The Neurobiology and Development of Compulsive Hoarding and Its Relationship to Obsessive-Compulsive Disorder

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January 28, 2009
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Abstract

Compulsive hoarding disorder (CHD) is a psychological phenomenon in which the individual's created environment is a product of their internal state. Currently, CHD is generally considered to fall under the umbrella of obsessive-compulsive disorder (OCD). However, recent neuropsychological evidence supports the hypothesis that CHD may best be characterized as a disorder separate from other forms of OCD. Not only does functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) data show that compulsive hoarding may be a neurobiologically discreet syndrome, but recent evidence from genetic studies as well as inquiry into the development of pathological hoarding leads to findings that may implicate a distinct disorder with specific neuropsychological impairments. Thus far, CHD has been explored primarily within the confines of OCD, and therefore, the neurobiology and development of this syndrome will be discussed within this context. This review seeks to integrate the previous research in CHD with the most recent findings to create a thorough overview of this pathology.
Introduction

Compulsive hoarding disorder (CHD) is a psychopathology unique in that the primary expression of the individual's internal state is in the disordered environment that they create for themselves. Frost and Hartl (1996) have identified three criteria that must be met in order for a hoarding disorder to be clinically significant. The first is the acquisition and failure to discard an excess number of items that appear to have no practical or constructive purpose. The second is that an individual's living space must be cluttered to such a degree that it precludes his or her ability to use the space for what it was intended. For example, the inability of a person to use his kitchen for cooking because the stove is used as a storage space for hoarded items and the counters are cluttered to such a degree as to render them useless. The third is that the person must be significantly distressed over their behavior. This factor is included because it is not uncommon for hoarders to have a profound lack of insight into their problem. Many people see their behavior as rational or even desirable (Black, Monahan, Gable, Blum, Clanck, & Baker, 1998; Steketee & Williams 2000).

Compulsive Hoarding and OCD

It is estimated that about 1-2% of the population suffer from a hoarding disorder (Steketee & Frost, 2003). Thus far, CHD has primarily been studied within the context of OCD. The Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) lists hoarding as one of the eight symptoms indicative of obsessive compulsive personality disorder (OCPD; American Psychological Association, 1994), and the behavior is commonly considered to be one of four or five subtypes of OCD (Frost, Krause, & Steketee, 1996; Rasmussen and Eisen, 1989; Samuels, Bienvenu, Riddle, Cullen, Grados, & Liang et al, 2002), a disorder in which a person has intrusive and unwelcome thoughts and uses ritualized behavior to neutralize them (Abramowitz, Wheatin, & Storch, 2008). However, there is no consensus as to how common hoarding is within OCD. Studies have put the prevalence of hoarding in this population at anywhere from 18% - 43% (Hanna, 1995; Rasmussen & Eisen, 1992; Samules, et al. 2002). Some researchers have proposed a classification system that differentiates pure hoarding disorder from hoarding within OCD (Grisham, Brown, Liverant, & Campbell-Sills, 2004).

Recent neuropsychological evidence supports the hypothesis that CHD may best be characterized as a disorder separate from other forms of OCD (Lawrence, Wooderson, Mataix-Cols, Speckens, & Phillips, 2006; Grisham,
Brown, Savage, Steketee, & Barlow, 2007). Not only does fMRI and PET data show that compulsive hoarding may be a neurobiologically discreet syndrome (Saxena, Brody, Maidment, Smith, Zohrabi, & Katz, et al., 2004; Tolin, Kiehl, Worhunshy, Book, & Maltby, 2008; An, Mataix-Cols, Lawrence, Wooderson, & Giampietro, 2008), but recent evidence from genetic studies (Samuels, Shugart, Grados, Willour, Bienvenu & Greenberg, et al, 2007; Liang, Wang, Shugart, Grados, Fryer, & Rauch, et al, 2008) as well as inquiry into the development of pathological hoarding behaviors (Grisham, Frost, Steketee, Kim, & Hood, 2005; Storch, Lack, Merlo, Geffken, Jacob, & Murphy, et al. 2007), lead to findings that indicate a distinct disorder with specific neuropsychological impairments.

