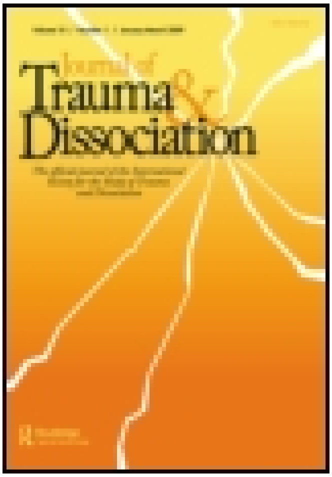

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EEG Coherence and Dissociative Identity Disorder

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EEG Coherence and Dissociative Identity Disorder: Comparing EEG Coherence in DID Hosts, Alters, Controls and Acted Alters

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ABSTRACT. This is the first study to apply EEG coherence analysis to the study of Dissociative Identity Disorder (DID). EEG coherence is argued to be an objective measure of cortical connectivity. Five DID patients were compared to five controls, who were professional actors. Fifteen dissociated DID alter states were studied, as were 15 "alters"

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simulated by the actor control participants. Comparisons of EEG coherence were made between DID participants and controls. Significant differences in EEG coherence were found in comparing DID host and alter personalities, with coherence found to be lower in the alter personalities. No significant differences were found in comparing DID host personalities and controls. The acted alters matched for age and gender, showed no significant differences in coherence compared to DID alter personalities. The results indicate that EEG coherence may be an objective measure of the neuronal cortical connectivity associated with DID.

KEYWORDS. DID, EEG coherence, dissociation, trauma

INTRODUCTION

Researchers have used neurophysiological techniques to examine differences in DID host personalities compared to alter personalities and to controls in an attempt to objectively validate the existence of DID and to better understand the physiological concomitants of this disorder. One electrophysiological parameter, the electroencephalogram (EEG), has been recorded for both host and alter personalities (Miller & Triggiano, 1992; Putnam, 1991; Putnam, Guroff, Silberman, Barban, & Post, 1986). Whilst some researchers have reported differences in the EEG between the host personality and some alters (Ludwig, Brandsma, Wilbur, Benfeldt, & Jameson, 1972; Rosenstein, 1994; Thigpen & Cleckley, 1954) others have reported few differences in specific EEG variables such as the amplitude between alters and role-playing controls (Coons, Milstein, & Marley, 1982). Flor-Henry, Tomer, Kumpula, Koles and Yeudall (1990) examined EEG measures in two cases of DID with four and five alter personalities. Eight of the nine alter personalities recorded greater alpha band spectral power in the right hemisphere compared to the left across all conditions (eyes open, eyes closed, and during verbal and spatial tasks).

Previous studies examining neurophysiological variables in DID have generally reported inconsistent results and have been based primarily on single case study designs. Petsche (1997) suggested that if electrical properties of a cortical system were to be studied using the

EEG, it would be more valuable to compare EEG signal parameters between different areas, rather than observe the amplitude or time course of activity at individual locations, which is the approach that is usually utilized in studies of EEG and event related potentials. An example of the former approach is EEG phase consistency or synchrony (Thatcher, Krause, & Hrybyk, 1986).

EEG coherence is an objective measure of phase synchrony, which has previously been reported to be useful for measuring brain topography related to cognitive tasks, psychopathology and other aspects of brain organization (Shaw, 1981, 1984). EEG coherence is a statistical estimate of the correlation between pairs of electrodes as a function of frequency, quantifying the correlation for a given discrete frequency band for selected epoch lengths independently of signal amplitude (French & Beaumont, 1984). Frequencies of EEG activity at each electrode or channel can be determined by a power spectral analysis and the covariance of spectral activity between two channels can be determined for each frequency by coherence (French & Beaumont, 1984; Petsche, 1997).

In a review of the application of coherence to the EEG, Shaw (1984) noted that subtle inter-channel differences may be interpreted as indicating differences in electrical activity in different parts of the cortex, and that these may have some functional significance. Thatcher et al. (1986) and Tucker, Roth, and Blair (1986) quantified the degree of connectivity between cortical regions on the basis of EEG coherence estimates. Kaiser and Gruzelier (1996) have compared early and late maturing adolescents in EEG coherence estimates. Late maturers demonstrated higher short distance coherence, and higher intra-hemispheric long distance coherence. It was suggested that the state of maturity of the cortex could be differentiated in terms of neuronal connectivity as measured by coherence. Such an interpretation may be relevant for DID particularly if they are hypothesised to show aberrant neural maturation.

