3

Dissociative Tendency, Anger Expression, and Frontal Activation During a Verbal Fluency Task

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1. Introduction

Dissociation in adolescence has been described as a part of severe psychopathology with a complex comorbidity or serious trauma including sexual abuse (e.g., Chu and Dill, 1990; Sar et al., 2006). In contrast, it is also possible for healthy subjects to experience nonpathological (nonclinical) dissociation including daydreams or defense from strong stressors (de Ruiter et al., 2006). It is important to clarify the etiology of dissociative experiences. For example, a lack of integration of consciousness, amnesia, derealization, or depersonalization, and some neural mechanisms underlying dissociation could be reasonably hypothesized as core features of dissociative disorders (DD). Particularly, self-reference related regions such as the medial prefrontal or ventral frontal area might be involved in identity diffusion or multiple identity disorder (Reinders et al., 2003). Actually, recent advances in neuroimaging technology enable us to explore the brain functioning of dissociation. Although it is ideal to examine a patient with DD who is experiencing dissociation in vivo, it is simultaneously intrusive to induce pathological dissociation using reminders or stressors. According to the spectrum of dissociative experiences, another option would be to examine nonclinical dissociation or dissociative tendencies in a typical setting. Dissociative experiences usually begin in childhood, and less than 8% of the DD diagnoses are made in adolescents between the ages of 12 and 19 (Kluft, 1984). Some of the experiences are not subjectively distressful; therefore, dissociation might be underestimated as a clinical phenomenon (Foote et al., 2006). Furthermore, recent campus mental health professionals in Japan have often indicated that a trend for defence mechanism is "to dissociate from repression" in young adults (e.g., Takaishi, 2000). Based on these assumptions, the present study focused on nonclinical dissociative tendencies and investigated frontal functioning during a cognitive task in healthy university students.

Aggression or impulsivity is another important mental health topic in youth including attention-deficit hyperactivity disorder (ADHD) or childhood bipolar spectrum including temper dysregulation disorder. Impulsivity is related to the loss of response inhibition, particularly to the lack of frontal functioning (e.g., Chamberlain and Sakahian, 2007). A recent study concluded that slower cortical thinning in the prefrontal cortex during adolescence is characteristic of ADHD, providing neurobiological evidence for the

dimensionality of this disorder (Shaw et al., 2010). Anger is the most relevant emotion closely associated with impulsivity or aggression. Activity in the dorsal anterior cingulate cortex is positively related to self-reporting of anger and individual differences in general aggression (Denson et al., 2009). Another study (Hewig et al., 2004) reported that subjects with relatively greater left than right frontal cortical activity showed higher anger-out scores and lower anger-control scores. Furthermore, anger induction was uniquely associated with increased regional cerebral blood flow to the right temporal pole and thalamus. Based on these studies, it appears reasonable to investigate functional correlates of anger expression in youth.

Interestingly, one descriptive study reported a relationship between dissociative experiences and anger proneness in late adolescent females (Calamari and Pini, 2003). The authors stated that significant correlations were obtained between the Dissociative Experience Scale (DES) and the State-Trait Anger Expression Inventory (STAXI), confirming a connection between anger proneness and dissociation described in patients with dissociative disorders in a nonclinical sample. We also speculate that dissociation may be one of the defence mechanisms to cope with anger, impulsivity, or aggression. Consequently, frontal functioning may determine individual styles including expression, control, and suppression.

Near-infrared spectroscopy (NIRS) and the newly developed optic brain functional imaging are promising techniques because of their non-invasiveness and convenience. NIRS employs near-infrared light emitted and detected on the skull skin (Boas et al., 2004). It allows the monitoring of hemodynamic changes, which include both cerebral blood volume changes and oxygenation state, using a small apparatus with a high time resolution of about 0.1 s. It also allows the monitoring of changes in both oxygenated haemoglobin concentration [o-Hb] and deoxygenated haemoglobin concentration [d-Hb]. NIRS is suitable for studies of higher brain function because it enables measurements in a natural setting compared with other brain imaging techniques. For example, subjects can undergo an NIRS examination in the sitting position, with their eyes open, or while speaking (Suda et al., 2009). Taking advantage of these characteristics, several NIRS studies on psychiatric disorders, such as schizophrenia (Grignon et al., 2008; Takizawa et al., 2008), depression (Matsuo et al., 2005), eating disorders (Suda et al., 2010a; Uehara et al., 2007), and ADHD disorder (Ehlis et al., 2008), have been conducted. These characteristics of NIRS have also enabled the investigation of subjective experiences in healthy subjects such as conversation, subjective sleepiness, and psychological fatigue (Suda et al., 2008, 2009, 2010b).