Some researchers have suggested that the classification of CHD may be most appropriate on the spectrum of impulse control disorders (ICDs) (Hahm, Kang, Cheong, & Na, 2001; Grisham & Barlow, 2005) due to the syndrome’s high correlation with issues such as pathological grooming (e.g. trichotillomania, nail biting, skin picking) (Samuels, Bienvenu, & Pinto, 2007), compulsive buying (Frost, Kim, Morrise, Bloss, Murray-Close & Steketee,1998), and compulsive gambling (Lawrence, et al., 2006). Also, patients with ICDs tend to experience their symptoms as ego-syntonic, they engage in their behaviors because it is pleasing to them at the time (Ferrao, Amnedia, Bedin, Rosa, & D’Arrigo Busnello, 2000); while patients with OCD find their symptoms ego-dystonic, they are bothered by symptoms which they are capable of perceiving as irrational but which they cannot stop themselves from engaging in (OCD, American Psychological Association, 1994). People with CHD often do not see their behavior as unreasonable, and may even see it as responsible (Frost & Gross, 1993), and certain aspects of the disorder, such as compulsive acquisition, may be highly ego-syntonic.

Aside from this nosological controversy, it is undeniable that pathological hoarding behaviors can occur in a variety of mental illnesses such as schizophrenia (Luchins, Goldman, Lieb & Hanrahan, 1992), anorexia (Frankenberg, 1984), and depression (Shafran & Tallis, 1996). Hoarding can also result from certain forms of dementia (Hwang, Tsai, Yang, Liu, & Liang, 1998; Liang, et al, 2008) and lesions to the orbitofrontal and medial frontal cortex (Anderson, Damasio, Damasio, 2005). It has also been observed in people with certain developmental and genetic disorders such as autism (McDougle, Kresch, Goodman, Naylor, Volkmar, & Cohen, et al, 1995), mental retardation (Stein, Seedat, & Potocnik, 1999) and Prader-Willi syndrome (Greaves, Prince, Evans, & Charman, 2006) and is significantly correlated with Tourettes Syndrome (Zhang, Leckman, Pauls, Tsai, Kidd, & Campos, et al., 2002). Hoarding can also emerge as a consequence of physical disability (Halliday, Banejee, Philpot, & MacDonald, 2000).
or in conjunction with Diogenes syndrome, a disorder that presents in elderly people and is defined by severe self-neglect, social withdrawal, and domestic squalor (Lebert, 2005). However, for the purposes of this review, it should be understood that mental and physical conditions such as these, which preclude individuals from most studies investigating CHD, can be considered separate phenomena.

**Behavioral Trajectory of Compulsive Hoarding Disorder**

In a 2004 study, Fontenelle and colleagues found the average age of onset for CHD in patients who had been diagnosed with OCD to be 11.3 years (n=15), significantly earlier than the 22.0 years (n=82) that the same group found for OCD patients who did not endorse hoarding symptoms. The average onset of OCD (including patients whose primary symptom is hoarding), has consistently been estimated to be between 19 and 20 years old (Rasmussen & Eisen, 1990, Flament, Whitaker, Rapaport, Davies, Berg, & Kalikow, et al., 1988). Since OCD is also seen in children, some researchers separate adult-onset OCD from childhood-onset OCD (Geller, Biederman, Jones, Shapiro, Schwartz & Parks, 1998; Sobin, Blundell, & Karayiorgou, 2000). This separation is particularly interesting to note since it is very rare for a hoarder to report an onset beyond their preteen years (Frost & Gross, 1993).

A progression graphic derived from the data of a 2005 study by Grisham et al. into the development of CHD is a useful visual tool:

Any Hoarding Symptom → Clutter & Difficulty Discarding → Acquiring → Recognition/Insight

People who have had hoarding difficulties throughout their lives can experience an explosion in their symptoms in young adulthood (Storch, Lack, Merlo, Geffken, Jacob, Murphy & Goodman, 2007), as once a person has left the family household, there is no one left to set the standard of environmental acceptability. The only thing that seems to limit a hoarder's behavior is constraints on the amount of room that they have to fill (Kellet, 2007). Indeed, in a retrospective study by Grisham and colleagues (2005), hoarders reported that recognition of their symptoms occurred a decade or more after the symptoms themselves began.

