.006	1	.006	3.943	.066
Bc_4_3	Within Groups	.024	15	.002		
	Total	.030	16			
	Between Groups	.043	1	.043	3.326	.088
Bc_4_4	Within Groups	.195	15	.013		
	Total	.238	16			
	Between Groups	.008	1	.008	2.954	.106
Bc_7_3	Within Groups	.040	15	.003		
	Total	.048	16			
	Between Groups	.003	1	.003	1.936	.184
Bc_7_4	Within Groups	.025	15	.002		
	Total	.029	16			
	Between Groups	.022	1	.022	2.029	.175
Bc_7_7	Within Groups	.161	15	.011		
	Total	.183	16			
	Between Groups	.014	1	.014	1.997	.178
Bc_8_3	Within Groups	.102	15	.007		
	Total	.116	16			
	Between Groups	.000	1	.000	.001	.976
Bc_8_4	Within Groups	.038	15	.003		
	Total	.038	16			
	Between Groups	.021	1	.021	2.636	.125
Bc_8_7	Within Groups	.117	15	.008		
	Total	.137	16			
	Between Groups	.000	1	.000	.007	.934
Bc_8_8	Within Groups	.253	15	.017		
	Total	.253	16			

Delta Coherence, Eyes Closed

Coherence between the different DMN regions was compared with personality type using ANOVA for the Delta frequency band. Coherence between any region of the DMN and a non-DMN ROI was not considered, nor was coherence between non-DMN regions. No significant interactions were observed (all p>.05). However, coherence within ROIs 4 and 7 were near significance (p≤.067 and p≤.051).

Table 18: ANOVA, Average Coherence, Region by Personality in Delta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
Dc_3_3	Between Groups	.049	1	.049	3.121	.098
	Within Groups	.237	15	.016		
	Total	.287	16			
Dc_4_3	Between Groups	.002	1	.002	3.153	.096
	Within Groups	.009	15	.001		
	Total	.011	16			
Dc_4_4	Between Groups	.048	1	.048	3.914	.067
	Within Groups	.184	15	.012		
	Total	.232	16			
Dc_7_3	Between Groups	.001	1	.001	.145	.709
	Within Groups	.143	15	.010		
	Total	.145	16			
Dc_7_4	Between Groups	.011	1	.011	2.662	.124
	Within Groups	.060	15	.004		
	Total	.070	16			
Dc_7_7	Between Groups	.029	1	.029	4.490	.051
	Within Groups	.096	15	.006		
	Total	.125	16			
Dc_8_3	Between Groups	.019	1	.019	1.328	.267
	Within Groups	.220	15	.015		
	Total	.239	16			
Dc_8_4	Between Groups	.000	1	.000	.031	.862
	Within Groups	.096	15	.006		
	Total	.097	16			
Dc_8_7	Between Groups	.031	1	.031	1.989	.179
	Within Groups	.232	15	.015		

	Total	.262	16			
	Between Groups	.002	1	.002	.111	.743
Dc_8_8	Within Groups	.224	15	.015		
	Total	.226	16			

Delta Coherence, Eyes Open

Coherence in this band was similarly compared with personality and ROI for the eyes open condition in the Delta band. Two statistically significant interactions were noted: coherence within ROI 4 (p<.035) and coherence within ROI 7 (p<.029).

Table 19: ANOVA, Average Coherence, Region by Personality in Delta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	.031	1	.031	1.863	.192
Dc_3_3	Within Groups	.252	15	.017		
	Total	.284	16			
	Between Groups	.002	1	.002	3.199	.094
Dc_4_3	Within Groups	.008	15	.001		
	Total	.010	16			
	Between Groups	.077	1	.077	5.343	.035
Dc_4_4	Within Groups	.216	15	.014		
	Total	.293	16			
	Between Groups	.014	1	.014	1.090	.313
Dc_7_3	Within Groups	.188	15	.013		
	Total	.201	16			
	Between Groups	.026	1	.026	2.316	.149
Dc_7_4	Within Groups	.168	15	.011		
	Total	.194	16			
	Between Groups	.040	1	.040	5.872	.029
Dc_7_7	Within Groups	.101	15	.007		
	Total	.141	16			
	Between Groups	.014	1	.014	1.303	.272
Dc_8_3	Within Groups	.166	15	.011		
	Total	.181	16			
Dc_8_4	Between Groups	.000	1	.000	.029	.866

