EXAMINING COGNITIVE FLEXIBILITY IN YOUNG ADULTS WITH SYMPTOMS OF OBSESSIVE-COMPULSIVE AND RELATED PROBLEMS

A thesis submitted
To Kent State University in partial
Fulfillment of the requirements for the
Degree of Master of Arts

by
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May, 2015
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Introduction

Recently, the National Institute of Mental Health (NIMH) proposed the Research Domain Criteria (RDoC) initiative to shift from the current classification of disorders on the basis of presenting signs and symptoms toward an emphasis on classifying clinical phenomena by shared biomarkers and neurological correlates between clusters of disorders (Insel et al., 2010). RDoC has established several domains (i.e., negative and positive valence systems, cognitive symptoms, arousal and regulatory systems, etc.) — thought to be transdiagnostic—of inquiry across several units of analysis (e.g., genes, molecules, circuits, behavior, self-reports). Within each of these domains, however, exist several constructs providing for more fine-grained scientific inquiry (e.g., attention, reward learning, and habit). This study seeks to examine the relationship between cognitive flexibility and repetitive, habitual, or compulsive behaviors (behavioral and self-report units of analysis) within the construct of habit as part of the broader domain of positive valence systems.

Cognitive flexibility is defined as the ability to switch attention from one task to another or change behaviors after receiving negative feedback and has been linked to many psychiatric disorders including attention-deficit/hyperactivity disorder (ADHD; Sergeant, Geurts, Huijbregts, Scheres, & Oosterlaan, 2003; Rommelse et al., 2007; Wilcutt, Doyle, Nigg, Faraone, & Pennington, 2005), obsessive-compulsive and related disorders (e.g., OCD, trichotillomania, pathological skin picking; Bannon, Gonsalvez,
Croft, & Boyce, 2006; Bohne et al., 2005; Britton et al., 2010; Chamberlain, Blackwell, Fineberg, Robbins, & Sahakian, 2005; Chamberlain et al., 2007a; Chamberlain, Fineberg, Blackwell, Robbins, & Sahakian, 2006; Chamberlain et al., 2007b; Deckersbach, Otto, Savage, Baer, & Jenicke, 2000; Kuelz, Hohagen, & Voderholzer, 2004; Lawrence et al., 2006; Odlaug, Chamberlain, & Grant, 2010; Okasha et al., 2000; Ornstein, Arnold, Manassis, Mendlowitz, & Schachar, 2010), anorexia nervosa and bulimia nervosa (Galimberti, Martoni, Cavallini, Erzegovesi, & Bellodi, 2012; Gillberg, Rastam, Wentz, & Gillberg, 2007; Tchanturia et al., 2004; Tchanturia et al., 2011), and depression (Lee, Hermens, Porter, & Redoblado-Hodge, 2012; Marazziti, Consoli, Picchetti, Carlini, & Faravelli, 2010; Meiran, Diamond, Todor, & Nemets, 2011), among others. From a clinical perspective, cognitive flexibility may be particularly beneficial in helping to explain the development of repetitive, habitual, or compulsive behaviors. For example, patients presenting with symptoms of OCD may exhibit persistent, repetitive hand washing despite negative feedback such as bleeding and chapped hands. Similarly, patients who pull their hair or pick their skin continue to do so despite the resulting bald spots, bleeding, scarring, and negative social feedback. Evidence from neuroimaging studies of OCD and trichotillomania suggests that performance on tests of cognitive flexibility may be mediated by the dorsolateral prefrontal cortices and frontal-striatal circuitry. These same brain regions have been implicated as potential areas of dysfunction in obsessive-compulsive and related disorders (OCRDs). For example, a study of patients with OCD found that performance on tests of cognitive flexibility is associated with decreased frontal-striatal circuitry (Britton et al., 2010). The small
number of neuroimaging studies in trichotillomania have produced mixed findings (Snorrason, Belleau, & Woods, 2012), though there is evidence for abnormalities in the striatum, several cortical regions (both linked to cognitive flexibility deficits) and the amygdalo-hippocampal complex (Chamberlain et al., 2010; Chamberlain et al., 2008; Grachev, 1997; Keuthen et al., 2007; Lee et al., 2010; O'Sullivan et al., 1997; Swedo et al., 1991). These findings suggest that—from a biological and phenotypic perspective—cognitive flexibility may represent an important construct for understanding the etiology of disorders characterized by repetitive behaviors (i.e., OCRDs). Findings in relation to the role that cognitive flexibility plays at a more behavioral level (i.e., performance on neurocognitive tasks) amongst disorders most typically characterized by repetitive behaviors, however, is somewhat mixed.