In studies of non-hoarding OCD patients, researchers found that symptoms followed either a static course or an ebb and flow type of pattern, and that only a small percentage of these patients (5-14%) deteriorated over time (Steketee, Eisen, Dyck, Warshaw, & Rasmussen, 1999; Goodman, Guze, & Robbins, 1969; Rasmussen & Tsuang,
1986; Skoog & Skoog, 1999). However, CHD is known to run a chronic and worsening course (Grisham, & Barlow, 2005). The average person to seek treatment for a hoarding problem is a middle aged woman (Frost, Steketee, Williams, & Warren, 2000). Due to what is known about the trajectory of this illness that is not to say that the onset of CHD is in middle age, but rather that by then, the problem is more likely to have reached such a level of severity that it can no longer be ignored.

Data has shown that hoarders seek treatment for their problem significantly later than people with other types of OCD. This is evinced by the demographics of studies which draw from clinics that treat both hoarding and non-hoarding types of OCD (Fontenelle, et al., 2004; Grisham et al., 2004). Hoarders are also less likely to seek treatment than people with non-hoarding OCD (Saxena & Maidment, 2004). Those individuals who do seek professional help for their hoarding symptoms are often pushed to do so by family members or the legal system (Greenberg, 1987; Thomas, 1997; Christensen & Greist, 2001). At times a person may be forced to seek professional attention due to health department notification or infestation (Lunchian, McNally, & Hooley, 2007). However, hoarding does not necessarily lead to neglect of oneself and the basics of one's home (Snowden, Shah, & Halliday, 2007).

**Environmental Factors**

CHD is not associated with childhood material deprivation (Frost & Gross, 1993), but hoarders have often had the experience of having something taken from them by force (Hartl, Duffany, Allen, Steketee, & Frost, 2004), and they consistently report some level of instability in their developmental years. In 2002, a study was conducted by Alonso, et al. on the perceived parental rearing style of patients with OCD. Although all patients perceived being raised in an atmosphere low in parental warmth, the difference was not statistically significant when compared to healthy controls except when the hoarding subtype was separated out. Researchers found that hoarding was the only dimension of OCD that could be partially predicted by perceived parental traits, namely, low emotional warmth. Therefore is theorized CHD behavior may be a result of poor attachment. Other research has suggested that ambivalent attachment is positively correlated with hoarding behavior, and that secure attachment is negatively correlated with this behavior (White, Krause, Williams, Frost, Steketee, & Kyrios, 2000).

Compulsive hoarders have a significantly higher rate of traumatic lifetime events (TLEs), over and above what is seen in other forms of OCD (Cromer, Schmidt, & Murphy 2007; Hartl, et al., 2005). Cromer et al. (2007) found that
hoarding severity was positively correlated to the number of TLEs, especially TLEs involving physical or sexual abuse (Hartl, et al. 2005). Interestingly, the degree of clutter was found to be positively correlated with the number of traumatic life experiences, but the other two aspects of CHD, acquisition and failure to discard, were not. It may be that hoarders develop emotional attachments to objects because life experience has taught them that objects are more reliable than people.

Current Theoretical Models of Compulsive Hoarding

There are currently two theoretical models of CHD in the literature on the pathology. The predominant model is the cognitive behavioral model, conceived by Frost and Hartl (1993) and refined by Frost and Steketee (1996). The second model, the site security model (Kellet, 2007), approaches the disorder from a more biological/evolutionary perspective, and has yet to be cited by other authors. This very well may be due to its more recent publication. A brief overview will be given of each model.