Although EEG coherence has not been studied specifically in DID, it has been studied in other forms of trauma. Teicher et al. (1997) used EEG coherence to study abnormal cortical development in physically and sexually abused children. Fifteen severely abused children who were inpatients were compared to 15 healthy controls. Intra-hemispheric coherence was computed for the alpha frequency band. Increased left hemispheric coherence was found in the abused children compared to the controls, suggesting that early childhood trauma may have a significant effect on regional cortical development and regional connectivity.

A number of difficulties remain in understanding previous studies employing EEG measures in the study of DID. First the over-reliance of single case studies does not provide an opportunity to use statistical measures with which to assess differences in neurophysiological parameters between DID hosts, alters, and controls. This is particularly important if small differences in neurophysiological variables exist, which may not be detected in a single case study design. Second, few studies have satisfactorily examined the false memory phenomenon, which is one of the most pressing aetiological issues in DID (Dell, 1988). Ross (1997) has noted that few studies have used role-playing controls to investigate the possibility of fabrication in this disorder. This is an important omission, because neurophysiological differences between DID patients, alter personalities and controls may merely reflect role playing by the DID patient's alter personalities. Such differences may help resolve questions raised by critics such as Merskey (1992) who has suggested that the unprecedented numbers of DID cases which have been diagnosed in the USA recently may be a result of widespread publicity, and that cases may possibly be iatrogenically produced in suggestible patients (see Beahrs, 1994, and Gleaves, 1996, for a review of this issue).

The suggestion by Flor-Henry et al. (1990) that EEG changes observed in the phenomenology of DID alter personalities may be associated with developmental changes in limbic structures is worth further investigation. The hippocampus has been implicated in the role of memory storage and retrieval and may be the primary locus for the generation of dissociative states (Mesulam, 1981). Flor-Henry et al. (1990) suggested that the experience of extreme trauma which characterises DID patients may lead to a "disruption of hippocampal inhibition, disrupting the organization of the dominant hemisphere, triggered later in life by right hemisphere modulated affective states" (p.158). Teicher et al. (1997) have reviewed the literature, suggesting that the brain is relatively plastic, and that its final form and function are guided by early experiences as well as by genotypic expression. If early stress and trauma adversely affect neural maturation then some brain regions may be more vulnerable, a conclusion also made by Bremner et al. (1995), who studied the effects of post-traumatic stress on regional brain atrophy. It has also been reported that when primate hippocampi were exposed to "stress" hormones associated with glucocorticoids for one year, damage was noted in the form of cell layer irregularity, soma shrinkage and dendritic atrophy (Sapolsky, Uno, Rebert, & Finch, 1990).

Teicher, Yutaka, Glod, Schiffer, and Gelbard (1996) also suggest that the prefrontal cortex has the most delayed ontogeny of any brain region, with myelination occurring during adolescence and continuing through the seventh decade. Dopamine projections to the prefrontal cortex have been reported by Teicher et al. (1996) to be specifically activated by stress. These authors theorised that stress may lead to early maturation, of the developing prefrontal cortex, which may halt further differentiation of this region and prevent it from reaching full adult functionality. Consistent with this hypothesis, abuse occurring before the age of 18 has been reported to have a greater impact on limbic system functioning than abuse after age 18 (Teicher et al., 1996).

The approach proposed by Teicher et al. (1997) in the context of early life trauma has direct application to investigating DID. The present study therefore applies EEG coherence techniques in the objective comparison of DID host and alter personalities. Furthermore, this comparison is augmented by comparing DID patients with professional actors who role-played on the basis of age and gender corresponding to each DID host and alter personality, as suggested by Hughes, Kuhlman, Fichtner, and Gruenfeld (1990), Putnam (1984) and Ross (1997). As variations in alpha EEG has been reported to be a consistent finding in the few DID EEG studies reported (Flor-Henry et al., 1990; Hughes et al., 1990; Larmore, Ludwig, & Cain, 1977; Ludwig et al., 1972; Teicher et al., 1996), it was hypothesised that differences in average alpha coherence will be observed in comparing DID host personalities, alter personalities, actors and acted alters. Specifically, from the observations in trauma reported by Teicher et al. (1997) it was hypothesised that coherence would be lower in DID hosts compared to controls, and that coherence would be lower in DID alters compared to host personalities. Significant differences in EEG coherence between host and alter personalities but not between control "hosts" and acted alters would provide physiological evidence for the authenticity of DID.

METHOD

Participants

The study sample comprised of five DID outpatients (age $M = 40.4$ years, $SD = 13.3$ years) attending a specialist medical centre in Melbourne, Australia. All patients met the DSM-IV diagnostic criteria for DID. DID patients had been in therapy for between two and eight years.

