Measuring the Executive Regulation of Emotion With Self-Rating Scales in a Nonclinical Population

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ABSTRACT. Prefrontal systems play an important role in the regulation of emotion as evidenced by clinical neuroimaging studies. Both subjective and objective neuropsychological tests provide functional evidence of executive dysfunction in emotional deregulation. The present authors evaluated these relationships here in a nonclinical community sample using the Frontal Systems Behavior Scale, Profile of Mood States (POMS), and Depression Anxiety Stress Scales (DASS). Positive correlations uniformly emerged between prefrontal system dysfunction and negative emotional states (anger, depression, anxiety, stress, confusion, and fatigue), whereas positive emotion (vigor) showed a modest inverse correlation with prefrontal system dysfunction, even after control for demographic influences. These relationships may result from cognitive strategies for managing emotion mediated by reciprocal connections between prefrontal systems and the limbic system. The findings corroborated those of other methodologies, supporting the Frontal Systems Behavior Scale (FrSBe) as a valid tool to measure prefrontal function in nonclinical populations.

Key words: emotion, executive, FrSBe, prefrontal, regulation

THE PREFRONTAL CORTEX IS RECOGNIZED AS PLAYING a critical role in the regulation of emotion, as indicated by convergent evidence from various methodologies. For example, clinical studies of individuals with neuropsychiatric illnesses involving dysfunction of circuits through prefrontal cortex, basal ganglia, and thalamic nuclei, show emotional dysfunction (Tekin & Cummings, 2002). Whereas orbitofrontal lesions tend to produce emotional and behavioral disinhibition, lesions of the medial prefrontal cortex produce apathy and abulia (Malloy, Bihrl, Duffy, & Cimino, 1993). Changes in emotional state and per-
sonality are well recognized in traumatic brain injury, which has a propensity to affect prefrontal and anterior temporal structures (Max, Robertson, & Lansing, 2001; Tate, 1999). Similar constellations of emotional and personality changes occur with frontal lobe epilepsy and frontotemporal dementia (Helmstaedter, 2001; Rankin, Kramer, Mychack, & Miller, 2003). Neurodegenerative diseases of the striatum are associated with emotional and personality changes as well. Greater apathy, industriousness, punctuality, inflexibility, cautiousness, and lack of novelty seeking are noted in Parkinson’s disease; some of these characteristics precede the motor manifestations of the illness (Menza, 2000; Pluck & Brown, 2002). Conversely, Huntington’s disease is associated with disinhibited changes in personality (Shiwach, 1994; Tekin & Cummings, 2002).

Studies of post-stroke sequelae allow for some degree of neuroanatomical specificity in the analysis of emotional changes. While orbitofrontal and medial prefrontal lesions are often associated with emotional changes, lateral frontal lesions have also been associated with emotional dysregulation, primarily resulting in depression (Paradiso, Chemerinski, & Yazici, 1999). Both left and right frontal strokes are associated with depression (Beblo, Wallesch, & Hermann, 1999; Shimoda & Robinson, 1999). Left frontal strokes are more associated with depression in the short term, with proximity to the frontal pole and lesion volume relating to severity. However, at one to two years post stroke, depression was more associated with right hemisphere lesion volume and proximity of the lesion to the occipital pole. Post stroke emotional lability is associated with lenticulocapsular strokes lesions, likely disrupting prefrontal-striatal-limbic circuits (Kim & Choi-Kwon, 2000). Dyscontrol of anger and aggression also occur after stroke, particularly with frontal-lenticulocapsular-pontine lesions, and is associated with motor dysfunction and dysarthria (Kim, Choi, & Kwon, 2002). Increases in both provoked and spontaneous anger may result.