1. A Cognitive-Behavioral Perspective

In the cognitive-behavioral model, it is believed that there are four primary neuropsychological deficits that lead to pathological hoarding behavior (Frost & Hartl, 1993; Frost & Steketee, 1996). First, hoarders attach an unusual amount of emotional significance to objects. Second, they have exaggerated beliefs about the nature and importance of their possessions. Third, they exhibit a high level of behavioral avoidance; and fourth, they have organic informational processing deficits. The last factor includes difficulty in organization and categorization (Wincze, et al., 2007), actual and perceived memory deficits (Hartl, Frost, Allen, Deckersbach, Steketee, Duffany, & Savage, 2004; Hartl, Frost, & Allen, 2004), impaired ability to make inferences from available information, (Fullana, Mataix-Cols, Caseras, Alonso, Menchón, Vallejo, & Torribia, 2004) and decision making difficulties (Lawrence, Wooderson, Mataix-Cols, Speckens, & Phillips, 2006). Indeed, some of the most prominent researchers in CHD consider decision making problems to be the “hallmark” of the disorder (Frost & Hartl, 1995). Each of these information processing deficits will be explored in greater detail following the discussion of the second model of CHD, the site-security model.
2. An Evolutionary Perspective

Kellet (2007) addresses the biological/evolutionary aspects of hoarding in his site-security model of CHD. He hypothesizes that the key biological theory of hoarding in animals: site-security; can be applied cross-species. Site-security is the idea that every small mammal will find food and take it to a secure location if it feels threatened. The animal continues to use this location as a place to eat and to store more food. They may do this for two reasons; the first being that their presence at the site minimizes the potential that they may be harmed, and the second is that visiting the site increases the animal's sense of security (Vander Wall & Jenkins, 2003). This is consistent with the use of objects as safety signals reported by hoarders (Frost, et al. 1995).

Animals will aggressively defend their sites from invasion, as disruption of their site is seen as catastrophic (Kramer, 2001; Vander Wall & Jenkins, 2003). Neziroglu, et al. (2004) conceptualized hoarding in humans as an effort to avoid the perceived catastrophic consequences of a breech in site-security. Indeed, hoarders react very negatively to unauthorized touching of their hoarded materials (Frost & Hartl, 1996; Steketee, Frost & Kyrios 2003), as there is an absolute need for control over the items in a his or her possession. One of the cardinal rules in the treatment of CHD is to never, ever touch a patients possessions without his permission, as doing so may constitute a breech of trust (Tolin, et al, 2007), or, in the context of Kellet's model, a breech of security.

It is clear that effective and substantial hoarding has been an evolutionary advantage throughout most of human history and all of mammal history. In individuals from families prone to CHD, this genotypic trait is not suppressed despite the ready availability of commodities in modern life (Kellet, 2007; Smith 2000). The advantageous nature of this behavior seems to distinguish CHD from other variants of OCD; as at one point in our evolutionary history every healthy human would have endorsed this behavior. The same cannot be said for other OCD types. Thus, CHD may partially result from gene selection gone awry.

Information Processing Deficits

Studies of patients with CHD have found that hoarders demonstrate four primary information processing deficits. Before each of these is discussed in detail, the perfectionistic tendencies that these patients endorse should be addressed, as these inclinations can be seen woven throughout each of these deficiencies. Perfectionism is a trait that compulsive hoarders share with OCD patients, as is indecisiveness (Frost & Gross, 1993), and perceptions of responsibility (Frost, Hartl, Christian & Williams, 1995). Although perfectionism is seen across all types of OCD, the
effects of this characteristic may be more consequential for the hoarding type. Often, hoarders do not only want to be perfect, they expect perfection of themselves (Saxena, Brody, Maidment Zohrabi, Baker, & Baxter, 2004). This characteristic seems counterintuitive due to the seemingly chaotic nature of the behavior, yet it is one of the most consistently and statistically significantly correlated traits (Frost, et al., 1995; 1996; Frost, Williams & Warren, 2000; Samuels, et al, 2002). Much of the material accumulation in cases of CHD can be attributed to a tremendous fear of throwing something away by mistake (Frost & Gross, 1993; Frost & Shows, 1993), and much of the clutter is due to the hoarder’s need to find the “perfect place” for an object but being unable to do so (Kellet, 2007; Tolin, et al. 2007).

