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The relationship between age and neurocognitive and daily functioning in adults with hoarding disorder

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Abstract

Objective—Given the increase in hoarding symptoms with age, there is a pressing need for understanding the clinical features as they relate to potential interventions for older adults with hoarding disorder (HD). The aim of the current investigation was to explore age-related differences in the level of functional and cognitive impairment in individuals with HD.

Methods—The current study utilized the baseline assessments of 122 adults with HD. Age-related differences in the raw scores of psychiatric, cognitive, and daily functioning were analyzed using a series of multiple regression models controlling for the possible age-related differences in premorbid IQ.

Results—Our results suggested that older adults with HD may experience increased levels of impairment in skills related to executive functioning and everyday functioning when compared with younger adults with HD.

Conclusions—Given these difficulties with neurocognitive functioning, older HD patients may require interventions that focus more on behavioral and functional skills, rather than focusing on changing thought processes.

Keywords

hoarding disorder; aging; cognitive impairment

Hoarding behaviors are characterized by difficulty discarding, urges to save, and excessive household clutter (Frost and Hartl, 1996). Hoarding disorder (HD) is further characterized by distress or impairment, as well as the specification that the hoarding behaviors are not caused by another psychiatric (e.g., obsessive–compulsive disorder) or medical (e.g., traumatic brain injury) disorder (American Psychiatric Association, 2013). Older adults with HD report that their symptoms increased over the course of their lifespans, and there have

been no reports of spontaneous remission of hoarding symptoms in the context of HD (Dozier *et al.*, 2015). Given that hoarding symptoms may increase with age, there is a pressing need to understand the clinical features of older adults with HD.

Cognitive impairment associated with hoarding disorder

Executive dysfunction has been theorized to be a possible contributing factor to the development of hoarding behaviors since the initial conceptualization of compulsive hoarding nearly two decades ago (Frost and Hartl, 1996). The cognitive–behavioral model of compulsive hoarding theorizes that executive dysfunction may contribute to the development and maintenance of hoarding behaviors (Steketee and Frost, 2007). Impairment in categorization and problem solving may interact with a person's genetic vulnerabilities and learned core beliefs to result in increased hoarding tendencies (Steketee and Frost, 2007).

A recent review of cognitive functioning in adults with clinically significant compulsive hoarding or who met the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria for HD concluded that while multiple aspects of cognitive functioning, including problem solving, attention, memory, and organization, are definitively associated with the presence of hoarding behaviors, several additional aspects of cognitive functioning, including categorization and inhibition, are likely to be linked to hoarding behaviors but require further investigation (Woody *et al.*, 2014). Because executive functioning may predict response to psychotherapy for HD, executive functioning may be especially critical to examine in hoarding samples (Ayers *et al.*, 2012a).

Because cognitive functioning decreases with age, even in healthy older adults (van Hooren *et al.*, 2007), it is necessary to examine the association between hoarding and cognitive impairment in geriatric samples in addition to mid-life samples. Only one study reviewed by Woody *et al.* (2014) utilized a geriatric hoarding sample (e.g., Mackin *et al.*, 2011). Using a sample of individuals with late-life depression, Mackin *et al.* (2011) compared individuals with ($n = 7$) and without ($n = 45$) hoarding symptoms on a variety of executive functioning measures and found evidence of increased impairment in the hoarding group for tests related to categorization, problem solving, and information processing speed with respect to the non-hoarding group. Although not included in the review by Woody *et al.* (2014), Ayers *et al.* (2013) found differences on a test of executive functioning when comparing older adults meeting DSM-5 criteria for HD ($n = 42$) with non-psychiatric older adults ($n = 25$).