The present study aimed to examine cortical activation using a verbal fluency task, which has been applied widely in clinical and nonclinical samples as a standard and specific paradigm to activate the frontal lobe. We used a newly developed multi-channel NIRS machine specified for frontal regions to explore differences in frontal activation according to the dissociative tendency. In addition, we examined correlations among frontal functioning, dissociation scores, and anger expression styles measured by self-report.

2. Material and methods

2.1 Participants

The study participants were 44 healthy university students (29 females), with a mean age of 20.5 years (SD, 2.0). They were all Japanese, and two students were left-handed. None of the

participants had any significant medical/psychiatric history. The participants were voluntarily recruited as subjects for this scientific study, and were paid 1,600 yen for a 2 hours exam as a co-operator as per the official provision. All subjects gave written informed consent prior to their participation in the study, which conformed with the provisions of the Declaration of Helsinki revised in Edinburgh in 2000. Privacy and anonymity of all participants were carefully preserved. The data was collected from August to December in 2009 and 2010.

2.2 NIRS (Fig. 1-3)

NIRS allows the calculation of changes in [Hb] parameters, including [o-Hb] and [d-Hb], by measuring the attenuation of near-infrared light at an approximate 800 nm wavelength. Neural activation induces regional hemodynamic changes in brain tissue, almost identical in pattern to spontaneous cerebral neural activity. Cortical activation is typically detected as an [o-Hb] increase or an [d-Hb] decrease; however, the direction of change in [d-Hb] can be ambiguous in the frontal lobe (Sato et al., 2007). Mainly changes in [o-Hb] at a depth of 2–3 cm from the scalp, that is, the surface of the cerebral cortex, are correlated with positron emission tomography (PET) hemodynamic changes (Ohmae et al., 2006) and blood-oxygenation-level-dependent signal changes in functional magnetic resonance imaging (fMRI) (Toronov et al., 2001; Mehagnoul-Schipper et al., 2002). NIRS does not measure cerebral luminescence but measures the attenuation of irradiated light intensity. Therefore, the combination of optical irradiation and photon detection determines the resolution. It characteristically measures not the 1:1 combination of irradiation and detection, but the light from one light source with 2 or more detectors arranged geometrically in the measurement system of NIRS. Thus, information on which detector measures the signal of which portion becomes important. Some methods are available for judging this channel separation. The first method, time division multiple access, makes a light source turn on in order, and separates the signal on a time axis. The second method, frequency division multiple access, is for modulating and irradiating two or more light sources with different frequencies and separating a signal based on frequency information after detection. The third method is code division multiple access (CDMA), using spectrum diffusion attenuation, which is applied in such applications as global positioning system or mobile phone. A new machine, OEG-16 (Spectratech, Inc, Yokahama, Japan), uses CDMA and is very convenient and portable. It can generate NIRS data under natural conditions noninvasively, and artifacts induced by hair can be avoided because of the adjustments only on the front of the head. The OEG-16 measures 16 channels on the frontal lobe (according to Broadman's map, provides data on 10, 11, 12, 44, 45, and 46). Its time resolution is 0.5 s, and space resolution is 2 cm. A headset was placed on the participant's head according to the 10/20 system, by which a central hole was coordinated with Fz. The measurement points for channels 1 to 8 were placed from the right lateral to the central pole. For channels 9 to 16, the measurement points were placed from the ventral/rostral to the left lateral (refer to the video content). These placements provided for relative changes in [Hb] concentration, and the values obtained were in arbitrary units (concentration × path length).

Details of NIRS methodology have already been described in major publications in Japan (Fukuda, 2009; 2011).

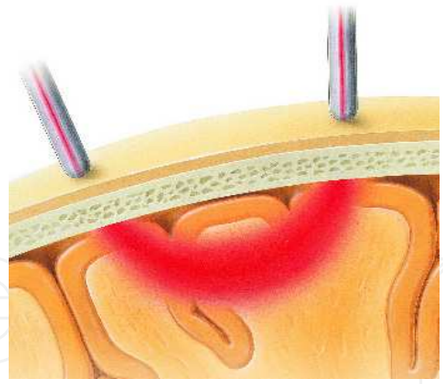

Fig. 1. Estimated areas for measuring the blood volume changes of cerebral cortex. (© Hitachi Medical Corporation, http://www.hitachi-medical.co.jp/info/opt/qa.html#q1)

Fig. 2. OEG-16 (18×17×4 cm, Spectratech, Inc.)

Fig. 3. Measuring points and headset. (Spectratech, Inc.)