1. Organization and Categorization

A well-established characteristic of OCD individuals is the use of an “under-inclusive” (Reed, 1969) style of thinking which can create problems in categorization and organization. Wincze et al. (2005) conducted an experiment in categorization using three subject groups: an OCD hoarding group, an OCD non-hoarding group, and non-clinical controls. They were given two sorting tasks. In the first, participants were asked to sort household items into piles according to categories, and in the second they were asked to do the same, but with personal items. All three groups created an equivalent number of piles when sorting household items, although the OCD group and the hoarding group took more time to sort than the non-clinical controls. When asked to sort personal items, the OCD hoarding group took more time and had more piles than both the OCD group and the controls, which had the same amount of piles when compared to each other. The authors conclude that sorting personal objects is especially problematic for OCD patients whose primary symptom is hoarding.

Hartl et al. (2004) found that OCD hoarders have more difficulty than OCD non-hoarders in planning and organization. Their method of copying the Rey complex figure (RCFT; Meyers & Meyers, 1995) was inefficient and atypical. Instead of drawing overarching features first, hoarders drew the figure in a disjointed and seemingly unmethdical way. This tendency to get lost in the details and miss the larger picture is characteristic of compulsive hoarders (Frost & Steketee 1998). This seems to be true in both concrete and abstract ways, and correlates with the difficulties in categorization that they present (Wincze, et al., 2007). Hoarders believe that they must know everything about every object, and that the consequences of forgetting information would be disastrous (Frost & Hartl 1996). Again, focus on details leads to environmental impairment.
2. Actual and Perceived Memory Deficits

Compulsive hoarders claim that their memories are deficient, and that they are afraid of forgetting (Frost & Gross 1993). They are convinced that their possessions must be in sight to serve as a memory aid (Frost & Hartl, 1996; Frost & Steketee, 1999; Hartl, et al, 2004), and there tends to be a strong emphasis on written materials in an individual’s hoard as the fear of loss of information is one of the primary drives behind CHD (Frost & Hartl, 1996; Fontenelle, et al., 2004). Indeed, neuropsychological testing within this population indicates difficulties with special processing and encoding. In a 2007 study by Grisham and colleagues, hoarders diagnosed with OCD were compared to a group of non-hoarding OCD patients and a group of non-clinical community controls using neuropsychological tests. Researchers found that hoarders presented difficulties in recalling verbal information in both short-term and delayed recall tasks (Grisham, et al., 2007; Hartl et al., 2004). Hoarders also showed markedly lower spatial and non-verbal intelligence than both of the other populations; however, their verbal intelligence was unaffected. This finding is consistent with a previous study (Hartl, et al., 2004) that investigated cognitive deficits in both OCD hoarders and hoarders that did not meet the diagnostic criteria for OCD. The intact verbal learning abilities of hoarding patients seem to differentiate them from non-hoarding patients whose verbal learning capacity has been found to be deficient (Fontenelle, et al., 2004).

3-4. Impairments in Making Inferences from Available Information and Decision Making Difficulties

Decision making impairments are considered to be the “hallmark” of CHD. In a 2006 study, Lawrence and colleagues found that hoarders performed worse on the Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994), a test of decision making ability as well as a measure of implicit learning, than did non-hoarding OCD types. Hoarders also showed a lower skin conductance response when performing this task, and the authors suggest that this physiological response is related to irregular functioning of certain brain areas involved in decision making and fear conditioning such as the ventromedial prefrontal cortex (VMPFC) and the amygdala. This hypothesis was largely confirmed by subsequent neuroimaging studies (An, et. al. 2008, Tolin et al., 2008, & Saxena, et al, 2004).
The Social and Emotional Profile of the Typical Compulsive Hoarder

Despite the more ego-syntonic nature of CHD behavior, these patients have been shown to have greater levels of overall psychopathology than their non-hoarding OCD counterparts (Frost, et al. 1996; Frost, et al., 2000). The quality of life and the level of functioning of hoarders are more debilitated due to their symptoms than non-hoarding OCD patients (Frost et al, 2000). Hoarders are often isolated (Tolin, Steketee, & Frost, 2007). The disorder is correlated with high levels of social phobia, over and above what is seen in other OCD types (Grisham et al., 2004; Lochner, Kinnear, Hemmings, Niehaus, Knowls, Daniels, et al., 2005; Samuels et al., 2007). In one study, the comorbidity rate of social phobia in hoarders was found to be as high as 75% (Frost, et al., 2000). Other co-morbid factors sometimes present in hoarding individuals, such as ADHD (Hartl, et al, 2004) and schizotypy (Grisham et al., 2004), may contribute to social dysfunction. Frost, et al. (1995) proposed that hoarders establish relationships with objects that are comparable or substitutable for relationships with other individuals.