Functional impairment associated with hoarding disorder

In addition to cognitive impairment, hoarding symptoms have been linked with functional impairment and decreased quality of life. A recent systematic review by Ong *et al.* (2014) concluded that individuals with hoarding exhibit increased impairment in daily functioning, including social and occupational disability, compared with individuals in the community or those with obsessive–compulsive disorder and when controlling for the effect of psychiatric comorbidities, age, and gender. Adults with HD or hoarding problems report increased impairment in interpersonal skills, in work attendance or performance, and in their familial

relationships (Ong *et al.*, 2014). These findings held true both for middle-aged and older samples (Ong *et al.*, 2014).

Geriatric HD is associated with impairment in daily functioning. Ayers and Dozier (2014) found that hoarding symptoms were significantly associated with health and safety concerns, and over 50% of older adults meeting DSM-5 criteria for HD reported problems related to falling, fire hazards, and personal hygiene. In older adults with HD, hoarding severity is strongly associated with degree of functional disability (Ayers *et al.*, 2013) and number of serious medical conditions (Ayers *et al.*, 2014). When compared with age-matched non-psychiatric peers, older adults with HD report significantly more serious medical conditions (Ayers *et al.*, 2014) and a higher degree of impairment in activities of daily living (Ayers *et al.*, 2012b).

The aim of the current investigation was to conduct an exploratory investigation of age-related differences in the level of functional and cognitive impairment in individuals with HD while controlling for normal age-related declines in functioning. HD, a severe psychiatric diagnosis, may contribute to age-related cognitive decline. Individuals who have lived with the debilitating consequences of HD for decades would both report and demonstrate decreased functioning beyond what is expected due to normal aging. Subsequently, we hypothesized that older adults with HD would demonstrate increased levels of impairment on a variety of cognitive and functional tests compared with younger adults with HD when using age-adjusted standardized scores to control for changes accounted for by normal aging processes. This is the first investigation of age-related differences in adults with HD. Understanding the presentation of HD across the lifespan allows researchers and clinicians to more effectively treat patients with this debilitating disorder.

Methods

Participants

The current study utilized the baseline assessments of 122 adults who participated in individual ($n = 52$) or group ($n = 70$) intervention studies for HD at the VA San Diego Healthcare System. Participants ranged in age from 29 to 85 years (mean age: 62.5; $SD = 9.3$, range: 29–85). The median age was 63, and 42% of participants were aged 65 years or older. Participants were mostly female (72%) and Caucasian (82%). Participants had an average of 15.7 years of education.

All study protocols were approved by the Institutional Review Board of the VA San Diego Healthcare System, and all assessment procedures took place at the VA San Diego Healthcare System. The analysis plan was approved by the VA San Diego Healthcare System, University of California, San Diego, and San Diego State University Institutional Review Boards.

Participants were required to meet DSM-5 criteria for HD, which was assessed using a consensus diagnosis supervised by a licensed clinical psychologist, to not meet criteria for active substance use disorders or psychotic disorders, to not be actively engaged in

psychotherapy, and to have made no changes to any psychiatric medication for the previous 3 months. Participants in the individual treatment study were further required to be 60 years of age or older and to not meet criteria for bipolar I or II disorder. Further exclusion criteria for the current analyses included scoring <15 on the forced choice recognition condition of the California Verbal Learning Test-Second Edition Standard Form (CVLT-II; Delis *et al.*, 2000) or the CVLT-II Short Form, a measure of performance validity. No participants were excluded for invalid performance.

Measures

Hoarding severity and mood—The Saving Inventory-Revised (SI-R; Frost *et al.*, 2004) is a 23-item self-report measure of core HD symptoms and includes a total scale and three subscale scores: difficulty discarding, saving, and clutter. Scores range from 0 to 92, and higher scores on the SI-R indicate increased hoarding severity. Scores over 40 are considered to be clinically severe, and HD samples typically report means in the 60s (Frost and Hristova, 2011). Reliability of the SI-R in the current sample was adequate (total: $\alpha = 0.90$; clutter: $\alpha = 0.91$; saving: $\alpha = 0.83$; difficulty discarding: $\alpha = 0.83$).