	Within Groups	.107	15	.007		
	Total	.107	16			
	Between Groups	.016	1	.016	.792	.388
Dc_8_7	Within Groups	.312	15	.021		
	Total	.329	16			
	Between Groups	.002	1	.002	.081	.780
Dc_8_8	Within Groups	.315	15	.021		
	Total	.316	16			

Theta Coherence, Eyes Closed

Coherence between the different ROIs within the DMN was compared between personality types using ANOVA in the Theta frequency band. Non-DMN regions were ignored, as with other frequency bands. Coherence within ROI 4 and between ROIs 3 and 4 had near significant interactions ($p \leq .054$ and $p \leq .052$) and coherence within ROI 7 had a significant difference between personality types ($p < .05$).

Table 20: ANOVA, Average Coherence, Region by Personality in Theta Band, Eyes Closed

		Sum of Squares	df	Mean Square	F	Sig.
	Between Groups	.049	1	.049	3.171	.095
Tc_3_3	Within Groups	.234	15	.016		
	Total	.283	16			
	Between Groups	.004	1	.004	4.363	.054
Tc_4_3	Within Groups	.013	15	.001		
	Total	.016	16			
	Between Groups	.054	1	.054	4.459	.052
Tc_4_4	Within Groups	.183	15	.012		
	Total	.237	16			
	Between Groups	.000	1	.000	.016	.900
Tc_7_3	Within Groups	.083	15	.006		
	Total	.083	16			
Tc_7_4	Between Groups	.005	1	.005	3.907	.067
	Within Groups	.019	15	.001		

	Total	.024	16			
Tc_7_7	Between Groups	.019	1	.019	4.586	.049
	Within Groups	.062	15	.004		
	Total	.081	16			
Tc_8_3	Between Groups	.010	1	.010	.713	.412
	Within Groups	.211	15	.014		
	Total	.222	16			
Tc_8_4	Between Groups	.000	1	.000	.004	.949
	Within Groups	.052	15	.003		
	Total	.052	16			
Tc_8_7	Between Groups	.023	1	.023	2.180	.161
	Within Groups	.155	15	.010		
	Total	.178	16			
Tc_8_8	Between Groups	.000	1	.000	.030	.866
	Within Groups	.240	15	.016		
	Total	.241	16			

Theta Coherence, Eyes Open

Coherence was compared with personality and ROI in the same manner for the eyes open condition in the Theta Band. For this condition, coherence within ROI 4 had a significant interaction with personality ($p<.027$). Coherence within ROI 7 approached significance ($p<.074$).

Table 21: ANOVA, Average Coherence, Region by Personality in Theta Band, Eyes Open

		Sum of Squares	df	Mean Square	F	Sig.
Tc_3_3	Between Groups	.037	1	.037	2.631	.126
	Within Groups	.211	15	.014		
	Total	.248	16			
Tc_4_3	Between Groups	.002	1	.002	2.524	.133
	Within Groups	.012	15	.001		
	Total	.014	16			
Tc_4_4	Between Groups	.086	1	.086	6.028	.027
	Within Groups	.213	15	.014		
	Total	.299	16			

	Between Groups	.000	1	.000	.066	.800
Tc_7_3	Within Groups	.062	15	.004		
	Total	.063	16			
	Between Groups	.013	1	.013	1.630	.221
Tc_7_4	Within Groups	.119	15	.008		
	Total	.132	16			
	Between Groups	.018	1	.018	3.689	.074
Tc_7_7	Within Groups	.075	15	.005		
	Total	.094	16			
	Between Groups	.010	1	.010	1.685	.214
Tc_8_3	Within Groups	.086	15	.006		
	Total	.096	16			
	Between Groups	.001	1	.001	.176	.680
Tc_8_4	Within Groups	.062	15	.004		
	Total	.062	16			
	Between Groups	.027	1	.027	2.209	.158
Tc_8_7	Within Groups	.183	15	.012		
	Total	.211	16			
	Between Groups	.002	1	.002	.130	.723
Tc_8_8	Within Groups	.286	15	.019		
	Total	.288	16			

Chapter 6

Discussion

Previous work comparing cortical networks and personality type has uncovered differences between introverts and extraverts, usually in terms of differing activity in specific frequency bands in specific regions of the DMN and other networks (Jausovec and Jausovec, 2007) (Fink and Neubauer, 2002) (Knyazev et al, 2012). Previous work has determined average differences in power between DMN regions, both as a function of personality and only in terms of differing regions (Knyazev, 2012). More detailed work comparing the various frequency bands has indicated that the theta and delta bands may be most significant for DMN activity, which is logical based on their activation during periods without external stimulation (Chen et al, 2008). In this study, the four frequency bands were each assessed separately for the ROIs important to the DMN as well as for other ROIs to provide potential comparisons.

