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Neural mechanisms of cognitive behavioral therapy response in Hoarding Disorder: A pilot study

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ABSTRACT

Hoarding Disorder (HD) is a common and chronic condition that is associated with distinct abnormalities in neural function. The impact of treatment on these abnormalities is not known. Six patients with HD and 6 healthy control (HC) participants underwent a functional magnetic resonance imaging (fMRI) task in which they made simulated decisions about whether to acquire or discard a variety of objects. The HD patients then received 16 sessions of manualized group cognitive behavioral therapy (CBT) for HD. After treatment, the HD patients completed the same fMRI decision-making tasks to identify changes in brain function elicited by decision-making. During acquiring decisions, reductions in HD patients' hemodynamic activity were observed in medial frontal gyrus, anterior and posterior cingulate, left insular cortex/postcentral gyrus, right caudate and putamen, paracentral lobule, bilateral posterior parietal lobe regions, right superior temporal gyrus, left hippocampus/parahippocampus, occipital cortex, and anterior cerebellum. During discarding decisions, reduced activity was observed in right superior/medial frontal gyri, left insula/putamen, posterior cingulate, precuneus, right posterior hippocampus, lingual/cuneus and right putamen. Prior to treatment, activity in these regions differed significantly between HD patients and HC participants. However, after CBT, most of these differences were no longer significant, suggesting normalization of neural function.

1. Introduction

Hoarding Disorder (HD), defined as the acquisition of and failure to discard large volumes of possessions, resulting in clutter that precludes normal use of living spaces (Frost & Gross, 1993; Frost & Hartl, 1996), is a common and potentially debilitating disorder with a significant public health burden. Neuroimaging research has implicated frontotemporal regions thought to underlie problems of decision-making, attachment, reward processing, impulse control, self-awareness, and emotion regulation. These findings include lower resting glucose metabolism in anterior cingulate cortex (Saxena et al., 2004) and greater hemodynamic activity in precentral gyrus and orbitofrontal cortex (Mataix-Cols et al., 2004; Tolin, Kiehl, Worhunsky, Book, & Maltby, 2009), ventromedial prefrontal cortex (An et al., 2009), parahippocampal gyrus (Tolin et al., 2009), and insula/anterior cingulate cortex (Tolin et al., in press) during symptom provocation.

The aim of the present study was to examine changes in hemodynamic activity elicited by decision-making about acquiring or discarding possessions following cognitive behavioral therapy (CBT) for HD patients. Historically, HD has proved quite difficult to treat effectively. In recent years, a tailored CBT that addresses maladaptive beliefs about and attachment to possessions, trouble with organization and decision-making, and behavioral avoidance has shown promise, with 50–69% of patients considered treatment responders (Steketee, Frost, Tolin, Rasmussen, & Brown, 2010; Tolin, Frost, & Steketee, 2007). This CBT protocol has been adapted to a group format, with similar outcomes (Gilliam et al., in press; Muroff et al., 2009). Therefore, these CBT methods not only are effective for reducing impairment for many patients with HD, but also represent a means to study the effects of successful treatment on patterns of HD-related brain dysfunction.

A growing body of literature shows that successful psychotherapeutic treatments (e.g., CBT) are associated with significant and replicable alterations in brain function (see Beauregard, 2007; Frewen, Dozois, & Lanius, 2008; Roffman, Marci, Glick, Dougherty, & Rauch, 2005, for reviews). For example, PET studies show that OCD patients receiving behavior therapy show reduced metabolic activity in right caudate nucleus as well as uncoupling of caudate, OFC, and thalamus (Baxter et al., 1992; Nakatani et al., 2003; Schwartz, Stoessel, Baxter, Martin, & Phelps, 1996). Based on a review of basic and clinical neuroimaging studies, Frewen et al. (2008) suggested that successful CBT for mood and anxiety disorders is likely to be

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associated with alterations in dorsolateral prefrontal cortex, ventrolateral prefrontal cortex, medial prefrontal cortex, ACC, PCC, amygdala, and insula. These regions are hypothesized to be linked to the general targets of CBT (e.g., increased problem-solving capacity, improved self- and other-directed information processing, improved emotional processing) (Murphy, Nimmo-Smith, & Lawrence, 2003; Northoff et al., 2006). One limitation of the extant research, as noted by Roffman et al. (2005), is that most studies have examined resting-state brain activity only, rather than employing cognitive tasks relevant to the underlying disorder. However, existing studies suggest that a general effect of CBT treatment is to alter abnormal profiles of brain activation towards profiles found in non-clinical samples.