Functional neuroimaging studies have corroborated a role for prefrontal systems in regulation of emotion in both clinical and healthy populations. A meta-analysis of functional neuroimaging studies of emotion implicated regions of medial prefrontal cortex in several aspects of emotion (Phan, Wager, Taylor, & Liberzon, 2002). Subcallosal cingulate is associated with sadness, while induction of emotion by recall or imagery and emotional tasks with a cognitive demand activate anterior cingulate. An important role of prefrontal systems appears to be in cognitive appraisal of situations. Ochsner, Bunge, Gross, and Gabrieli (2002) showed that healthy subjects who experience less negative affect through reappraising highly emotional negative scenes showed increased activation of lateral and medial prefrontal regions and decreased activation of the amygdala and medial orbitofrontal cortex. Subjects watching a sad film had activations bilaterally in the anterior temporal pole and midbrain, left amygdala, left insula, and right ventrolateral prefrontal cortex (Levesque et al., 2003). However, voluntary suppression of sadness activated right dorsolateral (BA 9) and right orbitofrontal cortex (BA 11).

Prefrontal cortex is also involved in the interpretation and labeling of emo-
tion. Subjects matching the emotional tone of facial expressions showed activation of the amygdala, whereas, when verbally labeling the same expressions, activation occurred in right prefrontal cortex with a diminished activation in the amygdala (Hariri, Bookheimer, & Mazziotta, 2000). Similarly, right prefrontal cortex also appears involved in emotional self-evaluation. Right dorsomedial prefrontal cortex is activated when subjects judged whether positive and negative personality traits described them, whereas positive traits caused a more robust activation (Fossati et al., 2003). In contrast, judging whether the trait was generally desirable activated the lateral prefrontal cortex instead. This line of research extends into the emotional regulation achieved by cognitive-behavioral therapy (CBT; Paquette et al., 2003). Individuals with a spider phobia (pre-CBT) showed right prefrontal (BA10) activation during exposure to a spider film whereas non-phobic subjects in the control group did not. However, after CBT, the right prefrontal activation did not occur in the formerly phobic patients. Paquette and colleagues hypothesized that the right prefrontal activation represented use of metacognitive strategies to self-regulate emotion. Aberrant activity in prefrontal-subcortical-limbic circuits has been noted in several disorders defined by a dysregulation of emotion, including mood disorders, anxiety disorders, and personality disorders (Bassarath, 2001; Malizia, 1999; Sheline, 2003; Soloff, Meltzer, Greer, Constantine, & Kelly, 2000).

Neuropsychological tests of executive function support the clinical and neuroimaging studies. Impairment has been shown using a variety of objective measures of executive function in several emotional disorders including depression, anxiety, obsessive-compulsive disorder, and aggression (e.g., Brower & Price, 2001; Moritz, Birkner, & Kloss, 2002; Toren, Sadeh, & Wolmer, 2000). Subjective rating instruments represent an alternate means of measuring the function of prefrontal systems. The Frontal Systems Behavior Scale (FrSBe) is a self-report scale with demonstrated sensitivity to prefrontal system function in various clinical samples (Cahn-Weiner, Grace, & Ott, 2002; Cecil, DelBello, Morey, & Strakowski, 2002; Grace, Stout, & Malloy, 1999; Paulsen, Ready, & Stout, 2000; Velligan, Ritch, & Sui, 2002). FrSBe scores also correlate with objective measures of executive dysfunction (Chiaravalloti & DeLuca, 2003; Velligan et al., 2002).

Given the demonstrated role of prefrontal systems in emotional regulation and the sensitivity of the FrSBe to prefrontal system dysfunction, we sought to examine emotional status in relation to the FrSBe. Because studies of clinical populations and healthy individuals have a demonstrated role for prefrontal systems in regulating emotion, this relationship should be measurable by reliable and valid self-report questionnaires. Although individuals with neurological illness or insult represent more extreme emotional and prefrontal dysfunction, it is likely that adaptive regulation of emotion by prefrontal systems exists to varying degrees in the normal population, based on a variety of neurobiological and psychological factors during one’s lifetime. If true, this would support the validity of the FrSBe to measure prefrontal system functioning in community samples. We
hypothesized that greater degrees of prefrontal system dysfunction in these studies would reflect greater degrees of negative emotion as measured by self-rating measures in a community sample.