In the power analyses between ROIs and personality and each frequency band, no statistically significant relationships were observed for either the eyes open or eyes closed conditions (Tables 2-13). Moreover, none of the interactions noted were near statistical significance, indicating that spectral power within the DMN is not closely related with personality type. While this is somewhat inconsistent with existing research, this may be due in part to the ways in which the brain regions were compartmentalized for analyses. Knyazev (2012) noted a specific difference in DMN activity between the anterior and posterior regions, which was not possible to analyze in this experiment because only non-DMN information (occipital lobes) and a DMN region of the brain that is potentially too deep to get accurate EEG data for (posterior cingulate cortex) were available for the posterior cortex. Therefore, this prevented a posterior-anterior comparison and replication of the aforementioned experimental results. Left and right ROIs were also grouped together, but there is not as much existing research to suggest DMN differences between these two sides, and this analysis was also not undertaken for spectral power. Furthermore, the lack of significance in both the eyes open and eyes closed conditions may indicate a lack of interaction between personality and the networks, since each of these conditions should theoretically activate different networks and allow that difference to be measured.

There also may be value to looking at frequency power averaged over the DMN as a whole, and compared to non-DMN regions to test for personality differences on a network level. This was performed for the Delta band (Tables 7 and 9) and the Theta band (Tables 11 and 13) for both conditions, but no significant interactions were detected in either band. Alpha and beta were not analyzed because of a lack of pre-existing research into DMN power in these bands. The lack of significant interactions between the network itself and personality indicates that in terms of this study, DMN and personality interactions are not easily elucidated by spectral power alone. Future studies may benefit from examining more non-DMN ROIs to draw comparisons, such as other cortical networks. This may lead to discovery of underlying interactions.

In addition to spectral power, coherence between different ROIs in each frequency band was analyzed against personality type for both eyes open and eyes closed conditions (Tables 14-21). Coherence could be particularly useful for network analysis compared to analysis of single brain regions because it better represents the correlated activity of the network as a whole, and not just transient similarities between different regions. Indeed, prior studies have indicated that coherence within the network is significant, and can be altered by outside stimuli such as anesthesia (Deshpande et al, 2010). In terms of personality, prior research with fMRI has indicated that synchronization between different DMN regions can be a good predictor of introversion or extraversion (Wei et al, 2011), while alpha and beta synchronization in EEG can be useful for assessing patients in vegetative state (Fingelkurts, et al. 2012).

In this study, coherence was compared between the DMN regions in each frequency band using ANOVA. For the eyes closed condition, there were no meaningful interactions in the alpha or beta bands (all $p<.05$), although difference in coherence between ROIs 3 and 4 (the left and right lateral parietal cortices) in the Beta band was near significance when compared between the two personality groups ($p<.061$, Table 16). A potential left-right interaction in Beta band is interesting, as prior studies have not focused on this type of spatial comparison. Since the Beta band is also less studied than the other frequency bands in the DMN, it is possible that this represents a new area of potential research, since other variables (such as handedness) could be interacting with personality type. Regardless, the difference was above the accepted threshold for significance and is to be rejected for the purposes of this study.

Coherence for the eyes open condition provided similar results. There were no significant interactions in the Alpha or Beta bands, but difference in coherence between ROIs 3 and 4 approached significance in the Beta Band ($p<.066$, Table 17). This similarity in the Beta band between the two conditions is intriguing, since Beta activity is commonly associated with active attentiveness, and would likely be more closely tied to the eyes open condition. An increase in neural activity during EEG has been tied to EEG shifts to the Beta band (Scheeringa, 2008). The similarity in coherence difference suggests a stimulus-independent coherence difference between these two brain regions when compared with personality type. While this may not be useful for comparing cortical networks that are active during either stimulation or a lack of stimulation, it could be useful for comparing discrete brain regions.

