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# Poor memory confidence mediates the association between inattention symptoms and hoarding severity and impairment

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ABSTRACT

Hoarding disorder (HD) is characterized by excessive saving and difficulty discarding possessions, which results in severe clutter and functional impairment. HD shows patterns of elevated comorbidity with the inattentive subtype of attention deficit-hyperactivity disorder (ADHD-I). ADHD-I symptoms are associated with more severe HD pathology (Tolin, Villavicencio, Umbach, & Kurtz, 2011), but the mechanisms underlying this association are unclear. The present study used serial mediation analyses in a sample of individuals with HD ($n=32$) and healthy controls ($n=26$) to test one potential pathway: ADHD-I symptoms lead to poor memory confidence, which leads to excessive saving of possessions to facilitate remembering, which in turn leads to clutter and corresponding functional impairment. The model provided a strong fit for the data, accounting for over 90% of the variance in functional impairment. Alternate models that did not include ADHD-I symptoms and poor memory confidence provided a weaker fit. These findings support and extend leading cognitive-behavioral conceptualizations of HD (e.g., Frost & Hartl, 1996) and point to inattention symptoms and memory confidence as potential targets for HD prevention and intervention research.



## 1. Introduction

Hoarding disorder (HD) is a costly and prevalent disorder that is defined primarily by difficulty discarding possessions, resulting in severe clutter that precludes use of living spaces (Frost & Gross, 1993; Frost & Hartl, 1996). Previously considered a subtype of obsessive-compulsive disorder (OCD), HD was classified as a distinct diagnostic entity in DSM-5. One reason for this reclassification was the observation that hoarding symptoms do not reliably co-occur with other OCD symptoms (e.g., excessive checking or cleaning) at elevated levels, as would be expected if hoarding was a subtype of OCD (Frost, Steketee, & Tolin, 2011; Pertusa et al., 2008). However, hoarding is characterized by elevated symptoms of depression and attention deficit-hyperactivity disorder (ADHD), particularly the inattentive subtype of ADHD (ADHD-I; Frost, Steketee, & Tolin, 2011; Hall, Tolin, Frost, & Steketee, 2013; Sheppard et al., 2010).

The elevated comorbidity between HD and ADHD-I has generated increased attention in recent years. Converging evidence from several studies suggests that between 20 and 33% of individuals with HD meet criteria for ADHD-I (Frost et al., 2011; Sheppard et al., 2010). Among individuals with clinically significant hoarding, the presence of inattention symptoms results in a more severe clinical presentation, including more problems with impulsivity, cognition, activities of daily living, and squalor, compared to HD without ADHD-I (Hall et al., 2013). Among individuals with HD, inattention (but not hyperactivity) is also associated with greater severity of core symptoms of hoarding disorder, including more severe clutter, acquiring, and excessive saving of possessions (Tolin & Villavicencio, 2011). ADHD symptoms also appear to differentiate individuals with and without clinically significant hoarding (Hacker et al., 2012).

Despite the clear association between HD and ADHD-I, there have been relatively few attempts to explain this elevated pattern of comorbidity, and to date no studies have attempted to examine mechanisms by which inattention symptoms may increase HD severity. A recent account points to shared neuropsychological and neurobiological impairments between HD and ADHD (Lynch, McGillivray, Molding, & Byrne, 2015). Neuropsychological findings in HD have been mixed, but several studies have linked HD to impairments in visuospatial memory (Blom et al., 2011; Hartl et al., 2004; Testa, Pantellis, & Fontenelle, 2011) and sustained attention (Grisham, Brown, Savage, Steketee, & Barlow, 2007; Tolin, Villavicencio, Umbach, & Kurtz, 2011; see Woody, Kellman-McFarlane, & Welsted, 2014 for a review). Similarly, adult ADHD is characterized by impairments in memory and sustained attention, among other

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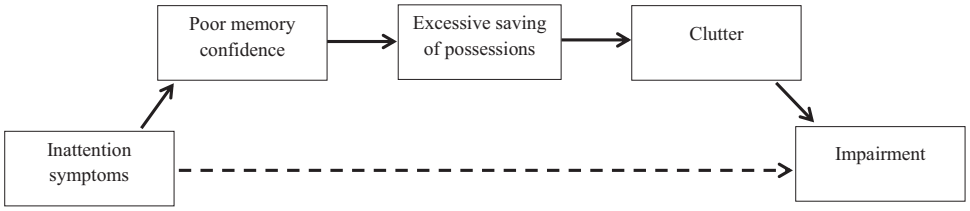