Apart from inhibitory control, cognitive flexibility represents the neurocognitive domain that has received the greatest degree of empirical attention among OCRDs and yet has also produced the most discrepant findings. Some studies have found that participants with OCD have impaired performance on tasks of cognitive flexibility (Bannon et al., 2006; Britton et al., 2010; Deckersbach et al., 2000; Kuelz et al., 2004; Lawrence et al., 2006; Okasha et al., 2000) while others find they perform similarly to healthy controls (Abbruzzese, Bellodi, Ferris, & Scarone, 1995; Abbruzzese, Ferris, & Scarone, 1997; Moritz et al., 2001, 2002). Though less prevalent, research examining cognitive flexibility in patients with trichotillomania (Bohne et al., 2005; Chamberlain et al., 2007a; Chamberlain et al., 2006; Grant, Odlaug, & Chamberlain, 2011; Grant, Odlaug, & Chamberlain, 2012; Stanley, Hannay, & Breckenridge, 1997) and pathological
skin picking (Grant et al., 2011; Odlaug et al., 2010) have yielded mixed findings though the majority of these studies do appear to support the importance of cognitive flexibility in understanding the etiology of these disorders. A potential explanation for the discrepant findings from studies of cognitive functioning in OCRDs as noted above may be the absence of a standardized method of assessing cognitive flexibility. For example, cognitive flexibility has been assessed using both computerized and paper-and-pencil methods of assessment, including the Object Alternation Test (Bohne et al., 2005), Trails B (Stanley et al., 1997), the computerized IDED task (Britton et al., 2010; Chamberlain et al., 2006; Grant et al., 2011; Grant et al., 2012; Odlaug et al., 2010), and the Wisconsin Cart Sorting Test (Ornstein et al., 2010). The multitude of potential methods for assessing cognitive flexibility, and the resultant lack of standardization creates difficulty in comparing results across studies. In addition, unstandardized approaches may lead to an increased potential for experimenter error or bias. The current study will attempt to remedy this limitation by utilizing a standardized, automated set-shifting task to examine cognitive flexibility in a more reliable manner.

The RDoC has placed, as a central tenant of its goal, an emphasis on examining relationships between differing units of analysis (i.e., behavioral tasks of cognitive flexibility, self-report of repetitive or ritualistic behavior) within broader constructs (i.e., habit behaviors). In this vein, the RDoC endeavors to be transdiagnostic in relation to its stated goals. Given this fact and the aforementioned relationship posited to exist between cognitive flexibility and repetitive behaviors, my primary aim for the current study is to investigate whether greater cognitive flexibility deficits—assessed using a computerized
measure—exist among college students exhibiting repetitive behaviors characteristic of OCRDs (i.e., compulsions, hair pulling, or skin picking)—viewed as a unitary group, rather than discrete diagnoses—compared to healthy controls. I predict that participants classified as part of this group will exhibit greater deficits in cognitive flexibility compared to healthy controls. This novel approach—viewing various repetitive behaviors as one group—also provides the opportunity to explore a potential cumulative load hypothesis. That is, a secondary aim of this study is to identify whether poorer performance on a task of cognitive flexibility predicts worsened repetitive behavior severity—as assessed using a composite score obtained via the summation of standardized scores from three validated measures of OCD, hair pulling, and skin picking severity for use among adults. I hypothesize that as the severity of cognitive flexibility deficits becomes greater, the severity of obsessive-compulsive and related behaviors (OCRBs) will also become greater (Chamberlain et al., 2005).
Method