The Clutter Image Rating (CIR; Frost *et al.*, 2008) is a self-reported three-item pictorial measure of clutter volume in the three main rooms of a typical home (living room, kitchen, and bedroom). The CIR has been validated in compulsive hoarding patients (Frost *et al.*, 2008) and in older adults meeting DSM-5 criteria for HD (Dozier and Ayers, 2014). Scores on the CIR range from 1 to 9 with higher scores indicating increased levels of clutter. There is high inter-rater reliability for patient and clinician scores on the CIR (Frost *et al.*, 2008; Dozier and Ayers, 2014). Reliability of the CIR in the current sample was adequate ($\alpha = 0.71$).

The Hospital Anxiety and Depression Scale (HADS; Zigmond and Snaith, 1983), a 14-item self-report measure with anxiety and depression subscales, was used to assess symptoms of depression and anxiety. Higher scores on both subscales are associated with increased psychiatric symptoms. Reliability of the HADS was adequate for both subscales (depression: $\alpha = 0.85$; anxiety: $\alpha = 0.79$).

Cognition—Cognitive functioning was assessed using the Wisconsin Card Sorting Test— 128 Items version (WCST-128; Heaton *et al.*, 1993), the Delis–Kaplan Executive Function System (D-KEFS; Delis *et al.*, 2000), the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechsler, 2008), and the computerized version of the Iowa Gambling Task (IGT; Bechara, 2007).

The WCST-128 assesses executive functioning using a card-sorting task. During the administration of the WCST-128, the participant is given a deck of cards featuring symbols that vary in color, number, and type. The participant is then instructed to place each card below one of four "key cards" and is given feedback after each card is placed as to whether the placement was correct or incorrect, without feedback of the correct matching principle. The variable of interest in the WCST-128 was total errors.

The D-KEFS assesses various aspects of cognitive functioning, including inhibition (Color–Word Interference Test), cognitive flexibility/switching (verbal fluency test and Trail Making Test), and planning (Tower Test). The verbal fluency test variables assess a participant's ability to generate words starting with different letters (letter fluency) and words belonging to different categories (category fluency), as well as the ability to switch between categories when generating words (category switching). The Trail Making Test variables assess an individual's ability to switch between numbers and letters with connecting dots (number–letter switching). The Tower Test assesses a participant's ability to replicate a configuration of various sized disks on three pegs in the fewest moves possible without violating any rules. The variable of interest in the Tower Test was the total achievement score. The Color–Word Interference Test variables assess a participant's ability to name the color of a series of words instead of reading the words (inhibition) and to switch between naming the color and reading the word (inhibition/switching).

The WAIS-IV subtests used in the current analyses included Digit Span and Letter–Number Sequencing, tests of attention and working memory, and Coding, a test of processing speed. During the Digit Span sub-test, the participant is prompted to repeat a series of digits as they were presented, in reverse order of presentation and in numerical order. In the Letter–Number Sequencing subtests, participants are prompted to repeat a series of letters and numbers in numerical and alphabetical order. The Coding subtest is a timed assessment in which participants must translate a series of numbers into symbols using a key at the top of the test booklet.

During the IGT, a test of decision-making, participants are given four decks of cards, each corresponding to an unknown rate of reward and loss and instructed to choose cards so as to maximize their gain. Decks A and B are associated with higher reward and higher loss, and decks C and D are associated with lower reward and also lower loss. The variable of interest in the IGT was the net total score.

Finally, the University of California San Diego (UCSD) Performance-Based Skills Assessment (UPSA; Patterson *et al.*, 2001) was utilized as a performance-based measure of functional capacity. The UPSA tests participants' skills related to various aspects of daily functioning, including finances, communication, comprehension/planning, transportation, and household skills. The UPSA has been successfully used to differentiate between healthy controls and individuals with mild cognitive impairment (Goldberg *et al.*, 2010) and has been recommended as a co-primary outcome measure for use in schizophrenia treatment studies (Buchanan *et al.*, 2005).