**Fig. 1.** Theoretical model of memory confidence, excessive saving, and clutter as mediators of the relationship between inattention and impairment.

deficits (Hervey, Epstein, & Curry, 2004). HD and ADHD also show similar patterns of neurobiological dysfunction, including abnormal glucose metabolism in prefrontal cortex, anterior cingulate cortex, and the amygdala, regions associated with executive functioning and emotion regulation (see Lynch, McGillivray, Molding, & Byrne, 2015 for a brief review). Lynch el al. (2015) suggest that these neurobiological and neuropsychological deficits may represent a shared vulnerability to both HD and ADHD, perhaps reflecting a shared genetic vulnerability.

Although the above account highlights a plausible explanation for elevated rates of ADHD-I among individuals with HD, it does not describe potential mechanisms by which inattention symptoms are associated with increased severity and impairment in HD. There are many potential pathways by which this association could take place. We propose one such pathway, a causal model that is illustrated in Fig. 1. We first suggest that ADHD-I symptoms result in poor memory confidence and overreliance on visuospatial memory strategies. For the present paper, we operationalize poor memory confidence as high scores on the memory subscale of the Savings Cognitions Inventory (Frost et al., 2004), which includes items such as "my memory is so bad I have to leave this [object] in sight or I'll forget about it," "saving this [object] means I don't have to rely on my memory," and "if I put this [object] into a filing system, I will forget about it."

To our knowledge, no study has examined memory confidence or maladaptive memory strategies such as saving in individuals with ADHD. However, ADHD symptoms are present since childhood by definition, and have been independently linked to global (Hervey et al., 2004) and visuospatial (Barnett, Maruff, & Vance, 2005) memory impairments. It therefore seems likely that inattention symptoms would lead to poor confidence in one's ability to remember important information, by virtue of their association with genuine memory deficits. The present model proposes that poor memory confidence leads to increased saving of possessions to facilitate remembering, which in turn contributes to clutter and functional impairment. As an illustration of the proposed model, an individual with a longstanding history of inattention symptoms might have little confidence in her ability to remember a discussion with a colleague without keeping a tangible reminder of the conversation (e.g., notes taken during the meeting). Excessive reliance on this memory strategy, perhaps in the absence of a clear organizational system and in the presence of other HD risk factors, may lead to excessive clutter and corresponding functional impairment.

This suggestion – that poor memory confidence leads to excessive saving of possessions – is in keeping with the leading cognitive-behavioral model of HD, which proposes that HD symptoms arise in part from perceived or actual memory disturbances (Frost & Hartl, 1996). Poor memory confidence and exaggerated beliefs about the negative consequences of forgetting are prominent in HD (Frost & Hartl, 1996; Hartl et al., 2004). These negative memory beliefs are proposed to lead to increased saving of possessions and keeping possessions within sight to facilitate remembering, which in turn contributes to clutter. We extend this model by proposing that poor memory confidence is the result of inattention symptoms, which are present on a continuum in the population (Marcus & Barry, 2011), independently associated with poor memory (Hervey et al., 2004; Barnett et al., 2005), and elevated in HD even in the absence of a DSM-5 diagnosis of ADHD-I (Hartl, Duffany, Allen, Steketee, & Frost, 2005).

It is important to emphasize that this model represents one of many potential mechanisms of hoarding pathology; it is necessarily simplified in order to allow an empirical test of one potential causal pathway. We do not include the multitude of other risk factors that may play a role in HD, including genetic vulnerabilities, deficits in planning and organization, and maladaptive beliefs that are unrelated to memory (e.g., "I must not be wasteful"). Nor do we attempt to distinguish between perceived and actual memory deficits, both of which have been identified in HD (Hartl et al., 2004). Instead, this model represents a first attempt to explain the mechanisms linking inattention symptoms to increased HD severity. To our knowledge, this is also the first study to use mediation analyses to test claims made by the leading cognitive-behavioral model of HD (Frost & Hartl, 1996).