2.3 Verbal fluency task

This standardized activation task is employed internationally for NIRS measurements, and it has been confirmed that this method provides widespread frontal activation reliably (Kono et al., 2007; Schecklmann et al., 2008; Kakimoto et al., 2009). The frontal activation task was a modified version of the verbal fluency task. A subject sat on a comfortable chair in a quiet room with their eyes open throughout the measurement. The activation task consisted of a 15-s pre-task baseline, a 30-s verbal fluency period, and a 15-s post-task baseline. During

the verbal fluency period, the subjects were instructed to verbally generate as many words as they could whose initial Japanese syllable (mora) was either /a/, /ki/, or /ha/. These three initial syllables were used in the above-mentioned order and changed every 10 s during the 30-s verbal fluency period to reduce the time during which the subjects remained silent. The number of words generated during the verbal fluency period was determined as a measure of task performance. During the pre-task and post-task baseline periods, the subjects were instructed to repeat the syllables /a/, /i/, /u/, /e/, and /o/ as the Japanese counterparts of A, B, and C in English. Two sets of this task were performed, and the respective data were superimposed and averaged.

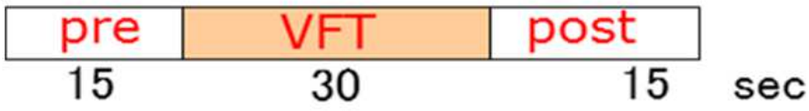

Fig. 4. One epoch of the verbal fluency test (VFT).

2.4 ADES and STAXI

The ADES was developed solely for adolescents by Armstrong et al. (1997) to detect dissociative behaviour in children between 11 and 17 years of age. It is a 30-item self-reporting scale composed of an 11-point scale ranging from 0 representing "never" to 10 representing "always". The total ADES score is equal to the mean of all item scores. A subject circles the number that best describes how often a given experience happens. On the title page, respondents were instructed not to count experiences that occur under the influence of any drugs. Several versions of the ADES are available in Japanese (e.g., Tanabe, 2004). We used the one developed by Matsumoto et al. (2004) because of its excellent psychometric properties.

The STAXI tool evaluates anger isolated from hostility and aggression, covering anger experience and expression (Spielberger, et al., 1998). The STAXI is a self-reported 44 items, and individuals answered on a four-point Likert scale (score range: 0–132) to assess either the intensity of their angry feelings or the frequency as state, trait, anger-in, anger-out, and anger-control subscores (expression of anger toward other persons or objects in the environment is anger expression-out; holding in or suppressing angry feelings is anger expression-in; and controlling angry feelings by preventing the expression of anger toward other persons or objects in the environment, or controlling suppressed angry feelings by calming down or cooling off is anger-control). The Japanese version was developed by Mine et al. (1997), and the first STAXI was used in the present study.

2.5 Data analysis

The continuous waveforms of the [Hb] changes on all 16 channels were acquired from all subjects during the paradigm. The individually averaged [Hb] waveforms were obtained as the average sum of two trials; a baseline realignment for 5 s before and after the task periods, and a task segment averaging two sets of 15-s image viewing periods. Thereafter, the grand average values of the baseline and task segments for each channel were calculated for all data. Figure 5 is an example of a grand average waveform for three parameters; the

red polygonal line indicates the relative changes in [o-Hb], the blue indicates those of [d-Hb], and the green indicates the changes in the total-Hb (sum of o- and d-Hb).

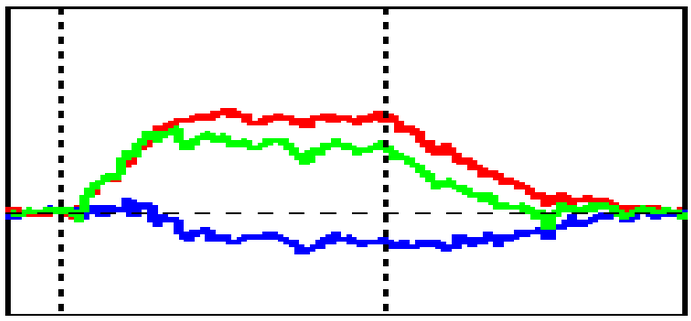

Fig. 5. The red polygonal line indicates the relative changes in [o-Hb], the blue indicates those of [d-Hb], and the green indicates the changes in the total-Hb (sum of o- and d-Hb).

We used only [o-Hb] values as cerebral blood volume changes for statistics, based on previous reports (Suto et al., 2004; Kameyama et al., 2006). Topography (video content) was presented on the frontal portion according to the time course. In this grand average data, channels that carried significant activation were analyzed between the pre-task and task periods using the t-test (http://www.brsystems.jp). Differences in the mean values were tested by combined variance, as the number of samples for the two periods was not equal.

