

**Universiteit Utrecht**



University of Utrecht

Faculty Social Sciences

Master thesis Clinical and Health Psychology



# **Inhibition and flexibility in Hoarding and OCD: similarities in neuropsychological profile**

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**Academic year: 2012-2013**

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## **Voorwoord**

Graag wil ik dr. Daniëlle Cath bedanken voor haar inspirerende begeleiding bij het schrijven van mijn masterthesis bij Altrecht Polikliniek Noord. Ook wil ik Jory Schoondermark en Mathilde Huisman, werkzaam bij het Altrecht Academisch Angstcentrum, bedanken voor hun ondersteuning bij de uitvoering van het neuropsychologisch onderzoek en bij de dataverwerking in SPSS. Mede door hun bijdrage heb ik een mooi afstudeeronderzoek kunnen volbrengen. Tot slot wil ik mijn mede-stagiaire Fleur Steenvoorden bedanken, met wie ik gedurende een half jaar nauw heb samengewerkt.

## Abstract

**Introduction** Cognitive impairment of executive functioning in patients diagnosed with Hoarding Disorder (HD) and Obsessive-Compulsive Disorder (OCD), particularly in the domains of mental flexibility and motor- and impulse control, is well established in a number of studies. However, research is inconsistent, leading to an ongoing debate on the conceptualization of Hoarding. Therefore, the aim of the present study was to examine whether there is a linking pin between Hoarding and OCD with respect to ADHD and ASD symptoms and with respect to neuropsychological symptoms. **Methods** 66 Participants were recruited: 19 OCD patients, 22 Hoarders and 22 Controls. Diagnosis of Hoarding and OCD was based on the Structured Interview of Hoarding Disorder (SIHD), the Saving Inventory-Revisited (SI-R), the Obsessive-Compulsive Inventory - Revisited (OCI-R) and the Structured Clinical Interview for DSM-IV Axis-I Disorders (SCID-I). Screening for ASD and ADHD symptoms was based on the Autism-Spectrum Quotient (AQ), the Connors Adult ADHD Rating Scales (CAARS) and the Behavioral Inhibition Scale (BIS). Obsessive-Compulsive Personality Disorder (OCPD) traits were measured by the Structured Clinical Interview for DSM-IV Axis-II Disorders (SCID-II), as an indicator for mental inflexibility. Cognitive function was assessed through a comprehensive and standardized neuropsychological test battery, comprising the Intra-Dimensional Extra-Dimensional Set shift task (ID/EDS), the Stroop-Color-Word Interference task as part of the D-KEFS and the Stop Signal Reaction Time task (SSRT). The executive functions under study were mental flexibility and motor- and impulse inhibition. **Results** The current study showed remarkable similarities between Hoarders and OCD patients, both at the symptom level (OC symptoms, behavioral inhibition, ADHD symptoms) and at the level of executive functions (motor and cognitive inhibition). Results on cognitive flexibility and set shifting pointed into different directions, suggesting that the problems of patients slightly diverge there. However, at the level of symptoms, Hoarding, OCD, ASD and ADHD by and large overlap. **Conclusion** The data partially confirmed that Hoarders and OCD patients show similar impairments in mental flexibility and motor- and cognitive inhibition, deficits that are also seen in ASD and ADHD. These data do not support the conceptualization of Hoarding as a separate disorder in the DSM-V. The findings are a step in the process of identifying shared and non-shared neuropsychological mechanisms underlying Hoarding, OCD, ASD and ADHD.

## Introduction

Obsessive-Compulsive Disorder (OCD) is, according to DSM-V, an anxiety disorder characterized by intrusive thoughts (obsessions) that produce anxiety and/or repetitive behavior (compulsions) to prevent or reduce this anxiety (American Psychiatric Association, 2013). According to a previous edition of the DSM, the DSM-IV-TR (American Psychological Association, 2000), a possible symptom dimension of OCD is extreme Hoarding behavior. Hoarding is defined as the excessive acquisition of and unwillingness/inability to discard seemingly worthless items (Sheppard, B., Chavira, D., Azzam, A., Grados, M.A., Umaña, P., Garrido, H., Mathews, C.A., 2010). In the DSM-IV-TR, Hoarding behavior was incorporated as a symptom dimension of OCD and a criterion for Obsessive-Compulsive Personality Disorder (OCPD). However, the past few years have been marked by an ongoing debate on the conceptualization of Hoarding as a subtype of OCD. This discussion was stimulated by studies revealing that Hoarders do not benefit from Cognitive Behavioral Treatment that is given to patients diagnosed with OCD (Saxena, S., 2008). Moreover, it was found that Hoarders often did not show other obsessive-compulsive symptoms and have differential motives for their pathological behavior (Mataix-Cols, D., Frost, R.O., Pertusa, A., Clark, L.A., Saxena, S., Leckman, J.F., Stein, D.J., Matsunaga, H., & Wilhelm, S., 2010). Therefore, Hoarding is included as a separate disorder in the DSM-V (American Psychiatric Association, 2013).

Clinical experience tells us that Hoarding often co-segregates with OCD and research reveals that Hoarders and OCD patients show common deficits in neuropsychological functioning (Grisham, J.R., Brown, T.A., Savage, C.R., Steketee, G., Barlow, D.H., 2007; Chamberlain, S.R., Fineberg, N.A., Menzies, L.A., Blackwell, A.D., Bullmore, E.T., Robbins, T.W., Sahakian, B.J., 2007). This suggests that Hoarding and OCD have a common etiology and should not be viewed as separate disorders. Disorders also shown to be highly prevalent in OCD and Hoarding populations are Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorder (ASD). ADHD and OCD often co-segregate in families and both groups show comparable deficits when submitted to neuropsychological testing, measuring aspects of executive functioning (Chamberlain et al., 2007). ASD is found to be highly prevalent (up to 25%) in first-degree relatives of probands with OCD. Moreover, OCD symptoms such as repetitive behaviors are frequently observed in ASD (Bejerot, S., 2007). The high co-morbidity rates and shared cognitive deficits that are found suggest an overlap in neuropsychological profiles between Hoarding, OCD, ASD and ADHD. The next section will outline the growing body of evidence, addressing findings on symptom level and neuropsychological level.