## 2. Method

### 2.1. Participants and procedure

Participants were treatment-seeking adults (age 20–60) with HD ($n=32$) and age-matched healthy controls with no current or past psychiatric disorders ($n=26$) who were recruited as part of a larger neuroimaging and treatment study. Both HD and healthy participants were included in the present study to ensure a full range of scores on the predictors and outcomes of interest, and because taxometric research indicates that hoarding is best conceptualized as a dimensional construct (Timpano et al., 2013). Inclusion criteria for the HD sample included a primary (most severe) hoarding diagnosis of at least moderate severity as assessed by a semi-structured diagnostic interview administered by a licensed psychologist. Exclusion criteria included a history of traumatic brain injury or loss of consciousness $>5$ min, current (past 12 months) substance use disorder, a previous adequate course ($>10$ sessions) of cognitive-behavioral therapy for HD, and MRI-related rule-outs (e.g., metal in the body). Certain medications (primarily selective serotonin reuptake inhibitors) were permitted provided that the dose was stable for 8 weeks prior to participation.

### 2.2. Measures

#### 2.2.1. Diagnostic status

HD and healthy control status were determined using a semi-structured diagnostic interview (the Diagnostic Interview for Anxiety, Mood, Obsessive-compulsive, and Related Neuropsychiatric Disorders [DIAMOND]; Gilliam et al., 2014; Tolin et al., in review), which was administered by a licensed clinical psychologist with considerable experience in diagnosing and treating hoarding. The DIAMOND, which assesses DSM-5 criteria for HD and other disorders, was administered by a licensed clinical psychologist. The DIAMOND shows good psychometric properties, including

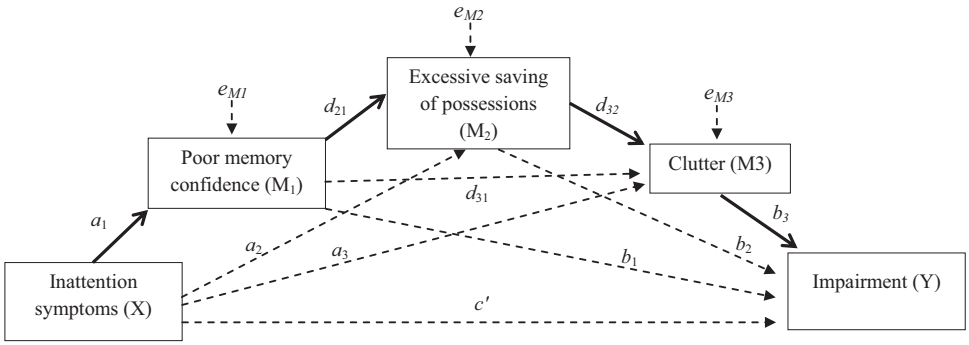


**Fig. 2.** Statistical model of memory confidence, excessive saving, and clutter as mediators of the relationship between inattention and impairment.

excellent interrater ($\kappa$=.86) and one-week test-retest ($\kappa$=.94) reliability for diagnosing HD (Tolin et al., in review). The DIAMOND HD module also shows good convergent validity vis-à-vis the Saving Inventory-Revised (SI-R; Frost, Steketee, & Grisham, 2004), reflected in considerably higher SI-R scores ($d$=3.29) for individuals diagnosed with HD via the DIAMOND compared to individuals not diagnosed with HD (Tolin et al., in review). Diagnostic status and severity were confirmed using the Hoarding Rating Scale-Interview (HRS-I), a semi-structured diagnostic interview with strong psychometric properties, including good inter-rater and test-retest reliability, convergent validity with other measures of HD, and ability to distinguish between HD and non-HD participants (Tolin, Frost, & Steketee, 2010).

### 2.2.2. Inattention symptoms

ADHD-I symptoms were measured using the inattention subscale of the Attention Deficit Hyperactivity Disorder Symptom Scale (ADHD-SS; Barkley & Murphy, 1998). The ADHD-SS is an 18-item self-report measure of ADHD symptoms with two reliable subscales, one assessing inattention and one assessing hyperactivity. Given the strong association between HD and the inattentive but not hyperactive subtype of ADHD (Tolin & Villavicencio, 2011), only the inattention subscale was included here. The ADHD-SS discriminates between individuals with ADHD and healthy controls (Barkley, Murphy, Dupaul, & Bush, 2002) and shows excellent internal consistency (Cronbach's $\alpha$=.88–.93; Murphy & Barkley, 1996), including in samples of compulsive hoarders (Hartl, Duffany, Allen, Steketee, & Frost, 2005; Cronbach's $\alpha$=.94 in this sample).

### 2.2.3. Memory confidence

Memory confidence was assessed using the memory subscale of the Saving Cognitions Inventory (SCI; Steketee, Frost, & Kyrios, 2003). The SCI is a 24-item inventory with four validated subscales that assess beliefs related to possessions. Because inattention symptoms are linked to memory deficits, we focused on the five-item Memory subscale (Cronbach's $\alpha$=.82; Steketee, Frost, & Kyrios, 2003; e.g., "Saving this means I don't have to rely on my memory"; Cronbach's $\alpha$=.91 in this sample) as a potential mechanism by which inattention might influence HD symptoms. Higher scores represent poorer memory confidence.