Combined variance: Ue2 = { (na - 1) ua2 + (nb - 1)ub2}/{na + nb-2}
Variance and numbers of sample a: ua2 and na
Variance and numbers of sample b: ub2 and nb
T-value: t0 = |mXa - mXb|/root{ue2(1/na + 1/nb)}
Average of each sample: mXa, mXb

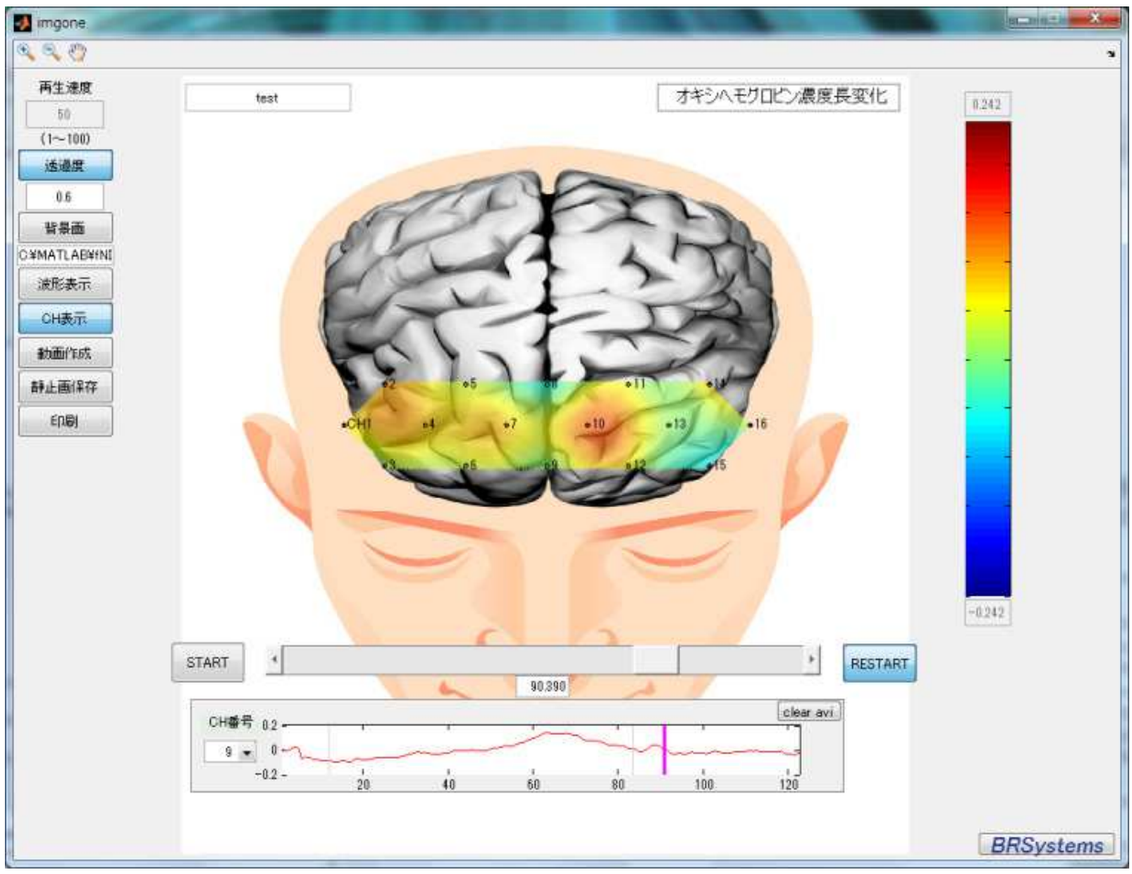

Fig. 6. An presentation using the Data Viewer (BR Systems, Inc.).

In the next step, differences were investigated according to dissociative tendencies followed by the t-test for each channel during the task period between the sample grand average data divided by the ADES mean scores ("strong" and "weak"). In the last step, the relationships between the [o-Hb] changes, the STAXI subscales, and the ADES scores were investigated. The channels, with significantly correlated changes, were analyzed by a nonparametric Spearman's correlation coefficient (two-tailed). Imaging software was used to analyze the NIRS parameters, and figure 6 shows an example of demonstration by this software (Data Viewer ver.1.1a, BR Systems Inc., Tokyo, Japan). The other statistical analyses were conducted using SPSS version 17.0 (SPSS, Inc., Tokyo, Japan).