Participants

Data were obtained from an ongoing study designed to examine the link between neurocognitive functioning and repetitive behavior problems among college students. Participants were recruited from February 2012 through November 2013 via the SONA Experiment Management System website at Kent State University (KSU). Participants consisted of current KSU students (N = 132) enrolled in psychology courses who were required to participate in ongoing research projects to receive course credit in entry-level psychology courses. Participants were required to be at least 18 years of age and provide complete data on all measures utilized in statistical analyses relevant to this study’s primary and secondary aims. Of the 132 participants, 124 met these criteria and were used to construct subgroups (see description of subgroup construction in data analytic plan). Demographic characteristics for the entire sample (N = 132) as well as the two subgroups constructed for the purpose of this study are provided in Table 1.
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Full Sample (N = 132)</th>
<th>OCRBs (n = 33)</th>
<th>Control (n = 33)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40 (30.3%)</td>
<td>12 (36.4%)</td>
<td>12 (36.4%)</td>
</tr>
<tr>
<td>Female</td>
<td>92 (69.7%)</td>
<td>21 (63.3%)</td>
<td>21 (63.3%)</td>
</tr>
<tr>
<td>Age</td>
<td>20.5 (SD = 2.64)</td>
<td>20.5 (SD = 1.82)</td>
<td>20.6 (SD = 2.02)</td>
</tr>
<tr>
<td>Class year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshman</td>
<td>49 (37.1%)</td>
<td>8 (24.2%)</td>
<td>10 (30.3%)</td>
</tr>
<tr>
<td>Sophomore</td>
<td>20 (15.2%)</td>
<td>5 (15.2%)</td>
<td>6 (18.2%)</td>
</tr>
<tr>
<td>Junior</td>
<td>31 (23.5%)</td>
<td>12 (36.4%)</td>
<td>8 (24.2%)</td>
</tr>
<tr>
<td>Senior</td>
<td>30 (22.7%)</td>
<td>7 (21.2%)</td>
<td>8 (24.2%)</td>
</tr>
<tr>
<td>Other</td>
<td>2 (1.5%)</td>
<td>1 (3.0%)</td>
<td>1 (3.0%)</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>97 (73.5%)</td>
<td>25 (75.8%)</td>
<td>24 (72.7%)</td>
</tr>
<tr>
<td>African American</td>
<td>19 (14.4%)</td>
<td>4 (12.1%)</td>
<td>5 (15.2%)</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>2 (1.5%)</td>
<td>1 (3.0%)</td>
<td>1 (3.0%)</td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islander</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Asian</td>
<td>7 (5.3%)</td>
<td>2 (6.1%)</td>
<td>2 (6.1%)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>7 (5.3%)</td>
<td>0 (0.0%)</td>
<td>4 (12.1%)</td>
</tr>
<tr>
<td>Other</td>
<td>7 (5.3%)</td>
<td>1 (3.0%)</td>
<td>1 (3.0%)</td>
</tr>
<tr>
<td>DASS depression total</td>
<td>8.5 (SD = 7.39)</td>
<td>9.0 (SD = 6.95)</td>
<td>8.0 (SD = 7.89)</td>
</tr>
<tr>
<td>DASS anxiety total</td>
<td>8.4 (SD = 7.09)</td>
<td>11.0 (SD = 7.54)</td>
<td>5.8 (SD = 5.56)</td>
</tr>
<tr>
<td>DASS stress total</td>
<td>13.6 (SD = 7.5)</td>
<td>15.6 (SD = 7.24)</td>
<td>11.6 (SD = 7.26)</td>
</tr>
<tr>
<td>PI-WSUR total</td>
<td>26.1 (SD = 20.82)</td>
<td>37.1 (SD = 23.65)</td>
<td>15.1 (SD = 8.50)**</td>
</tr>
<tr>
<td>MGH total</td>
<td>2.0 (SD = 5.12)</td>
<td>3.9 (SD = 6.73)</td>
<td>0 (SD = 0)</td>
</tr>
<tr>
<td>SPS total</td>
<td>4.6 (SD = 5.77)</td>
<td>7.7 (SD = 6.61)</td>
<td>1.5 (SD = 2.17)**</td>
</tr>
<tr>
<td>Cog. flex. composite total</td>
<td>7.46 (SD = 8.92)</td>
<td>7.0 (SD = 7.78)</td>
<td>5.9 (SD = 8.07)</td>
</tr>
<tr>
<td># Errors block 6</td>
<td>.54 (SD = .65)</td>
<td>.55 (SD = .71)</td>
<td>.55 (SD = .79)</td>
</tr>
<tr>
<td># Errors block 8</td>
<td>6.9 (8.83)</td>
<td>6.4 (SD = 7.87)</td>
<td>5.4 (SD = 7.73)</td>
</tr>
</tbody>
</table>