Fifteen alter personalities emerged for EEG recordings (age $M = 10.6$ years, $SD = 8.6$ years, ranging from 3 to 31 years) with two to four alters per host. Controls consisted of five age-matched professional actors (age $M = 39.6$ years, $SD = 12.2$ years) who role-played the various alter personalities. The actors were recruited through professional acting agencies and had a minimum of five years experience. The actors reported no prior history of psychiatric illness.

DID patients were requested to supply information about their alter personalities to assist in briefing the actors to realistically play the role of the alter personalities. The patients were recruited by their therapist. The DID patients were subsequently interviewed by the chief investigator (AH) in the presence of their therapist at the therapy center prior to recording, and after a complete description of the study the patients provided written informed consent. The research was approved by the Swinburne University Human Research Ethics Committee.

Procedure

Eliciting the Alter Personalities

During the initial interview between the investigator and the patients in the presence of the therapist there was an opportunity to establish some rapport and trust with the clients. In this setting the discussion included the question of which alters would like to participate in the study. In the same setting the electrode cap was demonstrated and worn by some of the hosts and alter personalities. Characteristics, gender and handedness of the alters were discussed and recorded for subsequent identification.

During the subsequent EEG recording session the investigator asked the host personality "who would like a turn next?" Alters emerged freely. They were asked their name and how they were feeling, and an explanation and a practice run of the cognitive task was undertaken. For all of the participants, it appeared that all alters remained stable throughout their recording period of approximately three minutes. All EEG recordings for all subjects were done in one sitting.

Recording

EEGs were recorded using a 64-channel electrode cap, based on the international 10-20 system (Jasper, 1958) with extra electrodes equally spaced in between the standard 10-20 electrodes, and signals were referenced to linked-earlobes with a vertex electrode as ground. Typical amplification was 375 K, with band pass filters set at 0.15 Hz and 30 Hz. Signal sampling rate was 248 Hz. Recording, digitization and processing of EEG data were carried out with SYN Amp amplifiers and a Neuroscan system–version 3.0 (Neuroscan, 1993). An averaged reference system was used. Due to the preliminary investigative nature of this study, the 21 lead montage of bipolar electrode pairs chosen were based on those advocated by Kaiser and Gruzelier (1996), Petsche (1997) and Thatcher et al. (1986). The electrode pairs selected were: FP1-F7, FP2-F8, F3-T3, F4-T4, T3-T4, T3-TCP1, T4-TCP2, T5-T6, C3-C4, C1-C2, C1-C2P, C2-C1P, C3-C1P, C4-C2P, C6-C4P, P3-P4 P3-P1P, P4-P2P, T5-O1, T6-O2 and O1-O2.

Participants were instructed to minimise movement and to attend to and perform a cognitive task. EEG signals were recorded continuously for five minutes, during which task events were recorded. Task stimulus events were used to retrospectively align task epochs for each trial. Epoch analysis started at 100 msec pre-stimulus and ended at 924 msec post-stimulus, with an average of thirty epochs for each condition. Baseline correction was applied using the pre-stimulus epoch segments. All epochs were visually examined and epochs contaminated with eye or muscle artefact were rejected. EEG signal epochs of 1.024 seconds were then analysed to calculate coherence. Coherence data were generated using a minimum of 10 artefact free epochs per subject per condition. Although coherence was recorded across all frequency bands, because of the large amount of EEG data generated and the subsequent large number of analyses that would need to be computed only alpha (8-13 Hz) coherence was analysed. The methodology closely followed methodologies employed in previous studies (Flor-Henry et al. 1990; Larmore et al. 1977; Ludwig et al. 1972; Teicher et al. 1997).

Cognitive Task

A cognitive task was administered to ensure uniformity of brain information processing in all subjects during the EEG recording. The task selected for this purpose was a spatial memory task (Neuroscan, 1993). Subjects were asked to remember the position of two blocks on a computer screen and to place blocks in matching positions in a following screen presented 0.5 seconds later. There was a delay of 0.5 seconds before the next trial. All participants, including the youngest alter personalities, were able to perform the spatial memory task successfully.

Analysis

The sample data was allocated to two conditions: Group (DID host/actor) and State (DID alter/acted-alter). A 2 (Group) by 2 (State) by 21 (Electrode pairs) analysis of variance (ANOVA), with repeated measures on State and Electrode pair variables, was conducted. Post hoc paired t-tests were used to investigate the significance of differences between DID host and alter personalities and between actor (control) and acted personalities. In the absence of prior studies of coherence in DID, EEG findings for early trauma reported by Teicher et al. (1997) and findings for DID reported by Flor-Henry et al. (1990) suggest that differences between host and alter personalities will be widely distributed across the cortex.

