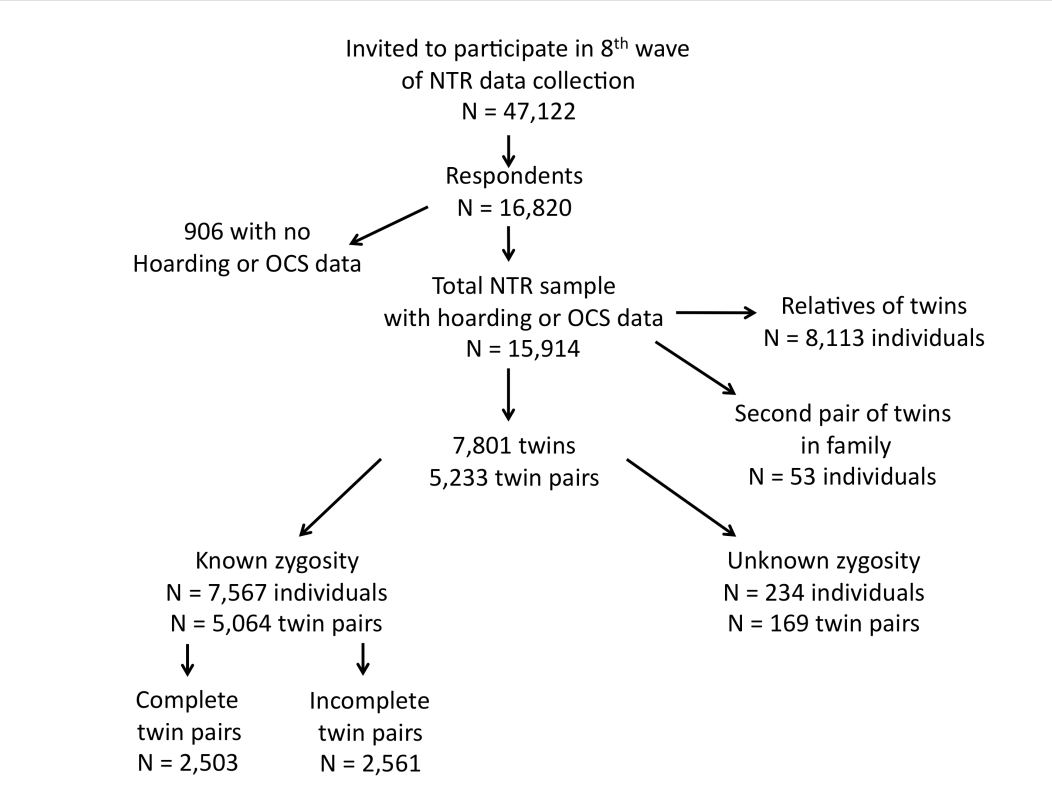
Supplementary Materials

Supplemental Methods:

Participants: The data for this study come from the 8th wave of surveys in the NTR (collected between 2009 and 2012), which was mailed to all twins aged 18 year or older and their family member (Geels *et al.*, 2013, Willemsen *et al.*, 2013). 47,122 individuals were invited to participate in Wave 8; the response rate for this wave was approximately 36%(Willemsen *et al.*, 2013). For 54.1% of same-sex twin pairs, zygosity was determined by DNA testing, and for the remaining twin pairs zygosity was determined by questionnaire items on physical similarity and frequency of confusion of the twins by family and strangers(Rietveld *et al.*, 2000). The accuracy of zygosity determined by questionnaire items compared to that obtained by DNA testing was 96% (when all available questionnaire data was used) to 98% (when only reliable data from multiple reports was used)(Willemsen *et al.*, 2013). For the genetic analyses, only one twin pair per family was examined. In the case of families with multiple twin pairs, the first-born pair was selected, while in the case of triplets, the first- and second-born individuals were selected for inclusion. Of the relative sample (N=8,223), 5,196 individuals were parents of twins, 1,771 were siblings, 770 were spouses, 56 were the child of a twin or other sibling, and the relationship was unknown for 215.