CHD is correlated with high levels of family discord. Hoarders are more likely to be divorced or to have never been married (Frost & Gross 1993; Samuels, Riddle, Cullen, & Liang, 2002) than non-hoarding OCD individuals. A recent study by Tolin, et al. (2008) investigating the economic and social burden of CHD found that 38% of hoarders brought in an income below the national poverty level and 11% were on disability or unemployed. For those who were employed, the average number of work days missed per month (7.0) due directly to their illness was on par with that of people diagnosed with a psychotic disorder. These findings are especially interesting to note in light of research that finds that hoarders have a higher level of education than patients with other subtypes of OCD who in turn have a higher level of education than the general population (Fontenelle, et al, 2004), although this overall statistic may be due to treatment-seeking bias. The fact that hoarders pose a danger not only to themselves but to other people, such as family and neighbors, is also analogous to those with psychotic disorders. Hoarding can lead to falling, fires, and even death (Frost, et al., 1999)

Genetics

The development of CHD may be a salient example of nature interacting with nurture. An astounding number of people with CHD report an immediate family member who has also struggled with a significant hoarding problem (Kellett , 2004; Winsberg, Cassic, & Koran,1999; Samuels, et al., 2007). In one study by Saxena, et al. (2007), some
85% of compulsive hoarders claimed at least one first degree relative with some level of hoarding behavior. Only 37% of these patients reported having a first degree relative with OCD.

In 2001, researchers at six different universities began an ongoing investigation into the genetic components of OCD called the OCD Collaborative Genetics Study or the OCDCGS (Samuels, et al., 2007). After the hoarding phenotype was separated from other forms of OCD, there was a significant linkage found on chromosome 14q 23-32 in families with at least two hoarding relatives (Samuels, et al, 2007; Liang, 2008). Although this is a relatively large portion of the human genome, supporting evidence for the involvement of this chromosome comes from certain types of dementia that are related to abnormalities on chromosome 14 (Shinosaki, Nishikawa, & Takeda, 2001). Often, one of the first symptoms of these dementias is hoarding. Indeed, in both the OCDCGS (Liang, 2008) and in a 2007 study by Matthews and colleagues, the hoarding phenotype was found to have the strongest estimate of hereditability.

**Brain Areas and Other Factors Associated with Hoarding Behavior in Animals**

Rodent studies indicate that the sites of hoarding behavior in the brain include sub-cortical limbic areas such as the thalamus and hypothalamus (Blundell & Herberg, 1973), the anterior cingulate gyrus (de Brabander, de Bruin, & van Eden, 1991), the hippocampus, the septum (Kolb, 1977), and the nucleus accumbens (Stern, Passingham, 1994). Other areas that have been implicated include the ventromedial striatum, the globus pallidus, and the medial dorsal thalamus (Mogenson, & Wu, 1988). Hoarding behavior can be stimulated in rodents through the use of both dopamine agonists (Blundell, Strupp, & Latham, 1977) and serotonin agonists (Fantino, Boucher, Faion, & Mathiot, 1988). Gonadal steroids (Coling, & Herberg, 1982), as well as the administration of certain medications like opiates (Kavaliers & Hirst, 1985) or benzodiazepines (MacNamara & Whishaw, 1985), may also play a role in the modulation of food hoarding behaviors. However, in spite of the considerable body of research into the hoarding behavior of animals, it remains unclear whether or not they are useful models for hoarding behavior in humans (Saxena, et al., 2004).