*Note.* P values for group differences. *p < .05, **p < .01, ***p < .001
Measures

Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995)

The DASS-21 is a 21-item version of the original 42-item self-report designed to measure depression, anxiety, and tension/stress. Items are scored from 0 to 3, with higher scores indicating increased frequency of symptoms. The DASS-21 consists of three subscales assessing depression ($\alpha = .86$), anxiety ($\alpha = .76$), and stress ($\alpha = .77$). The scale has frequently been used in college student populations and has been shown to have high reliability and adequate divergent and discriminant validity (Ng et al., 2007).

Padua Inventory—Washington State University Revision (PI-WSUR; Burns, 1995)

The Padua Inventory—Washington State University Revision is a 39-item self-report measure of the degree of disturbance caused by obsessions and compulsions ($\alpha = .94$ in the current sample). The scale consists of several subscales measuring contamination obsessions and washing compulsions, dressing/grooming compulsions, checking compulsions, obsessional thoughts of harm to self or others, and obsessional impulses to harm self or others. Items are scored on a range from 0 (“not at all”) to 4 (“very much”). The scale has been used in diverse populations and displays good psychometric properties (Burns, Keortge, Formea, & Sternberger, 1996).

Massachusetts General Hospital—Hairpulling Scale (MGH-HS; Keuthen et al., 1995)

The MGH is a 7-item self-report that assesses repetitive hair pulling ($\alpha = .97$). The MGH measures the severity of hair pulling, degree of resistance and control over hair pulling, and actual hair pulling. Items range from scores of 0 to 4, with higher scores indicating increased symptom severity. The MGH has been found to be internally
consistent, demonstrate good test-retest reliability, significant convergent and divergent validity, and sensitivity to change in hair pulling symptoms (O’Sullivan et al., 1995).

**Skin Picking Scale (SPS) (Keuthen et al., 2001)**

The SPS is a 6-item self-report scale assessing skin picking behaviors ($\alpha = .95$). Scale items measure the frequency of skin picking urges, intensity of urges, time spent on picking, interference due to picking, and distress and avoidance related to skin picking. Examinees are instructed to rate items on a 0 to 4 scale, with higher values indicating more severe symptoms. The SPS has been found to be a valid and reliable measure of skin picking severity (Keuthen et al., 2001).

**Intradimensional/Extradimensional Shift (IDED) Test**

The IDED is a computerized analogue of the Wisconsin Card Sorting test and is a test of cognitive flexibility. In this task, the examinee is presented with two images. Each image contains a color-filled shape and white lines. The examinee chooses one of the images and receives feedback as to whether they were correct or incorrect, based on an unknown rule. The examinee is then presented with two new images, required to choose the correct image based on the feedback received in the previous trial, and again receives feedback as to their correctness. The examinee is considered to have established the rule after 6 consecutive correct responses. The number of trials required for the test-taker to reach 6 consecutive responses is considered one block. The rule then changes without the test taker’s knowledge, requiring them to mentally “switch” to the novel rule and respond according to feedback. At block 6, the intradimensional set shift occurs. In block 1 to block 6, the rule is based on the pink, color-filled shape. Which pink shape is correct
varies throughout the different blocks, but it is always based on the shape dimension. At block 6 a novel set of shapes is presented and the examinee must apply the previous rule of shape to the novel shapes. Block 8 constitutes the extradimensional shift stage. At block 8, the examinee again is presented with novel shapes and lines, however, unlike in previous blocks, the rule depends on the line dimension rather than the shape dimension. Examinees are required to switch from the shape dimension rule they previously adhered to in the previous blocks, and apply a new line dimension rule. A final test block appears after block 8 to test acquisition of the new line dimension rule. In this block, examinees are rewarded for choosing the pattern with the line that was previously incorrect in the preceding block.
Figure 1. Schematic of the IDED task (Jazbec et al., 2007).
Procedure