RESULTS

The ANOVA revealed significant main effects between Electrode and Group ($F\ (1,20) = 2.09, p < .01$) and between State and Electrode ($F\ (1,20) = 2.45, p < .01$). There was no significant difference between State and Group ($F\ (1,20) = 0.88, p > .09$). A significant three-way interaction between Group, State and Electrode ($F\ (1,20) = 3.30, p < .001$) was also found. The Huynh-Feldt correction was used to minimise the effects of violation of the assumption of homogeneity of covariance.

Perhaps the most important series of analyses of coherence were conducted between host personality and alter personalities and between actor/control and acted personalities. Mean alpha coherence values for the DID Hosts, Alters, Actors and Acted Alters are shown in Table 1. It is apparent from Table 1 that the mean alpha coherence values were very similar for the DID Hosts, Actors and Acted Alters. However there were six significant analyses recorded between DID host and Alter Personalities. Paired t-tests on mean alpha coherence values for DID patients (Hosts) and Alter personalities across all electrode pairs, revealed significant differences in some frontal, temporal, parietal and central regions. Significant differences ($p < .05$) were found between host and alter personalities at the six regions, as seen in Figure 1, and these analyses suggest that the average alpha coherence values differ significantly at specific cortical areas between DID host and Alter personalities. Because this is the first study examining EEG coherence in DID, and because such a study is intended to develop specific testable hypotheses for future research a correction in the alpha level for the

TABLE 1. Mean alpha coherence values for DID host and alter personalities, actors and acted alters. Statistical comparisons are made between DID host and alter personalities and between actors and acted alters.

Electrode Pairs	DID Host n = 5	DID Alters n = 15	Actors n = 5	Acted Alters n = 15
FP1-F7	0.53	0.51	0.54	0.51
FP2-F8	0.54	0.60	0.65	0.52
F3-T3	0.35	0.41	0.41	0.32
F4-T4	0.29 *	0.21*	0.35	0.25
T3-T4	0.18	0.12	0.13	0.08
T3-TCP1	0.54	0.24	0.56	0.49
T4-TCP2	0.57 *	0.23*	0.51	0.42
T5-T6	0.27 *	0.47*	0.25	0.27
C3-C4	0.33	0.43	0.54	0.51
C1-C2	0.78	0.80	0.85	0.82
C1-C2P	0.70	0.25	0.74	0.77
C2-C1P	0.72	0.25	0.72	0.79
C3-C1P	0.73 *	0.37*	0.84	0.81
C4-C2P	0.75 *	0.28*	0.71	0.77
C6-C4P	0.78 *	0.31*	0.70	0.68
P3-P4	0.55	0.50	0.66	0.65
P3-P1P	0.85	0.57	0.87	0.85
P4-P2P	0.84	0.53	0.88	0.86
T5-O1	0.62	0.55	0.69	0.64
T6-O2	0.67	0.52	0.69	0.62
O1-O2	0.71	0.57	0.75	0.75

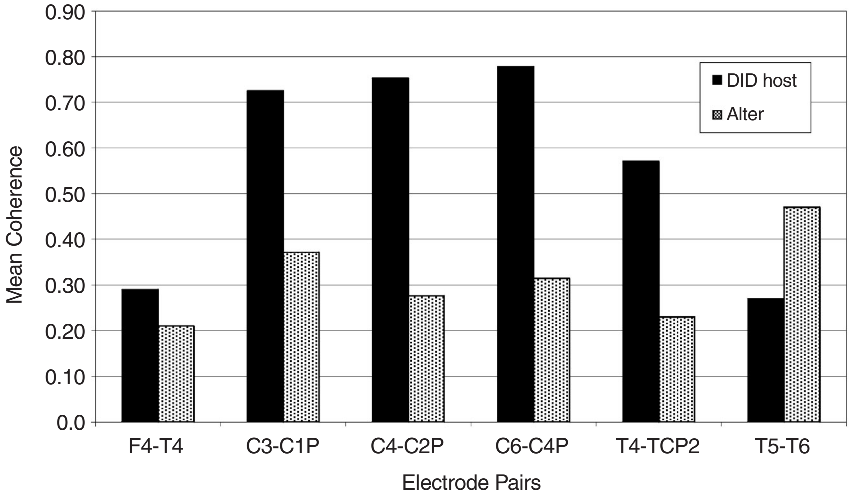
* $p < .05$

number of analyses was not performed. Examining the analyses conducted between host and alters indicates that by chance approximately 1 of the 21 tests should be significant at the .05 level by chance, assuming that the analyses are independent. The results of these analyses indicated that 6 out of the 21 tests were significant at the .05 level. Conversely, none of the analyses between control and acted alter were significant. This pattern of results suggests a robust finding in which we there is a high degree of confidence in concluding that some differences exist between host and alters but not between controls and acted alters.