3. Results

3.1 Waveform and dissociation

Figure 7 shows the grand average waveforms for the [Hb] changes for all participants, and figure 8 indicates the comparisons of waveforms according to the ADES average scores (mean = 13.9, S.D. = 12.8). 27 students scored under the mean as "weak" on the left, and the others as "strong" on the right. The red polygonal line indicates the relative changes in [o-Hb], the blue indicates those of [d-Hb], and the green indicates the changes in the total-Hb (sum of o- and d-Hb). The video content depicts the topography of the [o-HB] changes ("weak" on the left and "strong" on the right side), and redder areas represent greater

activation (grading to yellow, green, and opposite in deeper blue). Overall, gradual increases and fluctuations were generally observed in widespread channels during the task. The video file can be viewed on this website.
http://www.youtube.com/watch?v=g7IG5HG8q_U

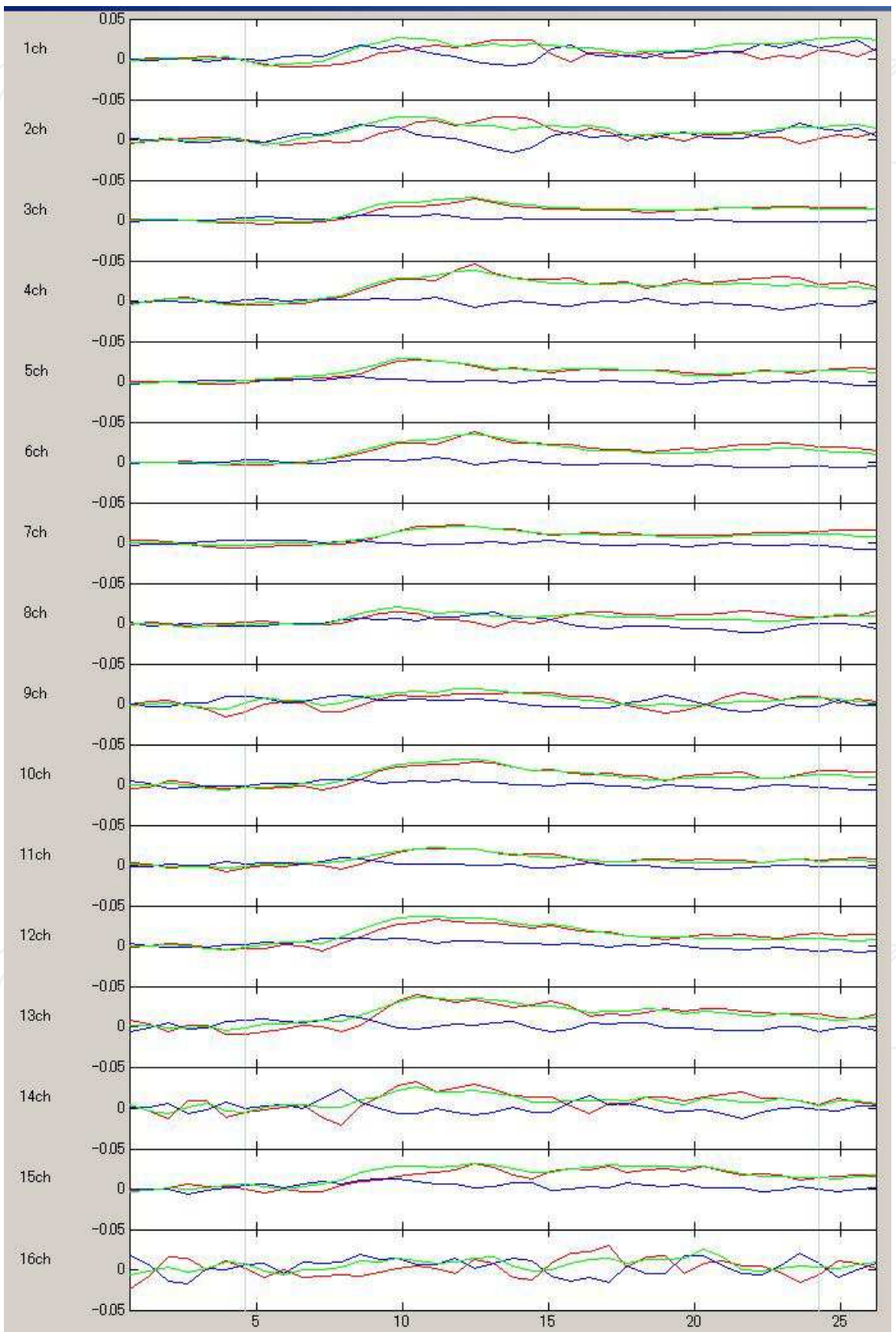

Fig. 7. Grand average waveforms

This demonstrated grand average waveforms of [Hb] changes for all participants' data. The red polygonal line indicates [o-Hb], blue indicates [d-Hb], and green indicates the total [Hb] (sum of o-HB and d-HB) relative changes. The vertical axis represents the relative changes in [Hb] (mMmm), and the vertical grey lines represent the start and end of task periods. The numbers on the abscissa indicate measurement time points (seconds). The data of the respective channels was placed according to each number from the top to the bottom.