Students elected to participate in the study by reading information posted on the Kent State University SONA Experiment Management System website and selecting a timeslot for participation. Upon arrival to the laboratory, participants were consented and asked to complete a demographic questionnaire and several self-report questionnaires. The demographic questionnaire was used to obtain information in relation to age, race, psychological and medical history, and other historical information as well as including items in relation to number of times per week students reported biting their nails, picking their skin, and pulling out their hair (for non-cosmetic reasons). Participants were then instructed to complete a variety of self-report questionnaires, including the DASS, PI-WSUR, MGH-HS, and SPS. Following completion of self-report questionnaires, participants completed several neurocognitive tasks from the Cambridge Neuropsychological Test Automated Battery (CANTAB), including the IDED task, on a tablet computer.

Data Analytic Strategy

Primary Aim

To examine this study’s primary aim—whether cognitive flexibility deficits exist among college students exhibiting OCRBs—an independent samples t-test was performed. The dependent variable was a cognitive inflexibility composite variable. The composite variable consisted of the sum of the number of errors to reach criterion at block 6 (assessing intradimensional set shifting) and block 8 (assessing extradimensional
set shifting; Galimberti et al., 2012). The grouping variable consisted of participants in the control group or OCRB group. Based upon methods used to determine group membership in previous research examining neurocognitive functioning in subclinical obsessive-compulsive disorder in a college student sample (Mataix-Cols, 1999), criteria for membership in the OCRB group were a score of 1 standard deviation above the mean—obtained from the larger sample of 124 participants—on either the MGH-HS, SPS, or the PI-WSUR. This resulted in a sample of 33 young adults constituting the OCRB group. Thirty-three age, gender, and medication status (i.e., current use of stimulants or SSRIs) matched control participants were selected from the remaining 91 participants. Independent samples t-test analyses revealed statistically significant differences between groups on OCRB measures (see Table 1). Prior to conducting the analysis, potential covariates [i.e., age ($r = .07, p = .56$), depression ($r = -.02, p = .88$), and medication status ($r = .07, p = .56$)] were examined and revealed no need to control for confounding influences on cognitive flexibility. Subsequently, assumptions related to t-test analyses were examined and revealed that all assumptions were met.

Secondary Aim

Prior to conducting analyses related to my secondary aim, existing literature was examined to determine potential variables that may be related to OCRB severity and would require controlling for in the regression analysis. Correlation analyses were performed for potential covariates of age, gender, medication status, depression, anxiety, and stress (Basso, Bornstein, Carona, & Morton, 2001; Britton et al., 2010; Chamberlain et al., 2007a; Lawrence et al., 2006; Masi, Pfanner, & Brovedani, 2013; Moritz et al.,
An alpha correction (p = .008) was performed to account for the large number of potential predictor variables (n = 6). Based upon these analyses, stress ($r = .34, p < .008$) and anxiety ($r = .49, p < .001$; assessed using DASS Stress and Anxiety subscale scores, respectively) but not age ($r = .28, p = .024$), gender ($r = .02, p = .90$), depression ($r = .19, p = .12$), or medication status ($r = .13, p = .31$), demonstrated a statistically significant relationship to OCRB severity. To examine the potential cumulative load effect of cognitive flexibility deficits, cognitive flexibility was utilized as a predictor of OCRB symptom severity in a hierarchical regression analysis within the 66-participant sample described previously. Stress and anxiety variables were entered into step 1 and the cognitive flexibility variable (described above) was entered in block 2. The outcome variable was a composite OCRB severity variable created using the sum of standardized total scores on the following scales: the PI-WSUR, MGH-HS, and SPS. Before examining my final regression model, assumptions related to the conduct of regression were examined; all assumptions were met.
Results

Independent Samples T-Test

Results failed to show a significant difference in cognitive flexibility between the control and OCRB groups, $t(64) = -.54, p = .589$. Analyses did indicate that participants in the OCRB group made more errors on the cognitive flexibility task ($M = 6.97, SD = 7.78$) versus participants in the control group ($M = 5.91, SD = 8.07$). This difference was not significant, and represented a small-sized effect (Cohen’s $d = .14$).