Difference in coherence between personality types in the Delta band for the eyes closed condition also did not meet the criteria for statistical significance (all $p>.05$), but two interactions were close and may warrant further review. Similar to the Beta band, ROI 4 represented a possible difference between personality types, but in this case, it was average coherence with ROI 4 itself. ROI 4 represents the right lateral parietal lobe, and in this case the interaction was near the threshold for significance ($p<.067$, Table 18). Coherence within a specific brain region differing between personality types may indicate local differences as opposed to network wide differences. Another ROI in the Delta band that came close to significance (p<.051, Table 18) was ROI 7, the medial prefrontal cortex. This ROI represents the anterior portion of the DMN, and is closely tied to self-referential DMN activity (Gusnard, et al. 2001). Self-referential thought, in turn, is tied with introversion, and is one of the justifications for studying the connection between these personality types and the DMN. Therefore, while not at statistical significance, this relationship in the Delta band could be potential evidence for the personality link.

Comparisons of delta coherence for the eyes open condition, on the other hand, did results in a significant interaction. Coherence within ROI 4 was significantly different between the two personality types and other ROIs (p<.035, Table 19). This interaction was similarly noted for the eyes closed condition, but did not reach statistical significance. Furthermore, difference in coherence within ROI 7, which was near significance for the eyes closed condition, was significant for the eyes open condition (p<.029, Table 19).

Lastly, coherence in the Theta band was compared with personality types. For the eyes closed condition, coherence difference by personality type within ROI 4 and between ROIs 3 and 4 were both just short of statistical significance (p<.054 and p<.052, Table 20) just as in the Delta and Beta bands, respectively. This is further potential evidence for the relationship between personality and these parts of the DMN. However, unlike the other frequency bands for the eyes closed condition, there was a statistically significant interaction between ROI coherence and personality type: coherence with ROI 7 (p<.049, Table 20). This is similar to the interaction observed in the Delta band. For the eyes open condition, difference in coherence within ROI 4 was significant (p<.027, Table 21) and difference in coherence within ROI 7 was near significance (p<.074, Table 21). This is further evidence for the relationship between this part of the network, which is already highly correlated with personality type, and introversion/extraversion. Furthermore, theta activity in particular has been correlated with DMN activity in the frontal cortex, as shown by Knyazev and associates (2012). In that study, extraversion was associated with higher activity in the frontal cortex and lower activity in the posterior cortex. While the posterior portion cannot be verified due to lack of posterior DMN ROIs in this study, and the anterior results are consistent and indicate a potential relationship between extraversion and DMN coherence in this region.

Recurring similarities in coherence differences between the two conditions (eyes open and eyes closed) may seem somewhat contradictory in terms of network activation, but similarities in EEG between the two baseline states is consistent with existing research (Yan, 2009). Instead, trends between the two networks in personality differences only strengthen the evidence for average network wide differences between the two personality types. While eyes closed behavior is most often associated with self-referential thought and subsequent DMN activation, it is also possible that the eyes open condition, with no other stimulation, may activate the DMN in a similar way. As mentioned by the authors of the study, this could have important implications for the creation and use of baselines at the beginnings of EEG studies.

Future research should focus on coherence values between different ROIs, and comparing overall coherence across the network between personality types. It would also be useful to compare power between different sides of the brain, which was no possible in this study, in order to search for some of the differences that were detected in coherence. ROIs 3, 4, and 7 would be useful areas to look at in future personality studies because of the significant interactions with personality type that were detected in this study. Furthermore, a comparison between different baseline conditions, such as eyes open and eyes closed, would be useful in elucidating the interactions detected within this study. The same general trends in coherence were detected for each condition, but a comparison would be useful. This would probably require greater statistical power (more participants) than what was available for this study. Indeed, greater power would be useful for exploring some of the detected interactions. Lastly, since there were some potential differences between the Left and Right brain between personality type, obtaining information on other Left/Right differences in participants could identify a potential lurking variable interaction.

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APPENDIX A: NEO-FFI Questionnaire

NEO-FFI

There are no “right” or “wrong” answers, and you need not be an “expert” to complete this questionnaire. The purpose of this questionnaire will be best served if you describe yourself and state your opinions as accurately as possible.