Behavior and daily functioning—The Frontal System Behavior Scale (FrSBe; Grace and Malloy, 2001) is a 46-item self-report measure with a total score and three subscales: apathy, disinhibition, and executive dysfunction. The FrSBe assesses behaviors that may be associated with frontal lobe impairment, including problems with initiation and loss of interest (apathy subscale), impulsivity and hyperactivity (disinhibition subscale), and problems related to problem solving and insight (executive dysfunction subscale). Higher scores indicate increased levels of behaviors associated with frontal lobe impairment.

Impairment in daily functioning was assessed utilizing the Activities of Daily Living Scale in Hoarding (ADL-H; Frost *et al.*, 2013), a 15-item self-report measure of functional impairment resulting from hoarding behaviors. Higher scores on the ADL-H are indicative of increased impairment. Reliability of the ADL-H in the current sample was adequate ($a = 0.92$).

Data analysis

All analyses were performed using Stata version 13.0 (StataCorp, 2013). Descriptive statistics were calculated for all variables, and data were examined for normality, missing values, and outliers. The percentage of participants with scores in the impaired range was calculated using a definition of scores outside of one standard deviation (Strauss *et al.*, 2006). This translated to a cutoff of <40 for T-scores on the IGT (demographically corrected for age, years of education, and gender) and on the WCST-128 (demographically corrected for age and years of education) and <7 for scaled scores on the WAIS-IV and D-KEFS sub-tests (demographically corrected for age). Clinically severe behavioral disturbances were established using a cutoff of >64 for T-scores on the FrSBe (demographically corrected for age, education, and gender; Grace and Malloy, 2001).

Age-related differences in the raw scores of all variables were analyzed using a series of multiple regression models controlling for the possible age-related differences in premorbid IQ using raw scores from the Wide Range Achievement Test-Fourth Edition (WRAT-4; Wilkinson and Robertson, 2006) word reading subtest. Where appropriate, the rreg command for robust regression in Stata was used to account for non-normality in the data. This command utilizes both biweighting and Huber weights and is 95% as efficient as ordinary least squares regression (Hamilton, 1991). The WRAT-4 reading raw score was selected over years of education as the control for differences in premorbid IQ because it provides a more standardized evaluation of achievement.

Because this study was designed as an exploratory investigation of multiple facets and variables related to functioning, there was no control for multiple comparisons. In not adjusting the a level, we sought to preserve the power of the analyses to tentatively detect age-related differences in functional variables. All results should be interpreted with caution and in the context of hypothesis generation.

Results

Age was not significantly correlated with raw scores from the WRAT-4 reading ($r = 0.045$, $p = 0.627$). Descriptive statistics for the psychiatric and functional variables are presented in Table 1. Participants reported high hoarding symptom severity on both the SI-R (total: 58.73, $SD = 12.31$; clutter: 24.75, $SD = 7.00$, saving: 14.63, $SD = 5.09$; difficulty discarding: 19.34, $SD = 4.18$) and on the CIR (4.12, $SD = 1.75$). Participants' scores on the ADL-H were consistent with having little difficulty with daily tasks (Table 1), but over 90% of all participants reported behavioral dysfunction on the FrSBe in the clinically severe range (total: 98%; apathy: 98%; disinhibition: 92%; executive dysfunction: 97%) (Table 1).

When controlling for premorbid IQ, age was not significantly correlated with the majority of the hoarding severity measures (all $ps > 0.05$; Table 2), with the exception of the SI-R saving subscale such that older participants reported significantly lower symptoms related to urges to save ($p < 0.01$). Scores on the HADS depression scale decreased with age ($p < 0.05$) such that older participants reported less severe depressive symptoms; however, there was no significant association between age and the HADS anxiety scale ($p > 0.05$). Age was not significantly correlated with the FrSBe total or subscale scores, with the exception of the apathy subscale, on which older participants reported significantly fewer dysfunctional behaviors ($p < 0.01$). Age was not significantly correlated with the ADL-H (Table 2).