Table 2
Hierarchical multiple regression of obsessive-compulsive and related behaviors (OCRBs) predicted by stress, anxiety, and cognitive flexibility deficits ($N = 66$)

<table>
<thead>
<tr>
<th>Step</th>
<th>B</th>
<th>SEB</th>
<th>$\beta$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>.25***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td>.03</td>
<td>.03</td>
<td>.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>.11</td>
<td>.04</td>
<td>.38**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>.29*</td>
<td>.05*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CF</td>
<td>.06</td>
<td>.03</td>
<td>.22*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hierarchical Regression

Results showed that a final regression model explained 29.4% of the variability in OCRB severity (Adjusted $R^2 = 26.0\%$; see Table 2). Anxiety was a statistically significant predictor of OCRB severity ($\beta = .38, p < .01$). Stress did not significantly predict OCRB severity. The addition of the composite cognitive flexibility variable (i.e., Blocks 6 and 8; $\beta = .22, p < .05$) significantly improved model fit ($F_{\Delta}(1, 62) = 4.16, p < .05$), revealing a small to moderate effect. These findings suggest that lower levels of cognitive flexibility predict greater OCRB severity.

After finding a significant effect of cognitive flexibility, two additional hierarchical regression models were performed to examine whether performance on the intradimensional (Block 6) or extradimensional (total errors in Block 8) set-shifting phases of the cognitive flexibility task is a better predictor of OCRBs in college students, after controlling for anxiety and stress. Results from the intradimensional set-shifting phase analysis showed that the final regression model explained 24.7% of the variability in OCRB severity (Adjusted $R^2 = 21.7\%$). Anxiety was a statistically significant predictor of OCRB severity ($\beta = .39, p < .01$). Stress did not significantly predict OCRB severity. The addition of the intradimensional set-shifting variable (i.e., total errors in Block 6) did not significantly improve model fit. Results from the extradimensional set-shifting phase analysis showed that the final regression model explained 29.6% of the variability in OCRB severity (Adjusted $R^2 = 26.2\%$). Anxiety was a statistically significant predictor of OCRB severity ($\beta = .39, p < .01$), but stress was not. The addition of the
extradimensional set-shifting variable (i.e., Block 8; $\beta = .23, p < .05$) significantly improved model fit ($F_{\Delta} (1, 62) = 4.36, p < .05$), revealing a small to moderate effect. These findings suggest that difficulty in extradimensional set-shifting (and not intradimensional set-shifting) is predictive of OCRB severity.
Discussion

Consistent with the purpose of the RDoC initiative—to classify psychological disorders on the basis of shared biomarkers and neurological correlates amongst clusters of disorders—the current study sought to examine the possibility that cognitive flexibility represents one such construct underlying disorders characterized by repetitive, habitual, or compulsive behaviors. Analyses indicated that young adults with obsessive-compulsive and related behaviors—specifically OCD-like behaviors, skin picking, and hair pulling—do not present with significantly greater cognitive flexibility deficits compared to healthy controls. These results should be interpreted with caution, however, due to the nature of the sample utilized in this study. Despite the lack of significant group differences, results indicated that there exists a cumulative load effect of cognitive flexibility deficits, such that greater deficits in cognitive flexibility—particularly extradimensional set-shifting deficits—predict greater severity of OCRBs. These findings represent a significant addition to extant literature by highlighting the importance of cognitive flexibility in predicting the severity of OCRBs in young adults.

Findings from the current study elucidate several important implications for understanding repetitive behavior disorders. First, these results suggest that cognitive flexibility may help explain why some people exhibit more severe repetitive, habitual, or compulsive behaviors. Young adults who perform OCRBs to a greater degree likely display greater difficulty with discontinuing performance of these behaviors upon
receiving negative feedback. Thus, when these individuals begin pulling their hair pulling or picking their skin, it may be difficult for them to stop doing so. This deficit may be especially reflected by deficits in the extradimensional set-shifting phase of the cognitive flexibility task, which requires participants to shift from a previous rule to a new rule based on negative feedback. In other words, performing an OCRB may provide initial reinforcement in the form of, for example, tension reduction and/or anxiety dissipation. However, when performance of the OCRB begins to result in increased negative feedback (i.e., bald spots, negative peer reactions, bleeding, pain, and disruptions in academic and social functioning) young adults exhibiting deficits in cognitive flexibility may experience difficulty switching from the rule that performing the OCRB is adaptive to the new rule that performing the OCRB is maladaptive. Further research is needed to examine whether a relationship exists between extradimensional set shifting and OCRB severity in clinical populations.