DISCUSSION

The hypothesis that there would be differences in average alpha coherence between DID patients, actors, the acted alters and the DID alter

FIGURE 1. Mean alpha coherence for DID host and alter personalities



personalities was supported. Significant interactions were observed between Group, State and Electrode pairs. DID hosts and controls matched for age and sex recorded similar patterns of coherence. Only for DID alters were significant differences observed in EEG coherence across electrode positions compared to the host personality. Coherence values for professionally acted alters did not resemble those recorded for the corresponding alter personalities. The professional actors were not able to simulate the coherence patterns of the alter personalities indicating that EEG coherence, at least in the present study is not able to be simulated or faked from information relating to age and sex.

The present study found significant differences between the host and alter personalities in EEG coherence in specific regions of the brain. The average alpha coherence was lower for the alter personalities, compared to the host personalities, at most electrode site pairs. It has been proposed on clinical grounds that the difference between host and alter personalities is that the dissociated parts store the traumatic memories experienced by the host (Ross, 1997). Significant differences in EEG coherence specific to DID, between host and alter personalities would permit the conclusion that there may be different underlying neural mechanisms which may be associated with their ability to dissociate. It has been argued that the performance by alter personalities may have been simulated. However if this was the case, then another explanation must be found to explain the observed differences between DID hosts and alters.

Following the report by Kaiser and Gruzelier (1996) of age-related EEG coherence changes, the EEG coherence differences among DID alter personalities could be suggestive of age-congruent EEG differences. From a developmental perspective, Thatcher et al. (1986) suggested that EEG coherence increases with myelination and development of association pathways. If decreases in coherence values are associated with disruption to these developmental processes, possibly related to early trauma, then neurophysiological changes may be evident in specific areas of the brain. Of course myelogenic changes can not be invoked to account for state differences in DID patients, only for trait differences between DID patients and controls. However, in the present study no significant differences in EEG coherence were observed in comparing DID hosts with controls. The principal differences observed were between host and alters, with the latter showing lower coherency. Given the arguments by Teicher et al. (1997) and Mesulam (1981), if it is accepted that DID patients have a significant cortical "maturational lag" compared to the controls, then the critical difference between DID patients and controls may be the capacity to dissociate in the former (Putnam, 1984). Reduced EEG coherence between the data from bipolar derivations associated with certain brain regions is thought to reflect functional disconnection (Dunkin & Leuchter, 1984, Thatcher et al. 1986; Tucker et al. 1986). Apter (1991) has equated functional disconnection with dissociative phenomenon, which is therefore consistent with the observation of lower coherence in the DID alters only.

Significant differences in alpha coherence for alter personalities were observed in frontal, central, temporal and parietal regions of the cortex. These differences may involve regions of the limbic association cortex (Putnam, Zahn & Post, 1990). Thatcher et al. (1986) postulated that greater topographic coherence in temporal regions may reflect greater amount of neural connectivity in these regions, compared to other cortical areas. This postulate is consistent with known anatomical connections to the temporal lobes, particularly that cortico-limbic interactions may occur through entorhinal and subicular pathways (Thatcher et al. 1986).

Putnam et al. (1990) has noted the risk that EEG differences between alter personalities may simply reflect differences in levels of arousal and muscle tension. Coons et al. (1982) added to this suggestion the possibility of artifactual differences due to variations in concentration intensity resulting from long duration of recording. None of these potential confounding factors could reasonably be suggested as the basis of the observed differences in EEG coherence between host and alter personalities in the current study.

In summary the present study found significant differences in EEG alpha coherence between Group (DID and actors) and States (alters and acting) across 21 electrode pairs. No significant differences were found between DID participants, actors, and acted alters. Differences were found between DID host and alter personalities at frontal, central, parietal and temporal regions of the cortex. These differences have been interpreted in terms of early trauma (amongst other causes) and to a "maturational lag" hypothesis in DID, possibly to greater degrees in some brain regions, and following the suggestions by Putnam (1984) it is postulated that this in turn may lead to a predisposition to dissociation. However, the exact cause of the differences in EEG coherence between alters and host is yet to be adequately studied.

The results from this preliminary study suggests that coherence may be an objective measure of the neuronal cortical connectivity associated with DID. It is envisaged that a further study of a larger group, incorporating all spectral bands and all electrode pairs may be a possible direction for future research. Importantly the results of the present study may allow future studies to test more specific hypotheses about brain coherence and DID.

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