**Brain Areas Implicated in Compulsive Hoarding in Humans**

To date there have only been a few neuroimaging studies which have investigated the specific glucose metabolism in the brains of compulsive hoarders. In recent years however, some data have been gathered from studies involving OCD patients who report hoarding as their primary symptom using hoarder-specific anxiety producing
paradigms. Two of these studies use fMRI technology (An, Mataix-Cols, Lawrence, Wooderson, Giampietro, & Speckens, et al., 2008; Tolin, Kiehl, Worhunsky, Book, & Maltby, 2008), and the other uses PET (Saxena, et al., 2004). This review attempts to create a visual summary of the results of these studies using the Caret software (Van Essen, Dickson, Harwell, Hanlon, Anderson, & Drury, 2001) to plot the stereotactic foci (peak activation) presented in each of the publications. Both models of higher activation and models of lower activation are presented and discussed. While this method of summation may not be ideal (in other words, some areas of activation may be difficult to see on the models and other areas may be difficult to explain behaviorally), the images do serve as useful tools for the further discussion of the brain structures involved in the pathology of CHD.

*Brain Areas Showing Higher Activation in Hoarders (n=37) in Comparison to Both Normal Controls (n=50) and Non-Hoarding OCD Patients (n=49)*


Pink: Tolin, et, al. (2008)
Saxena (et al., 2004) found that elevated levels of activity in bilateral sensorimotor areas were positively correlated with hoarding severity. Sensorimotor areas are important for the visual processing of emotional material, and the activation here likely reflects the anxiety that hoarders feel when provoked.

An, et al. (2008) found heightened metabolism in a number of areas important for decision making and risk evaluation such as the VMPFC, amygdala, and the nucleus accumbens, and the authors note that these areas are anatomically very close to areas in the rodent brain implicated in hoarding behavior. Hyperactivity in these regions may reflect the difficulty that these patients have when deciding what is valuable and what is not, and what can be thrown away and what cannot.

Both An (et al., 2008) and Tolin (et al., 2008) found elevated activity in the lateral orbitofrontal cortex. This area is important for the analysis of reward value, especially in the analysis of rewards that could be experienced as punishing (Kringelback & Rolls, 2004). The increased activity seen in this area may reflect the difficulties that hoarders have in decision making (Frost & Harlt, 1996; Steketee & Frost, 2003; Frost & Tolin, 2008) and their concern over making a choice that they may regret. Previous behavioral studies have shown that people with CHD are more sensitive to punishment than people with other types of OCD who are more sensitive to punishment than the general population (Fullana, et al., 2004).

Tolin and colleagues also found heightened glucose metabolism in the left parahippocampal gyrus and in the medial frontal gyrus. Activity in the parahippocampal gyrus is associated with memory search and retrieval (Gur, Ragland, Mozley, Mozlet, Smith, & Alavi, et al., 1997; Maquire & Mummert, 1999), and the associative properties of memory with objects (Yonelinas, Hopfinger, Buonxore, Kroll & Banes, 2001). It also plays a role in the processing of unpleasant emotions (Lane, Reiman, Bradley, Lang, Ahern, & Davidson, 1997). Activity here may also be correlated with decision making impairments. The medial frontal gyrus is an area that is crucial for learning and problem solving, error detection, motivation, and mediation of emotional response (Devisnyky, et al., 1995; Carter, et al., 1998, Bush, Luu, & Posner, 2000). The activation in this area may reflect the disordered attachment that hoarders often have towards their possessions and their tendency to catastrophize the consequences of a wrong decision (Saxena, et al., 2004).
Brain Areas Showing Lower Activation in Hoarders (n=37) in Comparison to Both Normal Controls (n=50) and Non-Hoarding OCD Patients (n=49)

Both An (et al., 2008) and Tolin (et al., 2008) found lower cerebral glucose metabolism in the dorsal anterior cingulate gyrus of compulsive hoarders. The cingulate gyrus is part of the limbic system, and it is concerned with executive functions such as attention, motivation, processing the emotional aspects of stimuli, conflict response, emotional self-regulation, and error detection (Devinsky, et al., 1995; Awh & Gehring, 1999). It also plays a role in decision making, especially in the cognitive processes involved in deciding between more than one conflicting option (Carter, Braver, Barch, Botvinik, & Cohen, 1998; Krawczyk, 2002), and evaluating the consequences of any potential choices (Walton, Croxson, Behrens, Kennerley, & Rushworth, 2008). Lower activation here may reflect the attention difficulties that hoarders have as well as problems with motivation and their unusual emotional attachment to objects. Lower activity may also reflect the impairments that hoarders show in decision making and in making inferences from
available information, and is consistent with their poor performance on the Iowa Gambling Task (Lawrence, et al., 2006).