Few studies have been performed that directly compare executive functioning of Hoarders to that of patients diagnosed with OCD. Most research focused on executive functioning for the disorders separately. Grisham (2007) found that Hoarders show higher impulsivity rates, lower reaction times and worse spatial attention and planning as compared to healthy controls, measured by the Visual Memory Span task. Chamberlain et al. (2007) revealed deficits in response inhibition and set shifting ability in a group of OCD patients, as measured by (respectively) the Stroop Color Word Interference Test (SCWI) and the Wisconsin Card Sorting Task (WCST).

Multiple studies investigated parameters of ADHD in Hoarders and OCD patients. Both groups show deficits that are characteristic of ADHD: High distractibility, indecisiveness and deficits in attention and concentration (Sheppard et al., 2010; Nydén, 2010). Furthermore, compared to the general population, high rates of ADHD symptoms have been found in patients diagnosed with OCD. Also, OCD patients with Hoarding symptoms were shown to have a tenfold risk to suffer from co-morbid ADHD compared to OCD patients without Hoarding (Sheppard et al., 2010). Little research has focused on the direct relationship between ADHD and Hoarding, though Hoarding often co-occurs with ADHD (Sheppard et al., 2010). Hartl et al. (2005) found elevated levels of inattention and hyperactivity symptoms in Hoarding patients. Overall, this population showed more cognitive deficits than non-Hoarders. Research by Grisham et al. (2000) revealed that Hoarders have difficulty sustaining attention and show high levels of impulsivity. Also, high levels of hyperactivity were found: On a behavioral inhibition task, Hoarders made more commission errors (responding where a response should be inhibited) compared to healthy controls, reflecting impaired impulse control. The ADHD-related deficits in executive functioning do not seem to be a direct consequence of Hoarding: Cognitive dysfunction precedes Hoarding behavior and is thus at the core of development of the behavior (Tolin et al., 2010). Moreover, the average onset for Hoarding is 14, whereas the average onset for ADHD is 4. ADHD symptomatology may either constitute an additional risk factor to develop Hoarding, or both disorders share commonalities in underlying cognitive dysfunction (Tolin et al., 2010). Finally, Hoarders report attentional problems on self-report questionnaires (Grisham, Brown, 2007; Hartl & Frost, 2005). Accordingly, 20% of individuals with Hoarding meets the inattention criterion for ADHD. In addition, Hartl et al. (2004) found that Hoarders report troubles organizing their items due to attentional problems.

Research suggests that Hoarders and OCD patients also display cognitive deficits that are seen in patients diagnosed with ASD, namely cognitive inflexibility (Maes et al., 2010). Increasing evidence points to mental inflexibility to play an important role in HD and OCD. One way to investigate this is to administer a task that measures the ability to display flexibility in the face of changing rules, 'set shifting'. A study by Lawrence et al. (2006) investigated mental flexibility in an

OCD group, by administering a task during which the participant must repeatedly switch strategy. OCD patients performed worse than a healthy control group. Anholt et al. (2010) found high frequencies of ASD symptoms in OCD patients. No specific association was found between the Hoarding symptom dimension of OCD and autism symptoms. However, a study by Grisham, J.R., Steketee, G., Frost, R. (2007) found Hoarding symptoms in OCD patients to be associated with social deficits and interpersonal problems, although more recent studies using Theory of Mind tests have found no abnormalities reported by Hoarders (Belmonte, M.K., 2008).

Accumulating research suggests Hoarding and OCD to be associated with specific cognitive deficits that are also seen in patients diagnosed with ADHD and ASD. Deficits in executive functioning may form the linking pin between Hoarding, OCD, ADHD and ASD. The current study will focus on two neuropsychological parameters: Mental inhibition and inflexibility, a parameter of ASD, and cognitive- and motor inhibition, a parameter of ADHD. It is hypothesized that (1) individuals diagnosed with Hoarding and OCD show elevated rates of autism on a symptom level compared to a control group and (2) show deficits in mental flexibility. The current study will focus on the non-social characteristics of ASD (Hoekstra, 2011). Furthermore, it is hypothesized that individuals diagnosed with Hoarding and OCD show elevated rates of ADHD symptoms ('hyperactivity' and 'inattention') compared to a control group and (4) show deficits in cognitive- and motor inhibition and flexibility.

## **Methods**

### **Participants**

A total of 66 participants were recruited from mental health care service Altrecht Polikliniek Noord (Utrecht). Due to a low IQ score on the Dutch Reading Test for Adults (Nederlandse Leestest voor Volwassenen; NLV: Schmand, Lindeboom & Harskamp, 1992) three participants were excluded from the study, leading to a total number of 63 participants: 19 OCD patients (53% male, mean age: 41, SD: 8.80), 22 Hoarders (45% male, mean age: 50, SD: 11.1) and 22 healthy controls (59% male, mean age: 47, SD: 13.0).

### **Procedure**

The exclusion criteria for all groups included major depression, mental deficiency, psychoses and substance abuse or dependence. The participants were matched on age, educational level and sex. To investigate co-morbidity, The Structured Clinical Interview on the DSM-IV Diagnose of Axis I Disorders (SCID-I; First, Gibbon, Spitzer, Williams & Benjamin, 1998) was administered to most participants. None of the Hoarding patients suffered from co-morbid OCD. The Structured Clinical Interview on the DSM IV diagnose of Obsessive-Compulsive Personality Disorder (OCPD SCID II; First, Gibbon, Spitzer, Williams & Benjamin, 2000) was conducted to the healthy control group to rule out the presence of OCPD symptoms. To rule out Hoarding symptoms, the Structured Interview of Hoarding Disorder (SIHD; Pertusa & Mataix-Cols, 2010) was conducted. Also, the controls were administered the Mini International Neuropsychiatric Interview (MINI; Lecrubier et al., 1997). Written informed consent was obtained from all participants.

### **Instruments**

#### ***Stroop Color - Word Test, as part of the D-KEFS***

The Delis-Kaplan Executive function System (D-KEFS) Color Word Interference Test is an extension of the traditional Stroop task (Stroop, 1935), including an inhibition/switching trial (Lippa, S.M., Davis, R.N., 2010). The speed at which each task is completed is noted. The instrument consists of 4 subtests. In the first subtest, written names of colors are shown (geel, groen, blauw, rood). The participant reads the words aloud. The second subtask shows the same colors in ink instead of letters. The participant names the colors. The third subtask (Inhibition) again shows written names

of colors. The color of the ink differs per item and is often incongruent with the meaning of the written word. The participant is instructed to name the color of the ink that the word is printed in. The ability to inhibit a response (reading the written word) is measured. The fourth subtask (Inhibition/Switching) measures the ability to inhibit a response and the ability to switch strategy. When the words are surrounded by a black square, one names the color of the ink. If not surrounded by a black square, one reads the written word. The completion time is scored in seconds, taking into account the age of the participant. Scores were rescaled from 1 (slowest) to 19 (fastest). The Stroop task is a reliable and valid assessment tool (Lezak, M.D., Howieson, D.B., Loring, D.W., 2004). In the scope of this masterthesis, errors of omission and commission were not evaluated.