### 2.2.4. Saving

Excessive saving of possessions was assessed using the saving subscale of the Saving Inventory-Revised (SI-R). The SI-R is a 23-item inventory with strong psychometric properties, including good convergent and discriminant validity (Frost et al., 2004). The Saving subscale of the SI-R contains 7 items reflecting excessive saving and difficulty discarding items. The subscale shows excellent internal consistency (Cronbach's $\alpha$=.88; Cronbach's $\alpha$=.96 in this sample), strong test-retest reliability ($r$=.89), and good convergent validity with a behavioral measure of excessive saving ($r$=.52; Frost et al., 2004).

### 2.2.5. Clutter

Clutter severity was assessed using the clutter subscale of the SI-R. The clutter subscale contains 9 items and shows excellent internal consistency (Cronbach's $\alpha$=.91; $\alpha$=.98 in this sample), strong test-retest reliability ($r$=.90) and convergent validity with an interviewer-rated measure of clutter (Frost et al., 2004).

### 2.2.6. Functional impairment

Functional impairment due to hoarding symptoms was assessed using the Functional Impairment item ("To what extent do you experience impairment in your life (daily routine, job/school, social activities, family activities, financial difficulties) because of clutter, difficulty discarding, or problems with buying or acquiring things?") of the clinician-rated Hoarding Rating Scale-Interview (HRS-I; Tolin et al., 2010), described above.

## 2.3. Statistical analyses

A serial mediator model (see Fig. 2) was evaluated using OLS regression implemented by PROCESS (Hayes, 2012) for SPSS. In mediation analysis, the total effect ($c$) of the independent variable (IV) on the dependent variable (DV) comprises the direct effect of the IV on the DV ($c'$) as well as the indirect effects of the IV on the DV ($a \times b$) through the mediators (M). In this equation, $a$ represents the effects of the IV on M and $b$ represents the effects of M on the DV, partialling out the effects of the IV. In a serial 3-mediator model, it is possible to estimate the total indirect effect as well as specific indirect effects for the paths of interest: IV on M1 ($a_1$) M1 on M2 ($d_{21}$), M2 on M3 ($d_{32}$), and M3 on DV ($b_3$).

In addition to the hypothesized serial mediation model (i.e., inattention → negative memory beliefs → saving → clutter → impairment), PROCESS automatically computes all alternate paths (i.e., IV on M2 [$a_2$], IV on M3 [$a_3$], M1 on M3 [$d_{31}$], M1 on DV [$b_1$], and M2 on DV [$b_2$] are also evaluated). That is, PROCESS automatically computes estimates for alternate mediation models (e.g., inattention → saving → impairment; inattention → clutter → impairment; inattention → negative memory beliefs → impairment; etc.). Although these paths are not predicted by our theoretical model, each pathway is presented for completeness and to evaluate the necessity of each variable in the model.

Following procedures recommended by Hayes (2013), significance testing of indirect effects was performed using 95% confidence intervals generated via bias-corrected bootstrapping with 5000 samples. Bootstrapping is a nonparametric procedure that uses available data to generate an approximation of the sampling distribution of a statistic. The sampling distributions of

the indirect effects are generated by taking a random sample (with replacement) from the dataset and calculating the indirect effects of those samples. This procedure is repeated to generate point estimates and 95% confidence intervals for the indirect effects. An indirect effect point estimate with a confidence interval that does not include 0 is considered to be statistically significant at the $p < .05$ level. Bootstrapping was selected in lieu of the traditional Sobel test (Sobel, 1982) because it is generally considered to be more powerful test and it relies on fewer assumptions about the shape of the sampling distribution of the indirect effect (e.g., Williams & MacKinnon, 2008).

Assumptions for normality of residuals, multicollinearity, and homoscedasticity were tested separately for each regression equation included in the overall model. Missing data ( < 5% of cases) was addressed using listwise deletion, which is a standard practice in estimation of mediation models (Hayes, 2013).