Saxena and colleagues (2004) found lower activation in the posterior cingulate cortex as well. This area is involved in a variety of cognitive functions including spatial orientation, the monitoring of visual events, episodic memory (Vogt, Finch, & Olson, 1992), and the processing of emotional stimuli (Maddock, 1999). Lower activity in this area may reflect the impaired spatial attention that compulsive hoarders present (Grisham, Brown, Savage, Steketee, & Barlow, 2007), as well as their actual and perceived memory deficits. Previous research has found that lower activity in both the anterior (Saxena, Brody, Ho, Zohrabi, Maidment & Baxter, 2003), and posterior (Mataix-Cols, Cullen, Lang, Zelaya, Amaro, & Brammer, et al, 2003) cingulate cortices is a reliable predictor of poor treatment response to medication. This is consistent with the treatment refractory nature of CHD.

Saxena (et al., 2004) also found diminished activity in portions of the occipital cortex. This finding is in agreement with previous studies which have found that OCD patients in general have lower metabolism in areas of the occipital cortex (Nordahl, Benkelfat, Semple, Gross, King, & Cohen, 1989; Kwon, Kim, Lee, Lee, Kim, & Loo, et al, 2003), and it is thought that this decrease in activity may be related to the deficiencies in visuospatial attention that OCD patients tend to exhibit (Purcell, Maruff, Kyrios, & Pantelis, 1998; Savage, Baer, Keuthen, Brown, Rauch, & Jenike, 1999). However, in this particular PET study (Saxena, et al., 2004), CHD patients showed a lower activation than not only that of the control subjects, but also that of the other OCD patients. This is consistent with findings that hoarders perform more poorly in tasks of visuospatial attention than do individuals with other types of OCD (Grisham, et al., 2007).

Tolin and colleagues (2008) found lower activation in the left superior frontal gyrus. This area has been associated with working memory (du Boisgueheneuc, Levy, Volle, Seassau, Duffau, & Kinkengenun, 2006), and reduced activity here may reflect the limits that hoarders show for self-reflection (Goldberg, Harel, & Malach, 2003) during an anxiety producing paradigm. This may also correspond to the lack of insight that hoarders are known to have into their problematic behavior (Black, et al., 1998; Steketee & Williams, 2000) as well as their distrust of their own memory capacity.
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*Treatment*

Serotonin Reuptake Inhibitor medications (SRIs) and Exposure Response Therapy (ERT) have been effective in treating OCD (Saxena & Maidment, 2004). Yet, hoarding has been found to be resistant to treatment both behaviorally (Baer, 1994; Christensen & Greist, 2001) and pharmacologically (Winsberg, et al., 1999; Black, Monahan, Gable, Blum, Clank, & Baker, 1998; Mataix-Cols, Raunch, Mazon, & Jenike, 1999). However, more recent behavioral interventions have been reported as moderately successful (Steketee & Frost, 2007). There are a variety of reasons that this syndrome is treatment refractory, irregularities in brain functioning being but one. Hoarders often fail to see the irrationality of their behavior and may even perceive it as responsible (Black, Monahan, Gable, Blum, Clanck, & Baker, 1998; Steketee & Williams 2000). They are not generally distressed by certain components of their illness, such as acquisition and failure to discard (Kellett, 2007), hoarders may even find these behaviors pleasurable (Grisham & Barlow, 2004; Kellett, 2007). Yet they are often distressed by the larger consequences of their behavior: an environment that is functionally impaired due to clutter and the shame that is felt over this chaos (Seedat & Stein 2002; Kellett, 2007).

*Conclusions*

Compulsive hoarding disorder is exceptionally difficult to treat both behaviorally and pharmacologically. The early onset and the chronic and worsening trajectory of this illness, as well as its ego-syntonicity suggest that this syndrome may be more of a charatological phenomenon than other forms of OCD. Genetic, neuroimaging, and behavioral data suggest that the official classification of compulsive hoarding disorder should be reevaluated.
References