Descriptive statistics for the cognitive variables are presented in Table 3. The majority of participants' scores were in the average range for all neurocognitive assessments, with 16% or less of participants demonstrating impaired performance on each cognitive variable (Table 3). Older participants performed significantly better on the Number–Letter Switching condition of the D-KEFS Trail Making test but performed significantly worse on the D-KEFS Tower Test total achievement and the WAIS-IV Letter–Number Sequencing when controlling for differences in academic achievement (Table 4). Age was significantly correlated with the UPSA total score, suggesting that impairment in daily tasks increases with age of participant. Age of participant was not significantly correlated with performance on the WCST-128, Digit Span, the D-KEFS verbal fluency or Color–Word Interference tests, or the IGT.

Discussion

This study represents the first investigation of age-related differences on psychiatric, neurocognitive, behavioral, and daily functioning in adults with HD and provides a background for future studies of the long-term impact of HD. We utilized a large sample ($n = 122$) of adults who met DSM-5 criteria for HD and whose ages spanned over five decades. The measures analyzed capture a wide range of functioning, including neuropsychiatric functioning, behavioral changes related to frontal lobe impairment, and performance on daily skills.

Psychiatric symptoms

Participants demonstrated moderate to severe hoarding symptoms similar to what has been reported in previous studies of both middle-aged (Frost *et al.*, 2004; Frost *et al.*, 2008) and geriatric HD patients (Dozier and Ayers, 2014). The results suggest that older HD patients report less-severe depression symptoms than do their younger counterparts, which is consistent with epidemiological studies of the effect of age on the HADS subscales (Hinz and Schwarz, 2001).

Behavior and daily functioning

Previous studies have suggested a link between compulsive hoarding and both self-reported and objectively measured impulsive behaviors (Grisham *et al.*, 2007). Over 90% of participants reported clinically severe behavioral disturbances consistent with frontal lobe impairment on the FrSBe total and subscale scores; however, participants overall

demonstrated average performance on the neurocognitive tests. Thus, there may be little relationship between actual and perceived difficulties with executive functioning problems in adults with HD. This discrepancy between actual and perceived impairment is congruent with other findings that HD patients have low insight into their symptom presentation (Tolin *et al.*, 2010; DiMauro *et al.*, 2013). Another potential issue is that the available executive functioning tests may not be sensitive enough to accurately capture the experience of individuals with HD.

Neuropsychological functioning

Older adults performed worse on the D-KEFS Tower Test and the Letter–Number Sequencing subtest of the WAIS-IV, suggesting an association between age and increased impairment in skills related to executive functioning. Older participants performed significantly better on a test of flexibility (D-KEFS Trail Making) when accounting for premorbid IQ and using age-adjusted standardized scores. This may be an artifact of utilizing a treatment-seeking sample; for example, older participants may require a higher relative degree of flexibility in order to have the motivation to seek out treatment for their hoarding behaviors. Furthermore, it is possible that the norms used to create the standardized scores for the Trail Making Test may have overcorrected in this sample due to a survivor cohort issue.

Performance on a test of daily functioning was negatively associated with age. Previous studies have noted that geriatric HD samples have a poor response to traditional cognitive–behavioral therapy for hoarding (Ayers *et al.*, 2012a), which may partially be explained by increased impairment in skills related to planning and communication. Older adults may also be less able to properly manage their finances, which could create an additional treatment barrier.