Supplemental Figure 1: Details of the NTR sample. Note: Total NTR sample (N = 15,914) includes individuals with either hoarding or OCS data—14,773 individuals have both hoarding and OCS data.

Zygosity	Complete pair (N)	Incomplete pair (N)	Total pairs (N)
MZ male	357	315	672
DZ male	182	267	449
MZ female	1068	620	1,688
DZ female	467	500	967
DOS	429	859	1,288
Total (N)	2,503 (5,006 subjects)	2,561 (2,561 subjects)	5,064 (7,567 subjects)

Supplemental Table 1: Zygosities of the twin pairs used in the analysis. MZ = monozygotic. DZ = dizygotic same-sex. DOS = dizygotic opposite-sex.

Assessment Questionnaires:

The general instructions for participants and the hoarding (HRS-SR) and OCS related questionnaires (PI-ABBR) used in this study, and the psychometric properties of the instruments are provided below.

General instructions for participants:

This questionnaire includes questions about such things as your family situation, health, life events, support, personality, and smoking and drinking habits. The questions have been grouped into sections (A to Y).

- You can answer the questions by putting a cross in the appropriate box or by explaining your answer in words. There are no right or wrong answers.
- In case of doubt, please give the answer that comes closest to your situation. When answering the questions, select the answer that best reflects how you feel now or your life at this moment. If you are currently going through an unusual period, you will have the opportunity to explain this at the end of the questionnaire.

Please also note the following:
Do not put a cross in more than one box, unless the question states that several answers are possible.

- If you accidentally cross the wrong box, place an arrow in the correct box.
- The order of the answer categories in the sections may differ. In some sections, for example, the answer categories start with ‘hardly ever’ and end with ‘almost always’. In other sections this is the reverse.
- If there is insufficient space anywhere in the questionnaire to complete your answer, you can do so in the space provided on the last page. All your answers will of course be treated with due confidentiality.

Modified Hoarding Rating Scale-Self Report (HRS-SR)

1. Because of the clutter or number of possessions, how difficult is it for you to use the rooms in your home?

0	1	2	3	4	5	6	7	8
It is not at all difficult		It is mildly difficult		It is moderately difficult		It is severely difficult		It is extremely difficult

2. To what extent do you have difficulty discarding (or recycling, selling, giving away) ordinary things that other people would get rid of?

0	1	2	3	4	5	6	7	8
I have no difficulty		I have mild difficulty		I have moderate difficulty		I have severe difficulty		I have extreme difficulty

3. To what extent do you currently have a problem with collecting free things or buying more things than you need or can use or can afford?

0	1	2	3	4	5	6	7	8
I have no problem		I have a mild problem—for example, occasionally (less than weekly) I collect or buy items I don't need, or I collect or buy a few unneeded items		I have a moderate problem—for example, regularly (once or twice weekly) I collect or buy items I don't need, or I collect or buy some unneeded items		I have a severe problem—for example, frequently (several times per week) I collect or buy items I don't need, or I collect or buy many unneeded items		I have an extreme problem—for example, very often (daily) I collect or buy items I don't need, or I collect or buy large numbers of unneeded items

4. To what extent do you experience emotional distress 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?

0	1	2	3	4	5	6	7	8
I am not at all distressed or impaired		I am mildly distressed or impaired		I am moderately distressed or impaired		I am severely distressed or impaired		I am extremely distressed or impaired

Padua Inventory-Revised abbreviated (PI-R ABBR)

The following statements refer to thoughts and behaviors that may occur to everyone in everyday life. For each statement, circle the reply which best seems to fit you and the degree of disturbance which such thoughts or behaviors may create