### ***Stop Signal Reaction Time Task***

The SSRT measures the ability to suppress a set up motor response. Speed and accuracy are recorded. The participant must respond to an X or an O, by pressing the X or O on the keyboard (go-stimulus). When the X or O is followed by a dollar sign \$, the participant must refrain from responding to the X or O (stop-stimulus). The task evokes competition between the go-process and the stop-process (Logan, G.D., 1994). The outcome variable that is being studied is the Stop-Signal Reaction Time (SSRT). The SSRT reflects the latency of the stop-process (inhibition). Two remaining outcome variables are left out of consideration, the Mean reaction time (MRT) and the within-subject Standard Deviation of Reaction Time (SDRT), both reflecting the latency of the go-process. The SSRT task is considered a reliable and valid instrument (Congdon, E., Mumford, J.A., Cohen, J.R., Galvan, A., Canli, T., Poldrack, R.A., 2012). In the scope of this masterthesis, errors of omission and commission were not evaluated.

### ***Intradimensional/Extradimensional Task***

The Intra-dimensional/Extra-dimensional Task (ID/EDS) is a variant of the Wisconsin Card Sorting Task. It is a computer task that measures the ability to shift attention, also known as set shifting. Figures are shown and the participant must detect a sorting rule. Once the rule is correctly identified by pressing the corresponding key on the keyboard (←, ↑, →, or ↓), the computer changes the rule. The participant must then again detect the pattern. The ID/EDS has found to yield sufficiently valid and reliable data (Garner, J.P., Thogerson, C.M., Würbel H., Murray, J.D., Mench, J.A., 2006).

## **AQ**

The Autism-Spectrum Quotient (AQ) is a self-administered instrument that measures the degree to which an adult with normal intelligence shows traits associated with the autistic spectrum (Hoekstra, R.A., Vinkhuyzen, A.A.E., Wheelwright, S., Bartels, M., Boomsma, D.L., Baron-Cohen, S., Posthuma, D., van der Sluis, S., 2011). The list consists of 5 subscales (Social Skills, Attention Switching, Communication, Imagination, Attention to Detail), each consisting of 10 items, with scores ranging from 1 'I fully agree' to 4 'I fully disagree'. Dichotomous ratings are computed. The total range is 0-50, with 1 and 2 rescored into 0 and 2-3 rescored into 1. A cut off score of  $\geq 32$  is indicative for an autism spectrum disorder (ASD). The subscales show a moderate to high internal consistency with a Cronbach's alpha between .5 and .8. The test-retest reliability has been found acceptable (Hoekstra et al., 2011).

## **CAARS**

The Connors Adult ADHD Rating Scales (CAARS) is a self-report questionnaire that measures the degree to which an adult shows traits associated with ADHD. The list consists of two subscales (Inattention/Memory Problems, Hyperactivity/Restlessness), each consisting of 9 items, with scores ranging from 0 (never) to 3 (very often). The CAARS represents a reliable and valid measure of ADHD symptoms Christiansen, H., Kis, B., Hirsch, O., Matthies, S., Hebebrand, J., Uekermann, J., Abdel-Hamid, Kraemer, M., Wiltfang, J., Graf, E., Colla, M., Sobanski, E., Rösler, M., Alm, B., M., Jacob, C., Jans, T., M. Huss., Schimmelmann, B.G., Philipsen, A., 2012).

## **BIS**

The Behavioral Inhibition Scales (BIS) is a self-report questionnaire that is administered to assess individual differences in sensitivity of a motivational system. The BIS regulates aversive motives, in which the goal is to move away from something undesired. The questionnaire consists of 13 BAS items (Fun Seeking, 4 items; Reward Responsiveness, 5 items; Drive, 4 items) and 7 BIS-items, with scores ranging from 0 ('totally disagree') to 3 ('totally agree'). The instrument is found to be reliable and valid (Franken, I.H.A., Muris, P., Rassin, E., 2005).

### **SCID-II OCPD**

The Structured Clinical Interview on the DSM-IV Diagnose of Obsessive-Compulsive Personality Disorder (First, M., Gibbon, M., Spitzer, R.L., Williams, J.B., Benjamin, L.S., 2000) measures the degree to which an adult shows traits associated with OCPD. A diagnose is made when meeting a minimum of 4 out of 8 OCPD criteria. The SCID-II OCPD is found to a reliable and valid instrument (Ekselius L, Lindstrom E, von Knorring L, Bodlund O, Kullgren G., 1994).

**TABLE 1. Co-morbid diagnoses in HD, OCD and Controls, measured by SCID I, SCID-II OCPD and SIHD. The MINI was administered for Controls.**

	OCD (N=19)	HD (N=22)	Controls (N=22)
Obsessive-compulsive disorder	19	4	0
Hoarding disorder	0	22	0
Obsessive-compulsive Personality Disorder with/ without hoarding item	4(21%)*/ 4(21%)*	11(50%)*/ 9 (41%)*	0
Major depressive disorder	0	1	0
Dysthymia disorder	1	1	0
Impulse-control disorder	0	5	0
Social phobia	0	3	0
Tourette syndrome	0	1	0
Panic disorder with/ without agoraphobia	3	0	0
Posttraumatic stress disorder	1/1	0/0	0
Alcohol abuse	0	2	0
	1	1	0

\*significant at the 0.05 level (2-tailed).

### **OCI-R**

The Obsessive-Compulsive Inventory-Revised is a 18 item self-report questionnaire that measures the degree to which an adult shows symptoms of Obsessive-Compulsive Disorder (OCD). The scores range from 0 ('not present') to 4 ('very much present'). The instrument differentiates well between patients with and without OCD (Foa, E.B., Huppert, J.D., Leiberg, G., Langner, R., Kichic, R., Hajcak, G. Salkovskis, P.M., 2002). The internal consistency and test-retest reliability is found to be good

(Timpano, K.R., Keough, M.E., Mahaffey, B., Schmidt, N.B., & Abramowitz, J., 2010).