## 3. Results

Demographic and clinical characteristics are presented in Table 1. Participants were 69.0% female, 91.4% Caucasian, and $M = 53.2$ ($SD = 7.63$) years old. HD and healthy participants did not differ with respect to age ($p = .409$) or gender ($p = .153$). As expected, HD participants were more severe with respect to hoarding symptoms, negative memory beliefs, and ADHD-I symptoms (all $p < .001$). Although hoarding symptoms, memory beliefs, and ADHD-I symptoms were intercorrelated ($r(57–58) = .64–.92$; see Table 2), statistical assumptions for normality of residuals, multicollinearity, and homoscedasticity were met.

### 3.1. Mediating effects of memory beliefs, excessive saving, and clutter in the relationship between inattention symptoms and functional impairment.

The results of the mediation analyses are presented in Table 3. The proposed model was supported. Specifically, inattention was positively associated with poor memory confidence ($a_1$; $\beta = .83$), which in turn predicted increased saving of possessions ($d_{21}$; $\beta = .68$), which in turn predicted increased clutter ($d_{32}$; $\beta = 1.17$), which in turn predicted greater functional impairment ($b_3 = .18$). Consistent with the theoretical model, paths $a^2$ (inattention directly predicting saving), $a_3$ (inattention directly predicting clutter), $d_{31}$ (poor memory confidence directly predicting clutter), $b_1$ (poor memory confidence directly predicting impairment), and $b_2$ (saving directly predicting impairment) were nonsignificant. The direct effect of inattention on impairment ($c_1$) was also nonsignificant once the indirect effects of the mediators were partialled out, indicating full mediation. The final model was highly significant, accounting for 91% of the variance in impairment, $F(4, 49) = 125.14$, $p < .001$. Moreover, the indirect effects for the alternative single and dual mediator models (e.g., inattention → poor memory confidence → impairment; inattention → saving → clutter → impairment) were nonsignificant (all $\beta \leq .04$, all $p \geq .05$), suggesting that the hypothesized model provides the best fit to the data.

**Table 1**
Demographic and clinical characteristics.

| | HD *M* (*SD*) | HC *M* (*SD*) | *t* | *p* | *d* |
|---|---|---|---|---|---|
| Age | 54.20 (7.40) | 52.50 (7.84) | .83 | .409 | .22 |
| ADHD-I total | 9.90 (7.29) | 2.69 (3.82) | 4.78 | < .001 | 1.24 |
| SI-R total | 58.03 (11.32) | 15.85 (10.99) | 14.30 | < .001 | 3.78 |
| SI-R clutter | 26.53 (5.05) | 4.88 (5.65) | 15.39 | < .001 | 4.04 |
| SI-R saving | 20.50 (4.36) | 5.04 (4.37) | 13.42 | < .001 | 3.54 |
| SCI memory | 20.13 (8.38) | 7.46 (3.08) | 7.31 | < .001 | 2.01 |
| HRS-I impairment | 5.28 (1.28) | .17 (.65) | 13.41 | < .001 | 5.03 |

*Note*: ADHD-I = ADHD-SS inattention symptoms; SI-R = Saving Inventory-Revised; SCI = Saving Cognitions Inventory; HRS-I = Hoarding Rating Scale Interview.

**Table 2**
Correlation between ADHD-I symptoms, memory beliefs, and hoarding symptoms and impairment.

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. ADHD-I | – | – | – | – |
| 2. SCI-mem | .64** | – | – | – |
| 3. Saving | .60** | .78** | – | – |
| 4. Clutter | .61** | .74** | .92** | – |
| 5. Impairment | .56** | .72** | .89** | .94** |

*Note:* ADHD-I = ADHD-SS inattention symptoms; SCI-mem = Saving Cognitions Inventory-Memory subscale.