Study 1

Method

Participants

Participants were 235 adults (96 male, 129 female; 10 did not indicate sex), aged 17 to 79 years ($M = 28.7, SD = 11.8$) who had completed between 9 and 18 years of education ($M = 14.4, SD = 1.7$). Our research assistants recruited them from the campus of Richard Stockton College of New Jersey and the local community. We instructed research assistants to find noninstitutionalized, community-dwelling adults. We asked participants to volunteer for a study that involved filling out a questionnaire on emotion and behavior without offering any further details so as not to bias their responses. The study was approved by an institutional review board and all participants agreed to an informed consent form in accordance with the ethical principles of the American Psychological Association and the Declaration of Helsinki. We had participants seal their questionnaires in envelopes before returning them to the research assistants, and we kept results of the testing confidential.

Materials

Frontal systems behavior scale. We administered the self-rating form of the FrSBe. It has three subscales derived by factor analysis in clinical samples: Apathy (A), Disinhibition (D), and Executive dysfunction (E), in addition to the total score (T) (Stout, Ready, Grace, Malloy, & Paulsen, 2003). Representative items include, “I sit around doing nothing,” “I do risky things just for the heck of it,” and “I repeat certain actions or get stuck on certain ideas” (Grace & Malloy, 2001). These subscales correspond to constellations of symptoms associated with dysfunction of medial prefrontal, orbitofrontal, and dorsolateral prefrontal cortex, respectively (Malloy et al., 1993; Masterman & Cummings, 1997). Whereas these scales are consistent with the function of different prefrontal regions, it has not yet been assessed how well they can localize or discriminate the function of separate regions. Thus any results can be said to indicate relationships with symptom clusters, but not necessarily with specific prefrontal regions.

Reliability and validity of the instrument have been documented (Grace & Malloy, 2001). Demographic influences occur on the FrSBe: scores are inversely associated with age and education, and males score slightly higher than females. Participants responded on a Likert-type scale (i.e., $1 = almost never, 2 = seldom,$
3 = sometimes, 4 = frequently, 5 = almost always). Items 1–32 represent deficits of prefrontal function, so that higher numbers indicate greater dysfunction and items 33 to 46 reflect positive executive functioning so that the Likert-type descriptors are reversed. Thus, higher scores on all FrSBe items and scales uniformly indicate greater executive dysfunction.

Profile of mood states. We used a 35-item version of the Profile of Mood States (POMS; Grove & Prapavessis, 1992); items consisted of adjectives used to describe different emotions, rated on a Likert-type scale (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely). We calculated scores for 6 subscales: Anger, Confusion, Depression, Fatigue, Tension, and Vigor. We calculated Total Mood Disturbance (TMD) as a sum of the negative emotional scales minus Vigor. Both the long form and short form of the POMS have shown good psychometric properties (e.g., Grove & Prapavessis; Reddon, Marceau, & Holden, 1985).

Results

We calculated partial correlations between scales of the FrSBe and POMS, controlling for the influences of age, sex, and education (see Table 1). We performed a total of 28 correlations, so a Bonferroni correction was applied. We regarded correlations for which $p < .0018$ as significant to maintain the alpha level at .05 (see Figure 1).

Correlation coefficients uniformly indicated a positive relationship between overall symptoms of prefrontal dysfunction (FrSBe T scale) and negative emotional states (i.e., Anger, Confusion, Depression, Fatigue, and Tension). In contrast, Vigor showed a modest inverse relationship with symptoms of prefrontal system dysfunction. We obtained an intermediate correlation between Total Mood Disturbance and the total score of the FrSBe ($r = .46, p < .001$). All of the FrSBe subscales related to the negative emotion scales, while only A and E related positively to Vigor.

We performed a one-sample Kolmogorov-Smirnov test to determine whether the scores on the FrSBe total differed significantly from a normal distribution. The results were not significant ($z = 1.28, p = .075$), indicating that the scores were normally distributed.