### ***SI-R***

The Saving-Inventory Revised is a self-report questionnaire that measures the degree to which an adult shows hoarding behavior, consisting of 23 items and three subscales (Difficulty Discarding, Excessive Clutter, Compulsive Acquisition). The scores range from 0 ('not present') to 4 ('extreme distress or permanent presence of symptoms'), with a total range from 0-92. The instrument has good internal consistency, test-reliability and divergent validity in non-clinical and clinical populations (Frost et al., 2004).

### ***BDI***

The Beck Depression Inventory is a self-report questionnaire that measures the degree to which an adult shows symptoms of depression, consisting of 21 items, with scores ranging from 0 ('not at all') to 3 ('severely'). The total score falls into a range from 0-63. The cut-off scores are <10 for no or minimal depression, 10-18 for mild to moderate depression, 19-29 for moderate to severe depression and 30-63 meaning severe depression. The BDI has found to be internally consistent, with a Cronbach's alpha of .86 for psychiatric patients and .81 for non-psychiatric patients. The COTAN has evaluated the instrument to be reliable and valid in both psychiatric and non-psychiatric populations (COTAN, 2002).

### ***BAI***

The Beck Anxiety Inventory (BAI) is a self-report questionnaire that measures the degree to which adults/adolescents older than 13 show symptoms of anxiety, consisting of 21 items, with scores ranging from 0 ('not at all') to 4 ('severe'). The total score falls into a range from 0-63. The cut-off scores are 0-7 for minimal anxiety, 8-15 for mild anxiety, 16-25 for moderate anxiety and 26-63 for severe anxiety. The COTAN evaluates the instrument as reliable and with a moderate criterion validity (COTAN, 2002).

## Results

### *Socio-demographic characteristics*

To test whether there are significant between group differences in age for HD, OCD and Controls, a One-way ANOVA was performed. A significant difference was found ( $F=3.65$ ,  $df=2$ ,  $p<.05$ ). A post hoc test using Bonferroni correction revealed that the HD group was significantly old compared to the OCD group. No significant between group difference was found for sex. The three groups did significantly differ on level of education ( $F=15.04$ ,  $df=4$ ,  $p<.01$ ). The OCD group consisted of less highly educated people compared to the HD group and the control group. Furthermore, the HD group was less highly educated compared to the control group. Level of education and sex were not correlated to the dependent variables under study, and were therefore not considered in subsequent analyses.

**TABLE 2. Socio-demographic characteristics (age, sex, education) for HD, OCD and Controls.**

	HD (N=22)		OCD (N=19)		Controls (N=22)		<i>F/χ<sup>2</sup></i>		
	Mean	SD	Mean	SD	Mean	SD	<i>F</i>	<i>df</i>	<i>P</i>
Age	49.86	11.10	40.58	8.8	47.18	13.0	3.65	2	.032
	<b>N (%)</b>		<b>N (%)</b>		<b>N (%)</b>		<b>χ<sup>2</sup></b>		
Male	10 (45%)		10 (53%)		13 (59%)		0,60	2	.751
Education ≥ HBO	10 (45%)		4 (25%)		18 (86%)		15.04	4	.005

### **SCID-II OCPD**

To investigate the presence of OCPD, the SCID-II OCPD interview was administered in all groups (First, Spitzer, Gibbon, Williams & Benjamin, 2000). 41% of the Hoarding group and 21% of the OCD group was diagnosed with OCPD, meaning that these participants met 4 or more criteria. To test whether there are significant between group differences on number of OCPD traits, a One-way ANOVA was performed. When excluding the Hoarding item, significant between group differences remained with respect to total number of OCPD traits ( $F=6.67$ ,  $df=2$ ,  $p<.01$ ). A post hoc test using LSD correction revealed significant differences between the OCD group and HD group versus the control group, the former showing a higher mean number of OCPD traits. No significant differences were found between the HD and OCD group.

**TABLE 3. Mean number of OCPD traits + Standard Deviation (SD) for HD, OCD and Controls.**

	HD (N=22)		OCD (N=17)		Controls (N=20)		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	SD	Mean	SD	Mean	SD			
OCPD-traits									
HD item included	5.23	2.78	4.76	3.46	1.65	3.39	7.48	2	.001
OCPD-traits									
HD item excluded	4.09	2.67	4.47	3.06	1.40	2.89	6.67	2	.003

**AQ**

To test whether there are significant between group differences between the HD and OCD group versus the control group on the AQ, a One-way ANOVA was used. A significant effect of the three groups on the AQ total score was found ( $F=8,25$ ,  $df=2$ ,  $p<.001$ ). Furthermore, a significant between group effect was found for 'Social skills' ( $F=11,80$ ,  $df=2$ ,  $p<.01$ ), 'Attention switching' ( $F=11,84$ ,  $df=2$ ,  $p<.01$ ), 'Attention to detail' ( $F=3,76$ ,  $df=2$ ,  $P<.01$ ), 'Communication' ( $F=5,80$ ,  $df=2$ ,  $P<.01$ ) and 'Imagination' ( $F=5,92$ ,  $df=2$ ,  $P<.01$ ). A post hoc test using LSD correction revealed that the HD group and the OCD group showed significantly higher scores compared to the control group on total score and all subscales. No significant differences were found between the HD and OCD group.

**OCI-R**

To test whether there are significant between group differences between the HD group versus the OCD and control group on the OCI-R, a One-way ANOVA was used. A significant effect of the three groups on the OCI-R total score was found ( $F=14,74$ ,  $df=2$ ,  $p<.01$ ). The effect remained significant when controlling for the Hoarding subscale in the total score ( $F=11,20$ ,  $df=2$ ,  $p<.01$ ). Furthermore, significant between group differences were shown on all subscales except for the subscale 'Neutralizing': 'Washing' ( $F=4,49$ ,  $df=2$ ,  $p<.01$ ), 'Obsessing' ( $F=11,53$ ,  $df=2$ ,  $p<.001$ ), 'Hoarding' ( $F=42,8$ ,  $f=2$ ,  $P<.01$ ), 'Ordering' ( $F=3,24$ ,  $df=2$ ), 'Checking' ( $F=9,05$ ,  $df=2$ ,  $P<.01$ ). A post hoc test using LSD correction revealed that the HD and OCD group showed a significantly higher total score compared to the control group, but no significant differences were found between the HD and OCD group. When controlling for the Hoarding subscale in the total score, the difference between the HD and OCD group remained insignificant. A post hoc test on the subscales revealed significant between group differences on all subscales for the OCD and HD group versus the control group. No significant differences were found between the HD versus the OCD group, except for the subscale 'Hoarding'. As expected, the HD group showed a significantly higher score on the subscale 'Hoarding' compared

to the control group and the OCD group.