In the present study, HD patients received an open trial of group CBT following the protocol used in previous research (Gilliam et al., in press; Muroff et al., 2009). Before and after treatment, patients underwent functional magnetic resonance imaging (fMRI) during a novel decision-making task adapted from the work of Preston, Muroff, and Wengrovitz (2009). A matched group of healthy control participants also completed the same task during fMRI for comparison purposes. It was predicted that: (1) compared to healthy controls, HD patients would exhibit greater hemodynamic activity in the frontotemporal regions seen in previous research (An et al., 2009; Mataix-Cols et al., 2004; Tolin et al., 2009; Tolin et al., in press); (2) hemodynamic activity in those regions of interest would decrease following CBT; and (3) following CBT, hemodynamic activity at post-treatment would normalize (i.e., would no longer differ significantly from that of healthy controls).

2. Method

2.1. Participants

6 HD patients and 6 healthy controls (HC), recruited via newspaper advertisements, participated in the study after providing written informed consent. All assessments were conducted by a postdoctoral fellow or trained postgraduate research assistant with experience in the evaluation of HD. Participants were classified as having HD if they met the clinical criteria outlined by Frost and Hartl (1996) and proposed for DSM 5 (Mataix-Cols et al., 2010), and HD was their primary diagnosis as defined by Clinical Severity Ratings (CSRs) on the Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV; Brown, DiNardo, & Barlow, 1994). The Clinician's Global Impression (CGI; Guy, 1976) rating was "moderately ill" or above, and symptom duration was 1 year or more. Where there were questions about the severity of hoarding, symptom severity was confirmed via home visit or analysis of current photographs of living space. Participants were excluded if they had a history of non-hoarding OCD, psychotic disorder, neurologic disorder, substance abuse, or serious suicidal ideation. Healthy controls were excluded if they met criteria for a current or past Axis I or Axis II disorder, had a history of neurological disorders, or were taking psychiatric medications. Participants who were unsuitable for fMRI (for example, severe claustrophobia, pregnancy, or metal implants) were excluded. Only one HD patient was taking psychiatric medications at the beginning of the protocol; no medication changes were allowed during study treatment.

2.2. Measures

HD diagnoses were made using the *Hoarding Rating Scale-Interview* (HRS-I; Tolin, Frost, & Steketee, 2010), a semi-structured interview that assesses the severity of clutter, acquisition, difficulty discarding, distress, and impairment, each on a 0–8 scale. Internal consistency was excellent in this sample (α=98). HD participants received ratings of 4 (moderate) or greater on the clutter, difficulty discarding, and distress or impairment scales; healthy controls did not meet this criterion, which reliably discriminates hoarding from non-hoarding participants (Tolin et al., 2010). Other psychiatric diagnoses were ascertained using the *ADIS-IV* (Brown et al., 1994). Reliability for the various DSM-IV categories contained in the ADIS-IV ranges from good to excellent (Brown, Di Nardo, Lehman, & Campbell, 2001). In addition, clinical ratings demonstrate strong inter-rater reliability for the different dimensions of the DSM-IV anxiety and mood disorders. Assessors (experienced postgraduate research assistants, supervised by licensed psychologists) were trained to criterion (100% agreement on diagnostic classification and within 1 CSR point on all diagnoses). Severity of the core features of hoarding (clutter, difficulty discarding, acquiring) was assessed using the *Saving Inventory-Revised* (SI-R; Frost, Steketee, & Grisham, 2004), a 23-item self-report measure of compulsive hoarding severity. Internal consistency is excellent for the total score and for the 3 subscales. The SI-R readily discriminates HD patients from OCD patients and community controls, and correlates significantly with ratings of clutter and associated impairment (Frost et al., 2004). Internal consistency was acceptable in this sample (Clutter α=98, Difficulty Discarding α=91, Acquiring α=80, Total α=97). Global impressions of illness severity were recorded using the *Clinician's Global Impression* (CGI; Guy, 1976) scale. Both groups (HD and HC) received the same measures.