Study 2

Method

Participants

A separate sample of participants were 122 adults (71 female, 45 male; 6 did not indicate sex), aged 17 to 65 years ($M = 27.7, SD = 10.6$), who had completed between 9 and 18 years of education ($M = 14.3, SD = 1.7$). The procedures for recruiting participants were identical to those in Study 1.
TABLE I. Partial Correlations Among Subscales of the Frontal Systems Behavior Scale (FrSBe) and Profile of Mood States (POMS-35), Controlling for Age, Sex, and Education

<table>
<thead>
<tr>
<th>Emotional state</th>
<th>A</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anger</td>
<td>.31†</td>
<td></td>
<td>.33†</td>
<td>.36†</td>
</tr>
<tr>
<td>Confusion</td>
<td>.48†</td>
<td>.45†</td>
<td>.48†</td>
<td>.53†</td>
</tr>
<tr>
<td>Depression</td>
<td>.38†</td>
<td>.29†</td>
<td>.36†</td>
<td>.39†</td>
</tr>
<tr>
<td>Fatigue</td>
<td>.33†</td>
<td>.20*</td>
<td>.21*</td>
<td>.28†</td>
</tr>
<tr>
<td>Tension</td>
<td>.30†</td>
<td>.34†</td>
<td>.27†</td>
<td>.34†</td>
</tr>
<tr>
<td>Vigor</td>
<td>−.31†</td>
<td>.04</td>
<td>−.22*</td>
<td>−.22*</td>
</tr>
<tr>
<td>TMD</td>
<td>.45†</td>
<td>.35†</td>
<td>.40†</td>
<td>.46†</td>
</tr>
</tbody>
</table>

*p = .001, two-tailed significance, df = 220. †p = < .001, one-tailed.

FIGURE 1. Scatterplot of Frontal Systems Behavior Scale (FrSBe) total scores and Profile of Mood State (POMS) total mood disturbance (N = 235).

Materials

In addition to the FrSBe, we used a 21-item version of the Depression Anxiety Stress Scale (DASS). The instrument has 3 scales: Depression (DASSd), Anxiety (DASSa), Stress (DASSs), each composed of 7 items. The reliability and
validity of the DASS have been demonstrated (Antony, Bieling, Cox, Enns, & Swinson, 1998; Brown, Korotitsch, Chorpita, & Barlow, 1997; Lovibond & Lovibond, 1995).

We chose this instrument to partly replicate the findings of the first study, and to examine the FrSBe in relation to a greater degree of pathological emotion. While the POMS is an effective mood rating scale, the DASS was constructed more specifically to identify dysfunctional emotion. Its items use full-sentence descriptors that are worded to focus more clearly on pathological degrees of emotion (e.g., “I couldn’t seem to experience any positive feeling at all,” and “I felt scared without any good reason.”). Further, the DASS has a stress scale which the POMS lacks.

**Results**

We calculated partial correlations between scales of the FrSBe and DASS, controlling for the influences of age, sex, and education. We performed a total of 12 correlations. We applied a Bonferroni correction to maintain an alpha level of .05, so correlations for which \( p \leq .004 \) were regarded as significant. We obtained significant positive correlations between all scales of the FrSBe and DASS (see Table 2).

We performed a one-sample Kolmogorov-Smirnov test to determine whether the scores on the FrSBe total differed significantly from a normal distribution. The results were not significant (\( z = .932, p = .350 \)), indicating that the scores were normally distributed.