### ***BIS***

To test whether there are significant differences between the HD and OCD group versus the control group on the BIS, a One-way ANOVA was used. A significant effect of the three groups on the BIS total score was found ( $F=12,12$ ,  $df= 2$ ,  $p<.01$ ). A post hoc test using LSD correction revealed that both the HD group and the OCD group scored significantly higher than the control group. No significant differences were found between the HD and OCD group.

### ***SI-R***

To test whether there are significant differences between the HD group versus the OCD and control group on the SI-R, a One-way ANOVA was used. A significant between group effect was found for the SI-R total score ( $F= 54,57$ ,  $df=2$ ,  $p<.01$ ). Significant between group differences were found on all subscales: 'Clutter' ( $F=34,38$ ,  $df=2$ ,  $p<.01$ ), 'Saving' ( $F=63,86$ ,  $df=2$ ,  $p<.01$ ) and 'Acquisition' ( $F=53,78$ ,  $df=2$ ,  $p<.01$ ). A post hoc test using LSD correction revealed that the HD group showed significantly higher scores compared to the OCD and control group. No significant differences were found between the OCD group and the control group.

### ***CAARS***

To test whether there are significant differences between the HD and OCD group versus the control group on the CAARS, a One-way ANOVA was used. Significant effects of the three groups on the ADHD total score ( $F=6,30$ ,  $df= 2$ ,  $p<.05$ ), the 'inattentive' subscale ( $F=5,95$ ,  $df= 2$ ,  $p<.05$ ) and the 'hyper' subscale ( $F=3,47$ ,  $df= 2$ ,  $p<.05$ ) were found. A post hoc test using LSD correction revealed that both the HD and the OCD group showed significantly higher total scores compared to the control group. When looking at the subscale 'Hyperactivity', no significant difference between the HD and OCD group was found. The OCD group did show significantly higher scores on the 'hyper' subscale compared to the control group. When looking at the subscale 'Inattentiveness', the HD and OD show significantly high scores compared to the control group. No significant differences were found between the HD and OCD group.

**TABLE 4. Mean scores (M) + SD on the AQ, CAARS, BIS, SI-R and OCI-R for HD, OCD and Controls.**

	HD (N=22)		OCD (N=19)		Controls (N=22)		F	df	P
	Mean	SD	Mean	SD	Mean	SD			
AQ total	21.95	8.93	19.53	10.17	12.00	5.96	8.25	2.00	.001
AQ imagin	4.50	2.14	3.29	2.14	2.52	1.66	5.92	2.00	.005
AQ commu	4.15	1.98	3.82	2.50	2.14	1.56	5.80	2.00	.005
AQ attdetail	4.95	2.67	4.76	2.39	3.24	1.34	3.76	2.00	.030
AQ attswitch	6.30	1.59	5.29	2.97	2.95	2.13	11.84	2.00	.000
CAARS hyper	2.26	2.02	2.64	1.97	1.19	1.36	3.47	2.00	.038
CAARS inattentive	3.58	3.01	4.00	3.04	1.19	2.23	5.95	2.00	.005
CAARS total	5.84	4.39	6.65	4.31	2.38	3.31	6.30	2.00	.003
BIS	17.82	3.24	18.94	2.82	13.76	4.01	12.12	2.00	.000
SIR clutter	27.22	3.43	16.75	5.73	14.61	3.43	34.37	2.00	.000
SIR saving	23.67	5.42	11.50	3.50	10.29	2.61	63.85	2.00	.000
SIR acquisition	22.72	4.64	12.50	2.92	12.48	2.48	53.78	2.00	.000
SIR total	73.61	15.00	39.53	40.75	11.34	8.02	54.57	2.00	.000
OCIR washing	1.80	2.82	2.59	3.62	0.14	0.65	4.49	2.00	.016
OCIR hoarding	7.15	2.83	1.12	1.45	1.57	2.20	42.68	2.00	.000
OCIR checking	3.55	3.33	4.65	3.53	0.81	1.60	9.05	2.00	.000
OCIR neutralizing	0.95	1.82	1.23	1.71	0.38	1.07	1.51	2.00	.229
OCIR obsessing	3.00	3.03	4.70	3.40	0.67	0.86	11.53	2.00	.000
OCIR ordering	3.65	2.87	2.70	3.85	1.38	1.71	3.24	2.00	.000
OCIR total	20.10	11.42	17.00	11.00	4.95	4.78	14.74	2.00	.000
OCIR total – H	2.95	2.13	3.17	2.08	0.67	0.67	11.20	2.00	.000

**BDI and BAI**

Symptoms of anxiety (BAI) and depression (BDI) were measured in all groups. A One-way ANOVA showed a significant main effect for both BAI ( $F=14,27$ ,  $df=2$ ,  $p<.01$ ) and the BDI ( $F=22,02$ ,  $df=2$ ,  $p<.01$ ). A post hoc test using an LSD correction revealed that the HD group and the OCD group shows significantly higher scores on the AI and BDI compared to the control group. No significant differences were found between the HD an OCD group. Correlations were calculated between BAI and BDI scores versus scores on the neuropsychological tests. No significant correlations were found. Therefore, it was decided not to control for BAI and BDI scores.

## Neuropsychological tests

### **SSRT**

To test whether there are significant between group differences in performance on the SSRT between the HD and OCD group versus the control group, a One-way ANOVA was used. No significant differences were found.

**TABLE 5. Mean scores + SD on the SSRT for HD, OCD and Controls.**

	HD (N=11)		OCD (N=9)		Controls (N=7)		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	SD	Mean	SD	Mean	SD			
SSRT score	226.7	42.1	187.2	113.4	218.8	58.4	.644	2	.535

### **ID/EDS**

To test whether there are significant between group differences in performance on the ID/EDS, a One-way ANOVA was used. No significant between group difference was found for number of participants that reached stage 8 (table 6). Within stage 8, the OCD group needed significantly more trials compared to the HD and control group (table 7).