A second implication of the current study is that, based upon these results, young adults exhibiting OCRBs do not perform significantly worse on tests of cognitive flexibility compared to people who exhibit these behaviors to a lesser extent. Thus, while participants in the OCRB group on average displayed more errors on the cognitive flexibility task compared to healthy controls, there may be more salient neurocognitive factors that help to distinguish people with OCRDs from those without. Specifically, though cognitive flexibility may be important in understanding the etiology of OCRDs, it may be only one of many important factors. In other words, while cognitive flexibility
appears to play a role in predicting the severity of OCRBs, other neurocognitive factors may be more salient in differentiating individuals who perform OCRBs from individuals who do not. Alternatively, this finding may be due, in part, to the fact that it is unlikely that a majority of participants in the sample met DSM-5 diagnostic criteria for OCD, trichotillomania, or excoriation (skin picking) disorder and therefore may not provide a perfect representation of what these behaviors may look like amongst clinical populations. Thus, subjects in the OCRB group may not have reported engaging in OCRBs to a level of severity that is sufficient to differentiate the OCRB group from the control group. Nevertheless, this finding indicates the need for additional research examining cognitive flexibility in a larger, clinical sample and should examine potential ancillary neurocognitive correlates underlying OCRDs (e.g., impulse control).

Despite the noteworthy findings described previously, several limitations to the present study should be noted. One such limitation is the utilization of self-reports as measures of obsessive-compulsive and related behaviors. Participants were required to estimate how many times per week they perform certain behaviors, which could be difficult for participants to remember. While a noteworthy limitation, this form of self-report has been used in prior research and is an efficient, reliable, and valid way to measure OCRBs in a large sample. Future research, however, may consider the use of clinician-administered measures to facilitate more accurate estimations of the frequency and severity of OCRB performance. Second, the use of convenience sampling from a college student population resulted in a relatively homogenous sample (i.e., mainly
female, Caucasian college students in their freshman year) that could decrease the generalizability of findings. This limitation is common in studies utilizing college student populations, however (Peterson, 2001), and highlights the need for replication in clinical populations. Relatedly, the use of a college student sample yielded scores on the OCRB measures that are lower than those obtained from clinical samples. In addition, subjects in the control group may not represent pure control participants, as they did report some level of OCRBs. Despite the fact that the groups were significantly different on measures of OCRBs, the insufficient elevation of scores on these measures in the clinical group as well as the presence of some level of OCRBs in the control group may have contributed to the lack of a significant difference between the groups. While a limitation to the current study, these results may indicate that cognitive flexibility exists on a continuum, such that individuals who exhibit OCRBs display greater cognitive flexibility deficits, and those who exhibit minimal OCRBs display some, but fewer, deficits in this domain. In fact, results from the hierarchical regression analyses conducted for this study are suggestive of this relationship. Future research should seek to compare subjects displaying clinically significant levels of OCRBs with participants who do not exhibit OCRBs to better identify whether deficits in cognitive flexibility differentiate healthy controls from clinical samples of patients exhibiting repetitive behaviors.

Despite the lack of significant group differences, cognitive flexibility was found to be a significant predictor of OCRBs severity. This finding represents an important contribution to the RDoC initiative to identify biomarkers and neurocognitive correlates
underlying clusters of disorders and provides support for past research examining etiological factors implicated in OCRDs. An additional benefit of the current study is the utilization of a standardized assessment method, which facilitates comparison across repetitive behavior disorders and decreases the opportunity for experimenter error and bias. Future research should endeavor to examine this relationship in a larger, clinical sample by utilizing similar standardized assessment techniques. Though cognitive flexibility is an important factor in understanding OCRDs, it is likely one of many neurocognitive correlates influencing repetitive behavior phenotypes. Cognitive flexibility, as well as other neurocognitive correlates (e.g., impulse control) should continue to be examined in future research. Knowledge of the neurocognitive correlates underlying OCRBs will facilitate a better understanding of factors related to the phenotypic presentations of OCRBs and will inform how to best treat these disorders in the future.
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