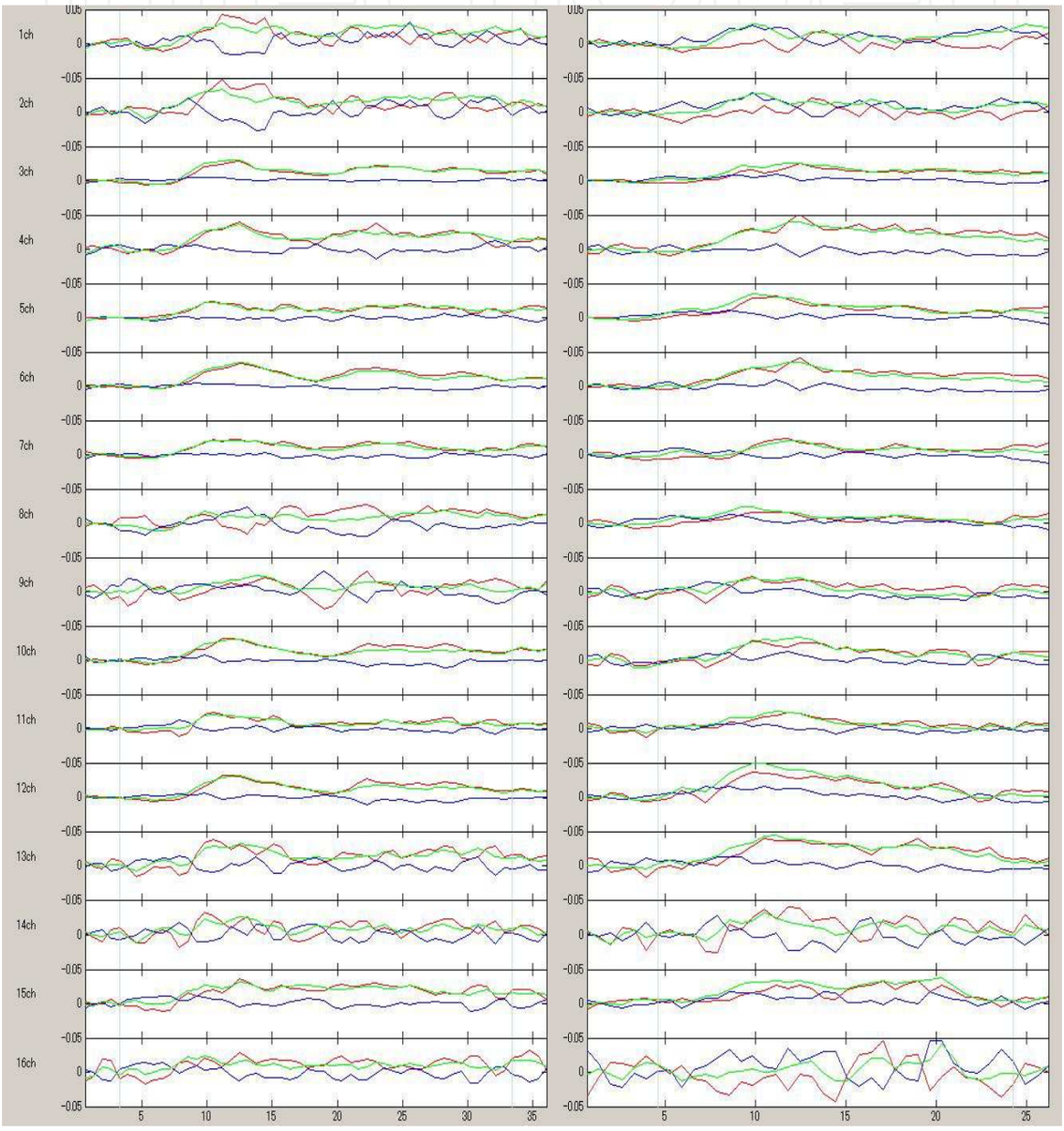

Fig. 8. Comparisons of the grand average waveforms according to dissociative tendency

This demonstrated grand average waveforms of [Hb] changes for all participants according to ADES, in which two samples were divided by the mean scores (the data over the mean is in the left and the data below the mean is on the right side). The red polygonal line indicates [o-Hb], blue indicates [d-Hb], and green indicates the total [Hb] (sum of o-HB and d-HB) relative changes. The vertical axis represents the relative changes in [Hb] (mMmm), and the vertical grey lines represent the start and end of task periods. The numbers on the abscissa indicate measurement time points (seconds). The data of the respective channels was placed according to each number from the top to the bottom.