**TABLE 6. Number of participants (N and %) that reached stage 8 for HD, OCD and Controls.**

	HD (N=14)		OCD (N=19)		Controls (N=15)		<i>F/χ<sup>2</sup></i>		
	N (%)		N (%)		N (%)		<i>F</i>	<i>df</i>	<i>P</i>
Reached stage 8	12 (86%)	86	14 (74%)		13(87%)		1.2	2	.553

**TABLE 7. Mean number of trials + SD needed in stage 8 for HD, OCD and Controls.**

	HD (N=14)		OCD (N=19)		Controls (N=15)		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	SD	Mean	SD	Mean	SD			
Trials	17.4	14.0	29.3	16.1	15.5	14.7	4.3	2	.020

To test whether there are significant between group differences in performance on the *different stages* between the HD and OCD group versus the control group, a repeated measures One-way ANOVA was performed. Group means were compared for stage 1-7 together, stage 8 and stage 9 (3 time points). Stages 1 to 7 consist of one relevant dimension (colour filled shapes) and reflect the

ability to learn a correct response and change response when the rule is changed. In stage 8, the participant must switch to another dimension (white lines) and the old dimension becomes irrelevant. In stage 9 the participant continues to satisfy the set criterion of learning. Mauchley's test indicated that the assumption of sphericity had been violated ( $\chi^2(2)=37.17$ ,  $P=.000$ ). Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ( $\epsilon=.63$ ). A significant main effect was shown ( $F=15.05$ ,  $df = 1.26$ ,  $p<.01$ ). No significant interaction effect was found. A significant difference in number of trials was found stage 1-7 versus stage 8, making the extra dimensional shift (table 8, 9). The number of trials was significantly higher in stage 8 compared to stage 1-7. Also, a significant difference in number of trials was found for time stage 8 versus time stage 9. The number of trials was significantly lower in stage 9 compared to stage 8. Stage 8 elicits a statistically significant increase in number of trials. A post hoc test using a Bonferroni correction revealed that the OCD group need a significantly higher number of trials in stage 8 compared to the control group (figure 1). No significant between group differences were found for the HD group versus the control group and the HD group versus the OCD group. However, when looking at the 9 stages separately (figure 2), a trend towards a significant effect was found for the HD group versus the control group, whereas the HD group needed more trials in stage 8 compared to the control group. From the mean number of trials, it can be seen that (though not significant) the OCD group needed a lower number of trials in stage 9. However, this may be due to the fact that 5 OCD patients did not reach stage 9, against 2 in the HD group and 2 in the control group. It should be noted that these differences were not significant.

**TABLE 8 . Mean scores + SD on the Stroop (using raw scores) for HD, OCD and Controls.**

	HD (N=14)		OCD (N=17)		Controls (N=15)	
	Mean	SD	Mean	SD	Mean	SD
Stage 1-7	9.67	3.52	10.56	4.77	8.10	2.26
Stage 8	17.36	14.01	28.29	16.58	15.47	11.74
Stage 9	12.42	12.56	7.06	5.75	8.53	5.77

**TABLE 9. Results of the Repeated Measures one-way ANOVA for the IDEDS: Main and interaction effects.**

	Df	MS	F	P
Stage	1.26	2915.07	15.06	.000
Stage x Diagnose	2.52	523.81	2.71	.064
Error	54.18	193.58		

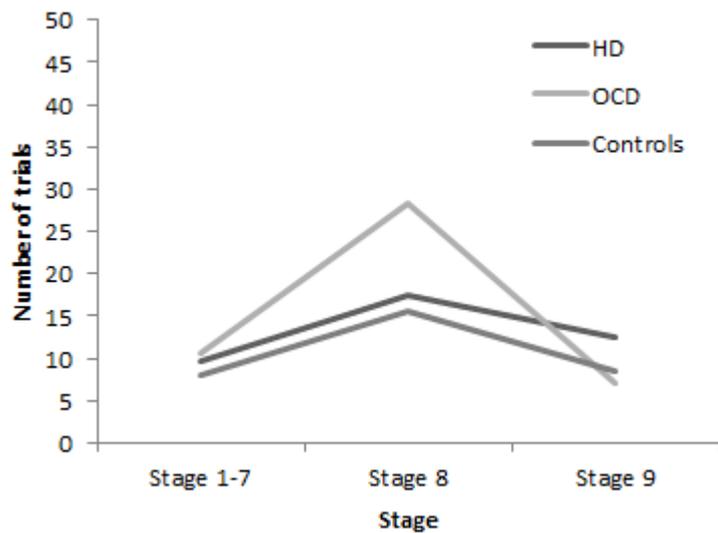


FIGURE 1. Mean number of trials in stage 1-7, stage 8 (reflecting the Intra-Dimensional Extra-Dimensional Shift) and stage 9, for HD, OCD and Controls.

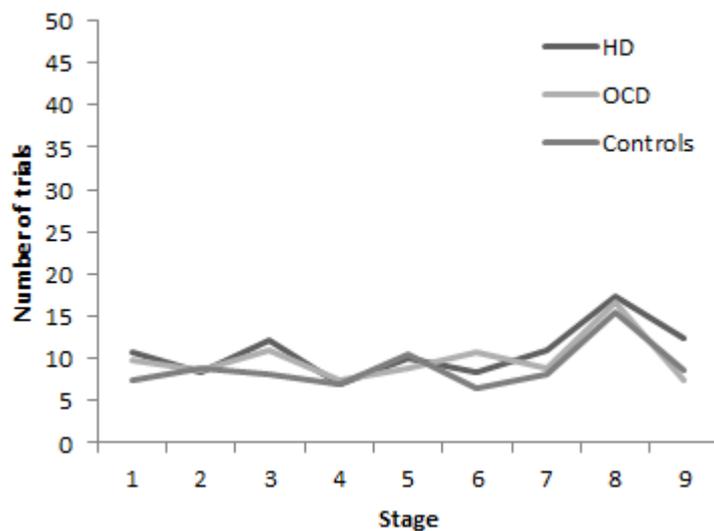


FIGURE 2. Mean number of trials used in each stage (9), for HD, OCD and Controls.

### ***Stroop Color-Word Task***

To test whether there are significant between group differences in performance on the Stroop Color-Word Task between the HD and OCD group versus the control group, a one-way ANOVA was performed, using scaled scores. No significant differences were found (table 10).