2.3. Apparatus

Imaging was implemented on a Siemens 3T Allegra scanner. The Allegra is a high performance head-dedicated system optimized for functional brain imaging. Head motion was restricted using a custom built apparatus that interfaced with the head coil. Functional image volumes were collected with an EPI gradient-echo pulse sequence (TR/TE 1500/28 ms, flip angle 65°, FOV 24 × 24 cm, 64 × 64 matrix, 3.4 by 3.4 mm in plane resolution, 5 mm slice thickness, 29 slices) that effectively covers the entire brain (145 mm) in 1.5 s. The thin slices and short TE make the Allegra optimal for examining orbitofrontal activity.

The fMRI task was implemented in E-Prime software (Psychology Software Tools, Inc.). Visual stimuli were presented using a projection system (5000 ANSI lumens) and displayed on a high resolution screen located just behind the subject's head. The participant viewed this screen using a mirror attached to the head coil. An MR-compatible fiber optic response device acquired subject responses for offline assessment.

2.4. Procedure

2.4.1. Neuroimaging tasks

After being placed in the scanner and being given sufficient time to habituate to the environment, participants engaged in a computerized task adapted from Preston et al. (2009). There were two separate fMRI tasks, delivered in fixed order. In Task 1 (Acquiring), participants were instructed as follows: "In this task, you will see a series of pictures. Imagine that all of the items pictured are here today in this building. You can take home anything you want today, for free. Underneath each picture you will see the words "TAKE IT" on the left, and "LEAVE IT" on the right. If you want to TAKE an item home today, press the button under your index finger. If you want to LEAVE an item here today press the button under your middle finger. When you TAKE an item, a green border will appear around the picture, meaning it is now YOURS to take home. When you LEAVE an item, a red border will appear around the picture, meaning you will not be taking it home. There is only one catch. You can take home anything you want today, for free; however, you can only take as many things as will fit in a standard shopping cart like this one [picture of standard supermarket shopping cart shown]. Once your shopping cart is full you will not be able to add or remove any items. Therefore, select your items carefully, only taking things that you really want. Remember, the items you see do not belong to you yet. But you can take home anything you want today, for free."

In Task 2 (Discarding), participants were instructed as follows: In the next task, you will see a new series of pictures. Imagine that all of the items pictured belong to you. Underneath each picture you will see the words "KEEP IT" on the left, and "DISCARD IT" on the right. If you want to KEEP an item press the button under your index finger. When you KEEP an item, a green border will appear around the picture, meaning it is still YOURS. When you DISCARD an item, a red border will appear around the picture, meaning you have put it into the trash. There is only one catch. You can keep anything you want today; however, you can only keep as many things as will fit in a standard shopping cart like this one [picture of standard supermarket shopping cart shown]. Once you have filled your shopping cart, you will not be able to add or remove any items. Therefore, select your items carefully, only keeping items you really want. Remember, the items you see belong to you. They are in your home, and you can keep or discard whichever items you want."

Both these tasks alternated trials requiring a decision about objects with trials representing the same control condition. For the control condition (task 3), participants were instructed as follows: "There also is another task you have to do. For some groups of items, you don't get to choose whether or not take them home. Instead, we will ask you to look at each item and indicate if it is "Organic" or "Inorganic". Organic means that something in the item is alive, or it is made of materials that were once alive. For example, items made of paper, cloth or things like food. Inorganic means that nothing about the item is alive or the item is made of materials that never were alive. For example, items like plastic, rocks, or electronics. In these groups, you will see the word "ORGANIC" on the left, and "INORGANIC" on the right underneath each picture. If the item is ORGANIC, press the button under your index finger. If the item is INORGANIC, press the button under your middle finger. When you indicate that an item is ORGANIC, a green