Comparisons between the baseline and task periods are summarized in Table 1. The respective arbitrary units and t-values for each channel are presented for all, "weak" and "strong" students; significant activations (two-tailed, DF = 32) were obtained on channels 3–15 for all students; on channels 2–7, 10, 12, and 15 for "weak" samples; and on channels 3–8 and 10–15 for the "strong" samples. Comparisons of the activation for the task periods between the "strong" and "weak" samples were calculated; t-values for every channel indicated that they were significantly lower on channels 1**, 2**, and 7* (dorsolateral to the ventral portion) in the right PFC, and higher in channel 13** and lower in channel 16** in the left PFC for "strong" than for "weak" samples (*p < .05, **p < .01, DF = 52) The total ADES scores were negatively correlated with activation in the center prefrontal channel 8 (rostral ventral PFC; r = −.30, p < .05).

	WEAK (n = 27)			STRONG (n = 17)			All 44 Students			Comparisons for task periodes between WEAK and STRONG	
channel	Rest	Task	t	Rest	Task	t	Rest	Task	t	t	p (DF = 52)
1	0.003	0.012	1.37	0	-0.002	-0.56	0.002	0.006	0.88	4.77	0.0002
2	0	0.015	2.36*	0.002	0	-0.61	0.001	0.008	1.44	5.48	0.00001
3	0	0.014	3.13**	0	0.012	4.00**	0	0.013	3.56**	0.51	0.61
4	0	0.018	2.91**	0.002	0.025	3.82**	0	0.022	3.79**	-1.91	0.06
5	0	0.013	4.53**	-0.002	0.014	4.31**	-0.001	0.013	4.90**	-0.40	0.70
6	0	0.016	3.53**	0	0.019	4.38**	0	0.018	4.21**	-0.76	0.45
7	0	0.012	3.42**	-0.002	0.008	2.58*	-0.002	0.010	3.53**	2.45	0.02
8	0	0.011	1.09	-0.002	0.006	3.35**	0	0.008	2.80**	1.08	0.29
9	-0.002	0.005	1.89	-0.001	0.006	1.80	-0.003	0.005	2.16*	-1.09	0.28
10	0	0.015	2.96**	-0.001	0.012	2.44*	0	0.013	3.00**	0.91	0.37
11	0	0.008	2.00	-0.004	0.009	4.18**	-0.003	0.008	3.30**	-0.65	0.52
12	0	0.014	2.76*	0	0.017	3.01**	0	0.015	3.35**	-1.40	0.30
13	0.003	0.014	1.73	-0.005	0.023	4.78**	-0.002	0.018	3.48**	-3.08	0.0031
14	0	0.009	1.30	-0.005	0.013	2.22*	-0.002	0.011	2.20*	-1.40	0.17
15	9	0.018	2.92**	0.005	0.016	2.25*	0.002	0.017	3.20**	0.83	0.41
16	0.005	0.011	1.08	0.010	-0.006	-1.66	0.007	0.003	-0.75	4.00	0.0003

arbitary unit: mMmol *; p < .05, **; p < .01 (DF = 32)
WEAK/STRONG; divided by the mean scores '13.9' of the adolescent dissociative experiences scale (ADES)

Table 1. Comparisons of activations according to dissociative tendency

3.2 Correlation with anger expression

Table 2 shows the descriptive values of the STAXI subscale scores for all participants. Spearman's correlation coefficients were calculated for the relative changes in [o-Hb] for the 16 channels and the STAXI scores. The anger-in STAXI scores were negatively correlated with channel 8 activation (frontal pole of PFC; r = -.31, p < .05). The other scale scores were not significantly correlated with any other channel activation.

	state	trait	AX/In	AX/Out	AX/Con	AX/EX
mean	12.3	20.3	19.2	14.3	22.0	27.5
S.D.	3.5	7.1	4.2	3.7	4.1	7.2

STAXI: State Trait Anger Expression Inventory
AX/In: anger expression in
AX/Out: anger expression out
AX/Con: anger expression control
AX/EX: expression, (AX/In+AX/Out)-Ax/Con

Table 2. Descriptive values of the STAXI

4. Discussion

Some interesting relationships were found between frontal activation and psycho-behavioural variables that can be summarized as follows: 1. Strong dissociative tendencies were generally related to lower PFC activation. In particular, the activation was relatively dominant on the lateral and right sides. 2. Only channel 13 (left inferior frontal gyrus, close to BA46) activation could be directly associated with dissociative reactions with regard to contrast of activations; significant increases in channel 13 and significant decreases in channel 7 (right BA46). 3. Analyses of the correlations revealed that frontal pole (channel 8, close to BA10) dysfunction may be linked to dissociative tendencies. This relationship was paradoxical to anger suppression; the "ANGER-IN" style was correlated with lower activation in this portion (rostral PFC, channel 8).