**TABLE 10. Mean scores + SD on the Stroop (using scaled scores) for HD, OCD and Controls.**

	HD (N=22)		OCD (N=18)		Controls (N=20)		<i>F</i>	<i>df</i>	<i>P</i>
	Mean	SD	Mean	SD	Mean	SD			
Stroop 1	10.1	3.3	10.6	4.7	10.9	1.9	.311	2	.734
Stroop 2	10.9	3.2	10.6	3.4	11.4	2.1	.398	2	.673
Stroop 3	12.0	3.0	12.9	2.5	12.7	2.5	.705	2	.499
Stroop 4	10.5	4.4	10.6	3.5	11.6	1.8	.688	2	.507
Stroop 4 vs 1,2	-.02	4.1	-.03	4.1	.42	2.0	.139	2	.870
Stroop 3 vs 1,2	1.5	2.2	2.3	2.6	1.6	2.4	.694	2	.504
Stroop 4 vs 3	-1.5	3.5	-2.3	1.9	-1.1	1.9	1.04	2	.360

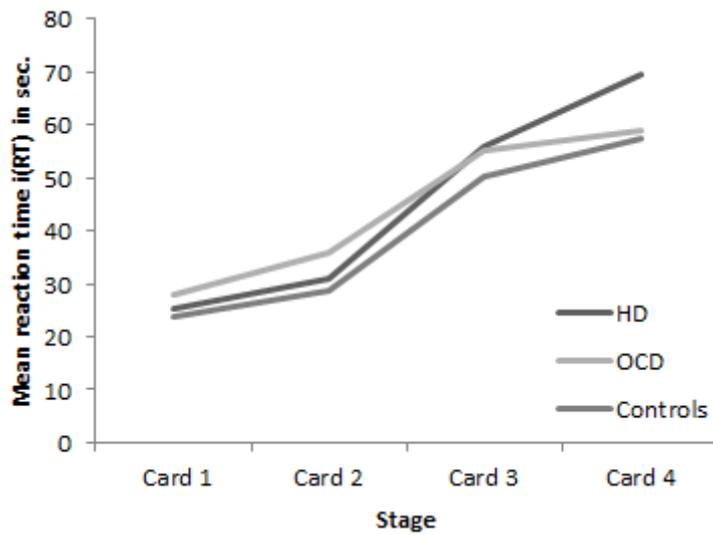
To further investigate whether there are significant between group differences in performance on the different stages between the HD and OCD group versus the control group, a repeated measures One-way ANOVA was performed, using raw scores (table 11, 12). Mauchly's test indicated that the assumption of sphericity had been violated ( $\chi^2(2)=111.25, P=.000$ ). Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ( $\epsilon=.65$ ). A significant main effect was found ( $F=146.59, df = 1.93, p<.01$ ). Furthermore, a trend was found towards a significant interaction effect between stage and diagnosis ( $F=146.59, df=1.93, p<.05$ ). The HD group was found to show a longer RT when performing stage 4, compared to OCD patients and controls (figure 3). When comparing RT between card 1, card2, card3 and card 4, significant differences were found between all cards. It was revealed that RT increased in every following stage, with card 4 showing the highest mean reaction time.

**TABLE 11 . Mean scores + SD on the Stroop (using raw scores) for HD, OCD and Controls.**

	HD (N=22)		OCD (N=18)		Controls (N=20)	
	Mean	SD	Mean	SD	Mean	SD
Stroop 1	25.27	1.75	27.94	1.94	23.95	1.84
Stroop 2	31.09	2.21	35.72	2.45	28.55	2.32
Stroop 3	56.09	4.39	55.28	4.85	50.05	4.60
Stroop 4	69.59	4.25	58.78	4.70	57.45	4.46

**TABLE 12. Results of the Repeated Measures one-way ANOVA for the Stroop (4 stages): Main and interaction effects.**

	<b>Df</b>	<b>MS</b>	<b>F</b>	<b>P</b>
Stage	1.93	27716.04	146.59	.000
Stage x Diagnose	3.86	403.20	2.13	.084
Error	110.22	189.07		



**FIGURE 3. Mean reaction time (RT) in seconds for each card (1-4), for HD, OCD and Controls.**

## Discussion

The aim of the current study was to investigate a linking pin between Hoarding, OCD, ASD and ADHD. The disorders often co-occur and previous research revealed that these groups show similar cognitive deficits, pointing in the direction of shared underlying neuropsychological mechanism. The current study focused on two neuropsychological parameters: Mental inflexibility, a parameter of ASD, and motor inhibition, a parameter of ADHD, and cognitive inhibition which might underlie both ASD and ADHD.

The first hypothesis, that Hoarders and OCD patients show elevated rates of autism symptoms, was confirmed. This is in line with a study by Bejerot (2007), stating that the behavioral characteristics seen in autism correspond to those seen in OCD, such as showing repetitive behavior. Moreover, Anholt et al.(2010) found elevated levels of autism symptoms in patients diagnosed with OCD. With respect to Hoarding, this was a remarkable finding, since the Hoarding dimension in OCD patients has not been associated with ASD but rather with ADHD symptoms (Anholt et al., 2010; Tolin et al., 2010). Administering the SCID-II OCPD also revealed that Hoarders and OCD patients show high rigidity/mental inflexibility compared to controls. One can argue that the 'Hoarding' item accounts for this outcome. However, the outcome remained when controlling for this item. 41% of Hoarders met criteria for the diagnosis of OCPD-II, which strongly supports the idea of mental inflexibility playing a role in Hoarding Disorder. 21% of the OCD patients met criteria for OCPD, which is in line with the literature stating that OC symptoms and OC personality traits are strongly related and possibly influenced by shared genetic factors (Taylor et al, 2011). It is striking that Hoarders and OCD patients both score equally high on OCPD traits. This may be due to high scores of both groups on one item in particular, that reflects the extent to which one has acquired a style of greediness with regard to themselves and others and whether money is seen as something that needs to be saved to prevent future catastrophes. This is in line with literature stating that 'harm avoidance' is a core motivational dimension of OCD (Ettelt, S., Grabe H.J., Ruhrmann, S., Buhtz, F., Hochrein, A., Kraft, S., Pukrop, R., Falkai, P., Maier, W., John, U., Freyberger, H.J., Wagner, M., 2008) and a behavioral motive that is frequently seen in Hoarding Disorder (Gordon, O.M, Salkovskis, P.M., Oldfield, V.B., 2013).