A	B	C	D	E
Strongly Disagree or Definitely False	Disagree or Mostly False	Neutral Agree or Equally True/False	Agree or Mostly True	Strongly Agree or Definitely True

1. I am not a worrier.
2. I like to have a lot of people around me.
3. I don’t like to waste my time daydreaming.
4. I try to be courteous to everyone I meet.
5. I keep my belongings neat and clean.
6. I often feel inferior to others.
7. I laugh easily.
8. Once I find the right way to do something, I stick to it.
9. I often get into arguments with my family and co-workers.
10. I’m pretty good at pacing myself so as to get things done on time.
11. When I’m under a great deal of stress, sometimes I feel like I’m going to pieces.
12. I don’t consider myself especially “light-hearted.”
13. I am intrigued by the patterns I find in art and nature.
14. Some people think I’m selfish and egotistical.
15. I am not a very methodical person.

16. I rarely feel lonely or blue.
17. I really enjoy talking to people
18. I believe letting students hear controversial speakers can only confuse and mislead them.
19. I would rather cooperate with others than compete with them.
20. I try to perform all the tasks assigned to me conscientiously.
21. I often feel tense and jittery.
22. I like to be where the action is.
23. Poetry has little or no effect on me.
24. I tend to be cynical and skeptical of others' intentions.
25. I have a clear set of goals and work toward them in an orderly fashion.
26. Sometimes I feel completely worthless.
27. I usually prefer to do things alone.
28. I like to often try new and foreign foods.
29. I believe that most people will take advantage of you if you will let them.
30. I waste a lot of time before settling down to work.
31. I rarely feel fearful or anxious.
32. I often feel as if I'm bursting with energy.
33. I seldom notice the moods or feelings that different environments produce.
34. Most people I know like me.
35. I work hard to accomplish my goals.
36. I often get angry at the way people treat me.
37. I am a cheerful, high-spirited person.
38. I believe we should look to our religious authorities for decisions on moral issues.
39. Some people think of me as cold and calculating.
40. When I make a commitment, I can always be counted on to follow through.
41. Too often, when things go wrong, I get discouraged and feel like giving up.
42. I am not a cheerful optimist.
43. Sometimes when I am reading poetry or looking at a work of art, I feel a chill or wave of excitement.
44. I'm hard-headed and tough-minded in my attitudes.
45. Sometimes I'm not as dependable or reliable as I should be.
46. I am seldom sad or depressed.
47. My life is fast-paced.
48. I have little interest in speculating on the nature of the universe or the human condition.
49. I generally try to be thoughtful and considerate.
50. I am a productive person who always gets the job done.
51. I often feel helpless and want someone else to solve my problems.
52. I am a very active person.
53. I have a lot of intellectual curiosity.
54. If I don't like people, I let them know it.
55. I never seem to be able to get organized.
56. At times I have been so ashamed I just wanted to hide.
57. I would rather go my own way than be a leader of others.
58. I often enjoy playing with theories or abstract ideas.
59. If necessary, I am willing to manipulate people to get what I want.
60. I strive for excellence in everything I do.

APPENDIX B: Beginning Baseline Conditions

Eyes Open Baseline

Instructions:

1). Please keep your eyes OPEN on the upcoming trial and keep your gaze on the computer screen. The trial will begin once these instructions disappear- about 1 minute from now.

2.) It is VERY important to keep your body as still as possible. This includes blinking and moving your eyes as little as possible. Body movements, blinking and eye movements interrupt our recording of your brain activity.

NOTE: Please do not limit your blinking so much that it irritates your eyes.

3.) The computer will let you know when the trial has ended.

4.) When these instructions disappear, it means the trial has begun and will last for 1 minute…

Eyes Closed Baseline

Instructions:

1.) Please keep your eyes CLOSED on the upcoming trial. The trial will begin once these instructions disappear- about 1 minute from now.

2.) It is VERY important to keep your body as still as possible. This includes moving your eyes as little as possible. Body movements, blinking and eye movements interrupt our recording of your brain activity.

3.) The experimenter will let you know when the trial has ended.

4.) When these instructions disappear, it means the trial has begun and will last for 1 minute…

ACADEMIC VITA

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Education

B.S., Biology, 2013, Pennsylvania State University, University Park, PA

Honors and Awards

- NSF REU Summer Fellowship, Dauphin Island Sea Lab, AL. 2012
- Summer Research Grant, Schreyer Honors College. 2010, 2011
- President's Freshman Award, Pennsylvania State University. 2010

Association Memberships/Activities

- Phi Beta Kappa

Research Interests

I have interests in psychiatric pathologies, particularly depression and addiction.

Professional Presentations

- "A Survey of DMSP in *Mugil cephalus* and Other Common Gulf Baitfish" Dauphin Island Sea Lab, Dauphin Island, Alabama. August 2012