Similar to the normal control data of many previous NIRS studies, the verbal fluency task provided excellent activation in widespread areas of PFC both in the "strong and "weak" dissociative groups, and this was reasonable, as our sample consisted of healthy students. However, according to ADES, a dissociative tendency might be associated with differences in prefrontal deactivation. In particular, lateral or right side deactivation may influence the dissociative tendency. The findings of the present study also suggest that suppression may be disturbed by over-function in the frontal pole (rostral PFC), and a contradiction could be seen in dissociative experiences. Considering dissociation and repression as coping mechanism to distresses, frontal pole deactivations may induce dissociative defence and the repression of anger expression.

Reviewing related studies, Bell et al. (2010) commented that dissociation is associated with increases in PFC activity and suggested that intervention by the executive system for both automatic and voluntary cognitive processing was common to both hysteria and hypnosis. We found only one study (Amrhein et al., 2008) that has investigated high/low dissociators in subjects without any psychiatric or neurological disorders and without prior trauma experiences. High dissociators show cognitive deficiencies, and a hippocampal and PFC dysfunction was assumed to be the core factor. Although the subjects had clinically disordered post-traumatic stress disorder (PTSD), Lanius et al. (2010) proposed that a dissociative subtype of PTSD is a form of emotion dysregulation that involves emotional overmodulation mediated by midline prefrontal inhibition of the limbic regions. Based on these studies, the results from the present study strongly support involvement of PFC with dissociation. A PET study stated that anger conditions are

associated with increased regional cerebral blood flow (rCBF) in the left inferior PFC and decreased rCBF in the right superior frontal cortex (Kimbrell et al., 1999). An fMRI study indicated that medial PFC activity (mostly identical to BA10 or 9) is related to self-reported rumination and individual differences in displaced aggression (Denson et al., 2009). As "ANGER-IN" means the frequency with which angry feelings are suppressed, rumination appears to be linked to this type of anger expression. Based on these findings and our results, the relationships between anger and bilateral ventral or rostral PFC involvement (dominantly left) can be assumed.

Some limitations of this study should be noted. The data could not be interpreted directly for DD because clinical subjects were strictly excluded. A future study should administer paradigms directly to induce dissociation or present specific stimulation. Similarly, tasks provoking anger such as visual stimuli should be considered. We did not reveal a correlation between frontal activation and state/trait anger, anger-out expression, or anger-control. We should still be conservative when discussing the association between anger suppression and brain function. This study used a frontal-specific methodology that should be complemented with a whole-brain measurement. Considering the importance of the clinical application, relative changes in cerebral [Hb] data as absolute values should be cautiously interpreted. Furthermore, anatomically identifying the measuring points is a major methodological challenge in multichannel NIRS, but the space resolution in NIRS ranges from 2 to 3 cm; therefore, it would not be problematic to discuss functional dynamism within broader frontal connectivity. Rather than being a weakness, high time resolution can contribute to clarifying the network or circuit based on detailed analyses of the time-course and activation patterns. Actually, the OEG-16 has already been applied in a psychological study, and its availability could be introduced (Uehara et al., 2011).

Differences in frontal activation suggest that dissociation might be related to PFC. Activation in the left inferior frontal gyrus could be associated with dissociative reactions in contrast to right side activation. We also suggest that a dissociative tendency and anger suppression could be associated with rostral PFC deactivations. Further study needs to include a clinical application and improve the task paradigm.

5. Acknowledgment

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A summary of this study was presented at the 16th ESCAP in Helsinki on June 2011.

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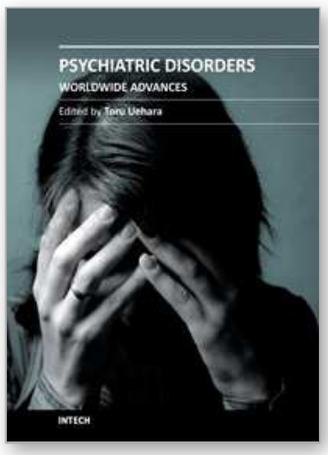

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A psychiatric disorder is defined as any complex condition that involves the impairment of cognitive, emotional, or behavioral functioning. Aside from knowing the physical organic factors, its causal pathology has remained a mystery. Regarding recent advances in psychiatry and neurosciences, psychiatric disorders have been closely associated with socio-cultural, psychological, biochemical, epigenetic or neural-networking factors. A need for diverse approaches or support strategies is present, which should serve as common knowledge, empathetic views or useful skills for specialists in the filed. This book contains multifarious and powerful papers from all over the world, addressing themes such as the neurosciences, psychosocial interventions, medical factors, possible vulnerability and traumatic events. Doubtlessly, this book will be fruitful for future development and collaboration in â€œworld psychiatryâ€.

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