The second hypothesis stating that Hoarders and OCD patients both show cognitive inflexibility on a neuropsychological level, a parameter of ASD, was partially confirmed. OCD patients were shown to have difficulty with 'set shifting', a cognitive capacity measured by the IDEDS. This group was found to show deficits in attentional shifting between stimulus dimensions and tended to perseverate on an old pattern where they should switch to a new strategy. It became apparent that OCD patients experience trouble when trying to switch from the intra to the

extradimensional shift, reflecting poor switching abilities. These findings are in line with a study by Chamberlain et al. (2007), who also measured cognitive flexibility in OCD patients by subjecting them to the IDEDS task. A family study was performed to investigate the genetic contributions to OCD. It was found that first-degree relatives of OCD patients also have difficulties with set shifting. In addition, Lawrence et al. (2006) found poor set shifting to be characteristic of OCD. Participants in this study were subjected to a task from which the IDEDS is originally derived, the Wisconsin Card Sorting Task, and the results revealed that OCD patients show poor attentional set shifting. However, it should be noted that the population of OCD patients is heterogeneous and consists of different subtypes that each seem to have a specific influence on executive functioning. This was illustrated by a study of Lawrence et al. (2006), which revealed that particularly participants showing symptoms on the symmetry/order dimensions show poor set shifting performance. The current study did not address this issue. With regard to the Hoarding group, the current study revealed a trend towards cognitive inflexibility. Results revealed that Hoarders show surprisingly intact set shifting ability and performed relatively well on the Intra-Dimensional Extra-Dimensional shift. It seems that OCD patients, not Hoarders, have trouble making the Intra-Extra Dimensional shift, and that the task reflects a deficit specific to OC problems. Interestingly, when administering the Stroop task, Hoarders show near-significant difficulties on the fourth card, in which a combination of inhibition and set shifting is required. Hoarders showed remarkably slow reaction times, reflecting poor strategy switching and inhibition. A possible explanation could be that this combination is a heavy load on the working memory, which is found to be impaired in Hoarders (Grisham, 2007).

The third hypothesis stating that Hoarders and OCD patients show elevated rates of ADHD symptoms, was confirmed. It was revealed that both groups show elevated scores on an ADHD screening list. This is in line with a study by Hart et al. (2005) that found Hoarders to show impairments in both the inattention and hyperactivity dimensions of ADHD. The authors suggest that it are these deficits that contribute to the problems Hoarders experience in cluttering and organization items. Furthermore, Anholt et al. (2010) found that ADHD symptoms are elevated up to 30% in patients diagnosed with OCD, especially those with co-morbid Hoarding, compared to controls.

The fourth hypothesis stating that OCD and Hoarders show deficits in cognitive- and motor inhibition, a parameter of ADHD, was partially confirmed. Results on the Behavioral Inhibition Scale questionnaire confirmed that individuals diagnosed with Hoarding and OCD have difficulties in behavioral inhibition, i.e. regulating aversive motives, in which the goal is to move away from something desired. Against expectation, Hoarders and OCD patients did not show difficulties

suppressing a set up motor response on the Stop Signal Reaction Task (SSRT). Earlier research by Blom, Samuels (2011) also failed to find differences in performance between Hoarders, OCD patients and controls. By contrast, Chamberlain (2006) found OCD patients (high on the symptom dimension 'washing and 'checking') to show poor impulse control compared to healthy controls.

Neurobiological studies have also pointed in the direction of SSRT being impaired in this population: OCD patients and first-degree family members show diminished grey matter in the frontal regions of the brain, whereas in the striatal, parietal and cingulate regions the amount of grey matter is elevated (Menzi et al., 2007). This raises questions as to whether the results in the current study accurately reflect the capacity of Hoarders and OCD patients to control their impulses. The high mean age of the study groups (M=46) might have distorted the outcome. According to Williams et al. (1999) inhibitory control reduces across the life span and it was thus expected that this would be reflected in the SSRT. Although not significant, the HD and control group (higher mean age) did show slower reaction times than the OCD group. Perhaps small sample size, especially of the control group, has led to an inability to pick up subtle between-group differences. Finally, impulse control was measured by the Stroop task. This task not only measures one's ability to switch strategy, but simultaneously measures one's ability to inhibit an impulse. Hoarders were found to show a trend towards impaired performance, reflecting difficulties inhibiting an old response while engaging in another, correct response.

### **Strengths and limitations**

A strength of this study was that the patients under study were compared to a healthy control group. Validated and reliable instruments were used to assess Axis I and II disorders and neuropsychological functioning. Moreover, the current study was not solely of descriptive nature, but also included neuropsychological testing directly measuring executive functioning for each study group.

There are some methodological limitations relevant to the interpretation of the current findings. The questionnaires that were used to measure symptoms of ADHD (CAARS) and Autism (AQ) are self-report assessments, enhancing the risk of validity problems. Patients may have over- or underreported symptoms due to, for example, lack of self-insight. Secondly, the sample size in the current study is relatively small, possibly explaining why group differences were not detected. Another limitation is that the overall mean age of the participants under study was relatively high (M=46). Future studies should include younger participant as well, taking into account the possibility of inhibitory control reducing across the life span.

A useful extension to this study would be to include a group of ASD and ADHD patients, creating the possibility to directly compare executive functioning in Hoarders and ASD, ADHD and OCD patients. When investigating the neuropsychological correlates of OCD, the influence of the specific subtypes of OCD on neuropsychological and symptom profiles should be accounted for, because the dimensions each seem to have a specific influence on executive functioning. Finally, efforts should be required to differentiate OCD patients with Hoarding Disorder from 'pure' OCD patients. In this study, 4 OCD patients had a co-morbid diagnosis for Hoarding Disorder.

## **Conclusion**

The current study showed remarkable similarities between Hoarders and OCD patients, both at the symptom level (OC symptoms, behavioral inhibition symptoms, ADHD symptoms) and at the level of executive functions (motor and cognitive inhibition). Results on cognitive flexibility and set shifting pointed into different directions, suggesting that the problems of patients slightly diverge here. However, at the level of symptoms, Hoarding, OCD, ASH and ADHD symptoms by and large overlap. The disorders often co-occur and previous research also revealed that these groups show similar cognitive deficits, pointing in the direction of a shared neuropsychological mechanism. This strongly suggests a shared etiology of the disorders and is contradictory to the current scientific movement that views Hoarding Disorder as a separate entity in the DSM-5. No definite conclusions can be drawn, but Hoarding might possibly be best defined as a symptom of OCD after all.

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