Limitations

A major limitation of the current study is the lack of longitudinal data. Future studies of the impact of HD may benefit from following participants over time. This study was designed to be an exploratory investigation of multiple aspects of psychiatric, cognitive, and daily functioning in adults with HD. As such, we decided to not control for multiple comparisons in our analyses, which may have affected the significance of our findings. We urge readers to interpret the results of the current study with caution. We intend these results to provide the background for future confirmatory studies of the relationship between age and functioning in adults with HD. The sample utilized in the current study was majority female and Caucasian and as such may have limited generalizability to the larger HD patient population.

Conclusions

Our results suggest that older HD patients may experience increased levels of impairment in skills related to executive functioning and daily functioning when compared with younger HD patients. In our sample, we found that older participants performed worse on a test of skills related to comprehension/planning, communication, financial skills, and transportation even when controlling for premorbid IQ.

Future directions and clinical implications

Future studies may want to investigate the observed discrepancy between actual and perceived difficulties with executive functioning problems, as well as investigate how this discrepancy may be affected by hoarding severity and demographic factors, such as age and education. The inflated reports of behavioral issues commonly related to executive dysfunction may be due to some of the associated features of hoarding (e.g., perfectionism, indecision, and procrastination; Timpano *et al.*, 2011). Clinicians are encouraged to follow up patient reports of executive dysfunction with formal neuropsychological testing in order to better determine the best course of treatment. Many HD participants may report problems associated with executive functioning that should be further explored with a particular emphasis in how this would impact treatment. If there truly are difficulties, any barriers to completing exposure to discarding exercises or arriving to treatment sessions on time should be resolved. Clinicians should also be aware that how they perform on performance-based tests may or may not illuminate the actual experience of patients. If undergoing a formal neurocognitive evaluation, sensitive tests rather than a global screening should be used. Geriatric HD adults may be less able to attend to and process new information. Clinicians seeking to work with geriatric HD patients should consider including compensatory cognitive training or more behavioral interventions that require less attention and cognitive flexibility than more traditional cognitive therapies.

Acknowledgments

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Key points

- Older adults with HD may experience increased levels of impairment in skills related to executive functioning and daily functioning when compared with younger adults with HD.

Table 1

Descriptive statistics of psychiatric and behavior and daily functioning variables in 122 adults with HD

			Mean (*SD*)	% Above clinical cutoff
Mood	SI-R	Total	58.73 (12.31)	—
		Clutter	24.75 (7.00)	—
		Saving	14.63 (5.09)	—
		Difficulty discarding	19.34 (4.18)	—
	CIR		4.12 (1.75)	—
	HADS	Depression	8.26 (4.43)	48.33
		Anxiety	10.01 (4.20)	67.23
Behavior and daily functioning	FrSBe	Apathy	80.74 (10.01)	97.54
		Disinhibition	82.56 (14.36)	91.80
		Executive dysfunction	80.27 (11.29)	96.72
		Total	84.97 (10.94)	98.36
	ADL-H		31.45 (11.73)	—

CIR, Clutter Image Rating; HD, hoarding disorder; SI-R, Saving Inventory-Revised; HADS, Hospital Anxiety and Depression Scale; FrSBe, Frontal System Behavior Scale (age-, education-, and gender-matched T-score); ADL-H, Activities of Daily Living in Hoarding.

Table 2

Associations among age and psychiatric and behavior and daily functioning variables in 122 adults with HD co-varying for premorbid IQ (WRAT-4 word reading)

			β (SE)	t	p
Mood	SI-R	Total	−0.12 (0.12)	−1.28	0.204
		Clutter	0.05 (0.07)	0.53	0.596
		Saving	**−0.26 (0.05)**	**−2.90**	**0.004**
		Difficulty discarding	−0.11 (0.04)	−1.23	0.223
	CIR		0.10 (0.02)	1.05	0.295
	HADS	**Depression**	**−0.22 (0.04)**	**−2.42**	**0.017**
		Anxiety	−0.13 (0.04)	−1.37	0.172
Behavior and daily functioning	**FrSBe**	**Apathy**	**−0.31 (0.12)**	**−2.77**	**0.007**
		Disinhibition	−0.12 (0.17)	1.00	0.321
		Executive dysfunction	0.014 (0.14)	0.12	0.908
		Total	−0.09 (0.13)	−0.71	0.479
	ADL–H		0.04 (0.13)	0.43	0.665