** $p < .001$.

**Table 3**
Mediation pathways between inattention symptoms, excessive saving, clutter, and functional impairment.

| | Impairment ($n = 54$) | | | | |
|---|---|---|---|---|---|
| | Estimate | *SE* | *t* | *p* | 95% CI |
| *Total effect: Inattention symptoms predicting outcomes* | | | | | |
| *Inattention → Impairment (*c*) | .22 | .05 | 4.89 | < .001 | .13–.31 |
| *Direct effect: Inattention symptoms predicting impairment, partialling out indirect effects of mediators* | | | | | |
| Inattention → Impairment (*c*') | −.03 | .03 | −1.27 | .212 | −.07–.02 |
| *Mediational path: Inattention predicting poor memory confidence* | | | | | |
| *Inattention → SCI memory ($a_1$) | .83 | .14 | 6.14 | < .001 | .56–1.10 |
| *Mediational path: Poor memory confidence predicting saving, partialling out inattention, and alternate pathways* | | | | | |
| *SCI memory → SI-R saving ($d_{21}$) | .68 | .11 | 6.32 | < .001 | .46–.89 |
| Inattention → SI-R saving ($a_2$) | .21 | .14 | 1.47 | .147 | −.07–.48 |
| *Mediational path: Saving predicting clutter, partialling out inattention and memory confidence, and alternate pathways* | | | | | |
| *SI-R saving → SI-R clutter ($d_{32}$) | 1.17 | .13 | 9.31 | < .001 | .92–1.42 |
| Inattention → SI-R clutter ($a_3$) | .16 | .13 | 1.24 | .222 | −.10–.41 |
| SCI memory → SI-R clutter ($d_{31}$) | .02 | .13 | .14 | .886 | −.24–.28 |
| *Mediational path: Clutter predicting impairment, partialling out memory confidence and saving, and alternate pathways* | | | | | |
| *SI-R clutter → Impairment ($b_3$) | .18 | .03 | 7.40 | < .001 | .13–.23 |
| SCI memory → Impairment ($b_1$) | .02 | .03 | .97 | .336 | −.07–.02 |
| SI-R saving → Impairment ($b_2$) | .03 | .03 | .78 | .439 | −.04–.91 |

*Note:* SCI = Saving Cognitions Inventory; SI-R = Saving Inventory-Revised.

* Path hypothesized a priori.

## 4. Discussion

The current study aimed to establish a mechanism by which symptoms of the inattentive subtype of ADHD (ADHD-I) lead to increased severity and functional impairment in hoarding disorder. We proposed and tested a serial mediation model, with functional impairment as the outcome of interest. In line with the theoretical model of HD proposed by Frost & Hartl (1996) and extended here, inattention symptoms led to poor memory

confidence, which in turn led to excessive saving of possessions, presumably to facilitate remembering. This excessive saving led to clutter, which led to functional impairment. The model provided a good fit to the data and accounted for a high percentage of the variance in the outcomes of interest ($r^2 = .91$). The direct path from inattention to impairment was no longer significant once the mediators were included in the model, suggesting full mediation. Importantly, alternative models that excluded one or more of the hypothesized mediators (e.g., inattention → poor memory confidence → clutter → impairment; inattention → saving → clutter → impairment; inattention → clutter → impairment) were weaker and nonsignificant, increasing confidence in the validity of the proposed model.

To our knowledge, this is the first study to use mediation analyses to test the leading theoretical model of HD. The current findings provide empirical support for one aspect of the model, namely the proposal that poor memory confidence leads to increased saving of possessions to facilitate remembering, which in turn leads to clutter and functional impairment (Frost & Hartl, 1996). The present findings also extend the model by linking poor memory confidence to symptoms of ADHD-I. Inattention (but not hyperactivity) is elevated among individuals with HD (Frost et al., 2011; Sheppard et al., 2010) and has been linked to increased severity of the core features of HD (Hall et al., 2013; Tolin & Villavicencio, 2011). The present model suggests that poor memory confidence that results in excessive saving to facilitate remembering is one mechanism explaining this association.

Importantly, the present study cannot differentiate between the effects of perceived versus actual memory deficits. This distinction is important, because it suggests two different potential targets for intervention. If perceived memory deficits exist in the absence of genuine deficits, it would suggest that cognitive interventions designed to decatastrophize forgetting and decrease reliance on possessions as memory crutches would be helpful in decreasing excessive saving. Conversely, if poor memory confidence is the result of genuine memory impairments, it would point to cognitive remediation or a similar intervention to improve memory performance.

Although we cannot draw firm conclusions based on these data, we suspect that poor memory confidence may be the result of genuine memory deficits. ADHD has been independently linked to deficits in several facets of memory, including working memory, long-term memory (Hervey et al., 2004), and visuospatial memory (Barnett et al., 2005). It seems likely that memory deficits would, over time, lead to poor memory confidence. Findings from the first step of our model (i.e., inattention → poor memory confidence) support this assertion. Genuine memory deficits, particularly with respect to visuospatial memory and ability, have also been found in hoarding (Blom et al., 2011; Hartl et al., 2004; Testa et al., 2011; Woody et al., 2014). However, additional research is needed to parse the relative contributions of perceived versus actual memory deficits to excessive saving of possessions. This and other research that elucidates specific intervention targets is particularly important in light of the relatively poorer efficacy of CBT for HD relative to other obsessive-compulsive and related disorders (Tolin, Frost, Steketee, & Muroff, 2015).