1. In certain situations, I am afraid of losing my self-control and doing embarrassing things

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

2. I check and recheck gas and water taps and light switches after turning them off

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

3. I feel obliged to follow a particular order in dressing, undressing and washing myself

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

4. When I see a train approaching I sometimes think I could throw myself under its wheels

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

5. I return home to check doors, windows, drawers etc., to make sure they are properly shut

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

6. When I start thinking of certain things, I become obsessed with them

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

7. I feel I have to repeat certain numbers for no reason

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

8. Unpleasant thoughts come into my mind against my will and I cannot get rid of them

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

9. My thoughts constantly go astray, therefore I find it difficult to attend to what is happening around me

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

10. I sometimes have to wash or clean myself simply because I think I may be dirty or 'contaminated'

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

11. I get upset and worried at the sight of knives, daggers and other pointed objects

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

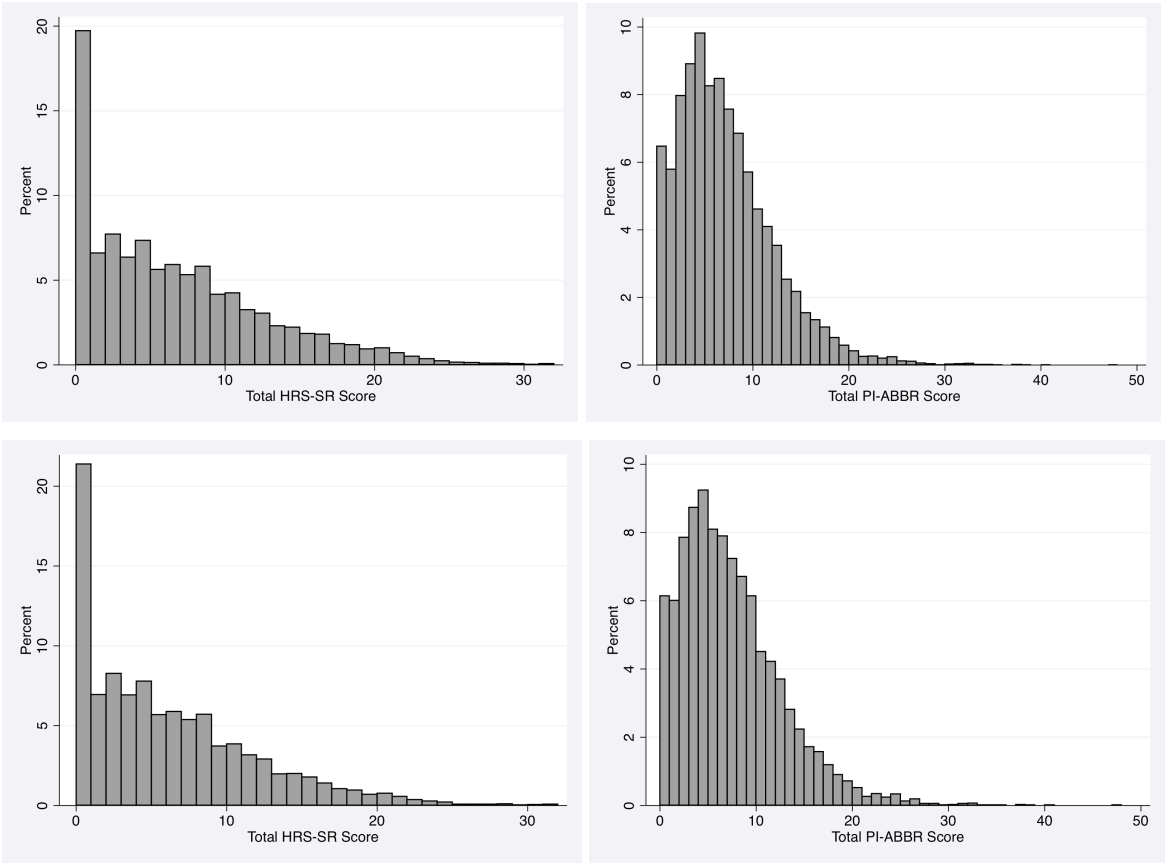
12. I touch something which I think is 'contaminated', I immediately have to wash or clean myself