CIR, Clutter Image Rating; HD, hoarding disorder; SI-R, Saving Inventory-Revised; HADS, Hospital Anxiety and Depression Scale; FrSBe, Frontal System Behavior Scale (age-, education-, and gender-matched T-score); ADL–H, Activities of Daily Living in Hoarding; WRAT-4, Wide Range Achievement Test, Fourth Edition (Raw scores).

Table 3

Descriptive statistics of cognitive variables in 122 adults with HD

		Mean (*SD*)	% Impaired
WCST-128	Total errors	48.99 (9.18)	16.39
D-KEFS verbal fluency	Letter fluency	10.95 (3.42)	13.11
	Category fluency	11.37 (3.47)	7.38
	Category switching	11.02 (3.78)	13.11
D-KEFS Trail Making	Number–Letter Switching	10.76 (2.83)	6.56
D-KEFS Tower	Total achievement	10.83 (2.82)	6.56
D-KEFS	Inhibition	10.36 (3.25)	13.11
Color–Word Interference	Inhibition/switching	10.63 (2.96)	8.20
WAIS-IV	Letter–Number Sequencing	9.60 (2.73)	7.38
	Coding	9.80 (3.24)	11.48
	Digit span	10.26 (2.68)	6.61
IGT	Net Total	48.97 (10.60)	10.66
UPSA	Total	89.60 (6.17)	—

WCST-128, Wisconsin Card Sorting Test—128 items version (age-matched and education-matched T-scores); D-KEFS, Delis–Kaplan Executive Function System (age-matched scaled scores); IGT, Iowa Gambling Task (age-, education-, and gender-matched T-score); UPSA, UCSD Performance-Based Skills Assessment (raw scores).

Table 4

Associations among age and cognitive variables in 122 adults with HD and group differences co-varying for premorbid IQ (WRAT-4 word reading)

		β (SE)	t	p
WCST-128	Total errors	0.09 (0.09)	1.05	0.298
D-KEFS verbal fluency	Letter fluency	0.01 (0.03)	0.09	0.927
	Category fluency	−0.02 (0.04)	−0.18	0.861
	Category switching	0.04 (0.04)	0.45	0.651
D-KEFS Trail Making	**Number–Letter Switching** [*]	**0.04 (0.02)**	**2.01**	**0.047**
D-KEFS Tower	**Total achievement**	**−0.19 (0.03)**	**−2.09**	**0.039**
D-KEFS	Inhibition	−0.03 (0.03)	−0.31	0.755
Color–Word Interference	Inhibition/switching	−0.13 (0.03)	−1.40	0.163
WAIS-IV	**Letter–Number Sequencing**	**−0.26 (0.03)**	**−2.95**	**0.004**
	Coding	−0.17 (0.03)	−1.83	0.070
	Digit span	−0.14 (0.02)	−1.67	0.098
IGT	Net total	0.13 (0.11)	1.28	0.205
UPSA	**Total**	**−0.41 (0.06)**	**−3.98**	**<0.001**

WCST-128, Wisconsin Card Sorting Test—128 items version (age-matched and education-matched T-scores); D-KEFS, Delis–Kaplan Executive Function System (age-matched scaled scores); WAIS-IV, Wechsler Adult Intelligence Scale-Fourth Edition (age-matched scaled scores); IGT, Iowa Gambling Task (age-, education-, and gender-matched T-score); WRAT-4, Wide Range Achievement Test, Fourth Edition (raw scores); UPSA, UCSD Performance-Based Skills Assessment (raw scores).

[*] Robust regression was used to adjust for skew in the distribution.