Future research should also emphasize behavioral measures of difficulty discarding and clinician assessments of clutter severity. In the present study, functional impairment ratings and HD diagnoses were made by licensed clinicians. However, inattention symptoms, memory beliefs, excessive saving symptoms, and clutter were made via self-report. The present study employed well-validated and widely-used self-report measures of these constructs and indeed, self-report may be the most appropriate method of evaluating memory beliefs. Nevertheless, confidence in the present findings would be increased by additional research that incorporates behavioral or clinician-rated measures of memory, inattention symptoms, and clutter.

Additional limitations of the present study include a reliance on cross-sectional data and investigation of a necessarily limited number of constructs. Mediation analysis is designed to facilitate causal conclusions, and the present model represents (in our view) the most plausible causal pathways for the variables of interest. However, other causal pathways, perhaps facilitated by mediators not examined here, remain possible. For example, it is possible that a long history of excessive clutter could reduce confidence in one's ability to remember the location of important possessions. Alternatively, genetically-influenced cognitive deficits could make independent contributions to poor memory confidence, excessive saving (e.g., due to impaired decision-making), and clutter (e.g., due to planning and organizational deficits). Finally, there may be environmental factors (e.g., modeling by parents or guardians) that contribute to HD symptoms. These potential pathways are elucidated in the Frost and Hartl model of HD and are not examined here. Thus, although the model proposed here account for a very large portion of the variance (over 90%) in the outcomes of interest, additional research is needed to more comprehensively evaluate cognitive-behavioral models of HD, with an eye toward improving treatment for this chronic and disabling condition.

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## References

Barkley, R. A., Murphy, K. R., Dupaul, G. J., & Bush, T. (2002). Driving in young adults with attention deficit hyperactivity disorder: knowledge, performance, adverse outcomes, and the role of executive functioning. *Journal of the International Neuropsychological Society*, *8*(5), 655–672.

Barkley, R. A., & Murphy, K. R. (1998). *Attention-deficit hyperactivity disorder: A clinical workbook*. Guilford Press.

Barnett, R., Maruff, P., & Vance, A. (2005). An investigation of visuospatial memory impairment in children with attention deficit hyperactivity disorder (ADHD), combined type. *Psychological Medicine*, *35*(10), 1433–1443.

Blom, R. M., Samuels, J. F., Grados, M. A., Chen, Y., Bienvenu, O. J., Riddle, M. A., & Nestadt, G. (2011). Cognitive functioning in compulsive hoarding. *Journal of Anxiety Disorders*, *25*(8), 1139–1144.

Frost, R. O., & Gross, R. C. (1993). The hoarding of possessions. *Behaviour Research and Therapy*, *31*(4), 367–381.

Frost, R. O., & Hartl, T. L. (1996). A cognitive-behavioral model of compulsive hoarding. *Behaviour Research and Therapy*, *34*(4), 341–350.

Frost, R. O., Steketee, G., & Grisham, J. (2004). Measurement of compulsive hoarding: Saving Inventory-Revised. *Behaviour Research and Therapy*, *42*(10), 1163–1182.

Frost, R. O., Steketee, G., & Tolin, D. F. (2011). Comorbidity in hoarding disorder. *Depression and Anxiety*, *28*(10), 876–884.

Gilliam, C. M., Bowe, W., Bragdon, L. B., Davis, E., Hannan, S. E., Ransom, J. B., … Tolin, D. F. (2014, November). Reliability and validity of the diagnostic interview for anxiety, mood, and obsessive-compulsive and related neuropsychiatric disorders. *Poster presented at the annual meeting of the Association for Behavioral and Cognitive Therapies*, Philadelphia, PA.

Grisham, J. R., Brown, T. A., Savage, C. R., Steketee, G., & Barlow, D. H. (2007). Neuropsychological impairment associated with compulsive hoarding. *Behaviour Research and Therapy*, *45*(7), 1471–1483.

Hacker, L. E., Park, J. M., Timpano, K. R., Cavitt, M. A., Alvaro, J. L., Lewin, A. B., & Storch, E. A. (2012). Hoarding in children with ADHD. *Journal of Attention Disorders* (pp. 1–10), 1–10.

Hall, B. J., Tolin, D. F., Frost, R. O., & Steketee, G. (2013). An exploration of comorbid symptoms and clinical correlates of clinically significant hoarding symptoms. *Depression and Anxiety*, *30*(1), 67–76.