**Discussion**

Negative emotional states (i.e., anger, depression, stress, anxiety, confusion, and fatigue) uniformly correlated with a greater severity of symptoms of prefrontal system dysfunction. Correlations ranged from modest to intermediate in magni-

<table>
<thead>
<tr>
<th>Emotional state</th>
<th>A</th>
<th>D</th>
<th>E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>.57†</td>
<td>.38†</td>
<td>.46†</td>
<td>.53†</td>
</tr>
<tr>
<td>Anxiety</td>
<td>.42†</td>
<td>.33†</td>
<td>.30*</td>
<td>.39†</td>
</tr>
<tr>
<td>Stress</td>
<td>.43†</td>
<td>.42†</td>
<td>.35†</td>
<td>.45†</td>
</tr>
</tbody>
</table>

*\( p = .001 \), two-tailed significance, \( df = 109 \). †\( p < .001 \), one-tailed.
tude, explaining between 4% and 33% of the variance. Conversely, prefrontal system dysfunction correlated inversely with positive emotion (as measured by Vigor), although this relationship was modest and only explained between 5% and 10% of the variance. Nonetheless, the pattern of correlations is consistent with what was anticipated based on prior experimental, clinical, and neuroimaging studies: Greater prefrontal system dysfunction relates to greater overall emotional distress. This pattern persisted despite correction for demographic influences and a conservative correction for controlling the probability of type I error.

Examination of the FrSBe subscales reveals that the pattern of correlations was essentially consistent across scales and not limited to any particular subscale. This tentatively suggests that dysfunction of any of the major prefrontal systems relates to greater emotional distress. This is also supported by prior research that has shown emotional dysregulation after lesions of medial prefrontal, orbitofrontal, and dorsolateral prefrontal cortex (Malloy et al., 1993; Paradiso et al., 1999; Phan et al., 2002). The only exception to this was lack of relationship between Vigor and the D scale. It is possible that there is no relationship between these variables. However, many individuals also experience elevated mood with disinhibition so that an inverse relationship may have offset any relationship with depression in this sample.

Another finding of note is the relationships found on measures of both normal and pathological emotional states. The POMS items consists of adjectives that apply across the normal range of human emotion (e.g., “Annoyed,” “Lively,” and “Discouraged”), whereas the DASS items are specifically worded to assess for a pathological degree of emotion (e.g., “I couldn’t seem to experience any positive feeling at all,” and “I felt scared without any good reason”). However, FrSBe scales showed relationships with both measures, indicating that prefrontal system dysfunction is not limited to those with clinical levels of emotional dysfunction. Rather, there appears to be a graded relationship that exists across the continuum. The use of a community sample in this study emphasizes this point.

One limitation of this study is that some of the participants in the community samples could potentially have had a brain injury or some other neurological illness that affected prefrontal system functioning. The sample was drawn from community dwelling, noninstitutionalized individuals, many of whom were recruited from the college campus. This reduces the likelihood of moderate to severe neurological illness or injury, although it cannot be entirely ruled out in this sample. Also, the scores for the FrSBe in this sample were normally distributed in this sample. Normal variations are known to occur in the structure and function of prefrontal systems, which could also account for the variation in executive function seen in our samples (Bartzokis et al., 2001; Luna et al., 2001).

Our study cannot directly address why prefrontal dysfunction results in greater emotional distress. However, prefrontal cortex has reciprocal connections with multiple limbic structures (e.g., Porrino, Crane, & Goldman-Rakic, 1981; Reep, 1984). Activity in prefrontal-subcortical-limbic circuits likely mediates the
intimate reciprocal relationships between cognition and emotion. As research reviewed here indicates, prefrontal structures likely contribute to cognitive appraisal of situations and metacognitive strategies for managing emotion (Ochsner et al., 2002; Paquette et al., 2003); and reduced prefrontal capacity to appraise and cope with situational stressors and susceptibility to various forms of emotional distress.

In the present study, we corroborated the findings of animal, clinical, and functional neuroimaging studies that showed a role for prefrontal systems in emotional regulation. In doing so, we also reinforced the ability of the FrSBe self-rating form to detect subtle gradations of prefrontal system function among normal individuals. This and other studies using subjective ratings of executive function in normal populations (e.g., Spinella, 2003; Spinella & Lyke, 2004) illustrate how instruments like the FrSBe can be used as an efficient means to test hypotheses regarding the role of prefrontal systems in human behavior.

REFERENCES