0	1	2	3	4
Not at all	A little	Quite a lot	A lot	Very much

Psychometric properties of the assessment instruments: The psychometric properties of the original HRS-SR (which includes a 5th item about impairment of symptoms), were reported by Tolin et al.(Tolin *et al.*, 2010) in a clinical sample of hoarding, OCD, and control participants, and by Iervolino et al. in a population-based sample of twins(Iervolino *et al.*, 2009). The overall internal consistency of the HRS-SR was 0.97 in the clinical sample, and the test-retest and cross-context reliability was between 0.85 and 0.94 for the individual items and 0.96 for the overall measure(Tolin *et al.*, 2010). Receiver operating curve (ROC) analyses suggested good discrimination between hoarding and OCD participants for all individual items and for the total HRS-SR score (areas under the curve

or AUC between 0.93 and 0.99), and the HRS-SR was strongly correlated with other measures of hoarding(Tolin *et al.*, 2010). The optimal cutoff score as determined by Tolin et al. for the total measure was 14 to discriminate hoarding from non-hoarding participants. In the population-based twin sample, the HRS-SR had an internal consistency of 0.86, and an ROC analysis suggested a cutoff core of greater than 17 to discriminate hoarding from non-hoarding cases (sensitivity of 0.95)(Iervolino *et al.*, 2009).

The psychometric properties of the PI-ABBR are described by van Oppen et al(Van Oppen *et al.*, 1995) in a clinical sample of OCD, psychiatric control and population-based control participants. The internal consistency of the scale was 0.73, and an ROC analysis suggested good discrimination between OCD participants and psychiatric controls (AUC = 0.78) and between OCD participants and population controls (AUC = 0.93). The ROC analysis suggested that a cutoff score of 16 best discriminated between OCD and non-OCD cases, with a specificity of 0.72 and a sensitivity of 0.74(Van Oppen *et al.*, 1995).



Supplemental Figure 2: Distribution of hoarding symptoms, measured as HRS-SR scores (left panel) and obsessive compulsive symptoms, measured as total PI-ABBR scores (right panel) in the entire sample, top, and the twins-only sample, bottom. HRS-SR = Hoarding Rating Scale-Self Report. PI-ABBR = Padua Inventory-Revised, Abbreviated.

	Total HRS-SR	Total PI-ABBR	Cluttering	Discarding	Acquiring
Total HRS-SR		0.20	0.45	0.57	0.51
Total PI-ABBR			0.13	0.15	0.15
Cluttering				0.24	0.24
Discarding					0.27

Supplemental Table 2. Phenotypic correlations for hoarding symptoms and OCS total scores in the entire sample (including twins and relatives). Correlations were calculated using Kendall's tau. All correlations are significant at $p<0.00001$. The same results are obtained when the twin only sample was used.

	% female	Mean age (SD)	% with discarding scores ≥ 3	% with acquiring scores ≥ 3	% with cluttering scores ≥ 3
Hoarding only	62%	48.6 (15.9)	96%	86%	87%
Hoarding + OCS	49%	45.6 (18.6)	96%	87%	87%
OCS only	65%	35.5 (17.0)	45%	34%	25%
Neither Hoarding nor OCS	64%	41.0 (15.6)	33%	19%	14%
X^2 or F*	17.4	96.11	1.6×10^3	2.2×10^3	3.2×10^3

Supplemental Table 3: Clinical and demographic characteristics of individuals with clinically significant hoarding only (HRS-SR scores ≥ 17), clinically significant OCS only (PI-ABBR scores ≥ 16), or those with both clinically significant hoarding and OCS. *all p-values <0.001.

	MZM	**DZM**	**MZF**	**DZF**	**DOS**
cluttering	0.32	0.16	0.33	0.16	0.01
acquiring	0.22	0.19	0.22	0.11	0.04
discarding	0.38	0.19	0.36	0.18	0.11
distress	0.24	0.20	0.34	0.17	0.06

Supplemental Table 4: Twin correlations for the individual hoarding symptoms MZM = monozygotic male. DZM = dizygotic male. MZF = monozygotic female. DZF = dizygotic female. DOS = dizygotic opposite-sex.