Hartl, T. L., Duffany, S. R., Allen, G. J., Steketee, G., & Frost, R. O. (2005). Relationships among compulsive hoarding, trauma, and attention-deficit/hyperactivity disorder. *Behaviour Research and Therapy*, *43*(2), 269–276.

Hartl, T. L., Frost, R. O., Allen, G. J., Deckersbach, T., Steketee, G., Duffany, S. R., & Savage, C. R. (2004). Actual and perceived memory deficits in individuals with compulsive hoarding. *Depression and Anxiety*, *20*(2), 59–69.

Hayes, A. F. (2012). *PROCESS: A versatile computational tool for observed variable mediation, moderation, and conditional process modeling*. Retrieved March 2015 from ⟨www.afhayes.com/public/process.pdf⟩.
Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York: Guilford Press.
Hervey, A. S., Epstein, J. N., & Curry, J. F. (2004). Neuropsychology of adults with attention-deficit/hyperactivity disorder: A meta-analytic review. *Neuropsychology*, *18*(3), 485–503.
Lynch, F. A., McGillivray, J. A., Moulding, R., & Byrne, L. K. (2015). Hoarding in attention deficit hyperactivity disorder: Understanding the comorbidity. *Journal of Obsessive-Compulsive and Related Disorders*, *4*, 37–46.
Marcus, D. K., & Barry, T. D. (2011). Does attention-deficit/hyperactivity disorder have a dimensional latent structure? A taxometric analysis. *Journal of Abnormal Psychology*, *120*(2), 427–442.
Murphy, K., & Barkley, R. A. (1996). Attention deficit hyperactivity disorder adults: Comorbidities and adaptive impairments. *Comprehensive psychiatry*, *37*(6), 393–401.
Pertusa, A., Fullana, M. A., Singh, S., Alonso, P., Menchón, J. M., & Mataix-Cols, D. (2008). Compulsive hoarding: OCD symptom, distinct clinical syndrome, or both? *American Journal of Psychiatry*, *165*(10), 1289–1298.
Sheppard, B., Chavira, D., Azzam, A., Grados, M. A., Umaña, P., Garrido, H., & Mathews, C. A. (2010). ADHD prevalence and association with hoarding behaviors in childhood-onset OCD. *Depression and Anxiety*, *27*(7), 667–674.
Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *Sociological Methodology*, *13*(1982), 290–312.
Steketee, G., Frost, R. O., & Kyrios, M. (2003). Cognitive aspects of compulsive hoarding. *Cognitive Therapy and Research*, *27*(4), 463–479.
Testa, R., Pantellis, C., & Fontenelle, L. F. (2011). Hoarding behaviors in children with learning disabilities. *Journal of Child Neurology* (pp. 574–579), 574–579.
Timpano, K. R., Broman-Fulks, J. J., Glaesmer, H., Exner, C., Rief, W., Olatunji, B. O., & Schmidt, N. B. (2013). A taxometric exploration of the latent structure of hoarding. *Psychological Assessment*, *25*(1), 194–203.
Tolin, D. F., Frost, R. O., & Steketee, G. (2010). A brief interview for assessing compulsive hoarding: The Hoarding Rating Scale-Interview. *Psychiatry Research*, *178*(1), 147–152.
Tolin, D. F., Frost, R. O., Steketee, G., & Muroff, J. (2015). Cognitive behavioral therapy for hoarding disorder: A meta-analysis. *Depression and Anxiety*, *32*(3), 158–166.
Tolin, D. F., Gilliam, C., Wootton, B., Bowe, W., Bragdon, L. B., Davis, E., …, Hallion, L. S. (2015). Reliability and validity of a semi-structured diagnostic interview for DSM-5. *Anxiety, Mood, and Obsessive-Compulsive and Related Disorders* (submitted for publication).
Tolin, D. F., & Villavicencio, A. (2011). Inattention, but not OCD, predicts the core features of hoarding disorder. *Behaviour Research and Therapy*, *49*(2), 120–125.
Tolin, D. F., Villavicencio, A., Umbach, A., & Kurtz, M. M. (2011). Neuropsychological functioning in hoarding disorder. *Psychiatry Research*, *189*(3), 413–418.
Williams, J., & MacKinnon, D. P. (2008). Resampling and distribution of the product methods for testing indirect effects in complex models. *Structural Equation Modeling*, *15*(1), 23–51.
Woody, S. R., Kellman-McFarlane, K., & Welsted, A. (2014). Review of cognitive performance in hoarding disorder. *Clinical Psychology Review*, *34*(4), 324–336.