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Brief Report: Using Cognitive Screeners in Autistic Adults

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Abstract

By comparing 51 autistic adults and 49 age-matched controls (aged 30–73 years) we tested if (1) the Montreal Cognitive Assessment (MoCA) is more sensitive in measuring cognitive impairments than the Mini Mental State Examination (MMSE) and (2) if we can replicate the MoCA-findings of Powell et al. (2017) with the Dutch MoCA(-NL). Results showed that: (1) The MoCA-NL is more sensitive, and (2) like Powell, no group differences were observed on the MoCA-NL. However, in contrast to Powell, we did not observe that older autistic adults show more impairment than controls on the MoCA-NL. Nonetheless, as the MoCA-NL is more sensitive to cognitive impairment, it is the recommended screener for older autistic adults.

Keywords Autism spectrum condition · Ageing · Older adults · Cognitive screening · MoCA · MMSE

In general healthcare, one can expect more and more (older) adults with an autism spectrum condition (ASC)¹ diagnosis to have questions regarding their cognitive abilities, given that studies have highlighted that the subjective report of cognitive difficulties is much higher in autistic adults in comparison to typically developing adults (Davids et al. 2016; Lever and Geurts 2015; van Heijst and Geurts 2015). Moreover, age-related neurodegenerative disorders seem to be more common in the older autistic population as compared to the general population (Hand et al. 2019). Thus, it is clinically relevant to know which screening instruments for detecting cognitive impairments are useful in older autistic adults.

Two widely used cognitive screening instruments to detect cognitive impairments are the Mini Mental State Examination (MMSE; Folstein et al. 1975) and the Montreal Cognitive Assessment (MoCA; Nasreddine et al.

2005). Both consist of a short paper-and-pencil test that cover multiple cognitive functions and are frequently used in healthcare settings to screen for cognitive problems. The MMSE focusses mostly on memory, language, and orientation (Folstein et al. 1975). The MoCA focusses on attention and executive functioning² (Nasreddine et al. 2005) in addition to the three aforementioned cognitive domains. Moreover, the MoCA has better psychometric properties (e.g., test-retest reliability MoCA: $r = .94$; Nasreddine et al. 2005; vs. MMSE: $r = .38$ to $.84$; Tombaugh and McIntyre 1992). The MoCA also trumps the MMSE in its sensitivity to detect cognitive impairments as the MoCA seems to detect milder changes in cognition in various conditions like dementia (Hsu et al. 2015), Parkinson's (Hoops et al. 2009) and schizophrenia (Wu et al. 2014). Taking these results into account, one can hypothesize that adults who do not (yet) show difficulties on the MMSE could display cognitive impairments on the MoCA. Therefore, our first goal was to test if the MoCA is also the preferred screening instrument in autistic adults. We tested if autistic adults who scored within the normal range on the MMSE might already show cognitive difficulties on the MoCA.

Objective measurements suggest that autistic adults might encounter more cognitive challenges due to a different 'cognitive style' (i.e., processing bias; Happé and Frith 2006)

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¹ The formal term following the DSM is *Autism Spectrum Disorder*. However, we chose the term ASC in accordance with UK practice.

² Executive functions are an umbrella term used to describe several cognitive skills required to start, change and stop (complex) behaviour (Ozonoff et al. 2004).

but, so far, findings regarding age-related cognitive differences in test performance are rather inconsistent (Abbott et al. 2018). In general, it seems that autistic adults have a so-called “old” cognitive profile, i.e. middle-aged autistic adults perform similar to older typically-developing adults on cognitive tests (Bowler 2006). Moreover, it has been argued that executive functioning will be most sensitive for accelerated cognitive decline in autistic adults (Walsh et al. 2019; Abbott et al. 2018). The first step to evaluate cognitive functioning is often to administer a cognitive screener, such as the MMSE or MoCA, instead of a full cognitive test battery. So far, the MoCA has only been tested in autistics adults once; Powell et al. (2017) tested if IQ, age, diagnosis, and the age-by-diagnosis interaction predicted performance. Results showed that age, but not IQ, predicted performance in autistic adults in such a way that older autistic adults showed larger cognitive impairments than typically-developing adults. However, younger autistic adults (< 45 years) performed similar to controls. The second goal of this study was to replicate the findings of Powell et al. (2017) with a larger sample size.

Methods

Participants

A total of 51 individuals with a formal DSM-IV or DSM-5 ASC diagnosis (aged 30 to 73 years) and 49 age- and gender-matched adults without ASC were recruited for this study. All diagnoses were determined by experienced clinicians in a multidisciplinary team. All participants took part in a large-scale study; details regarding recruitment and selection criteria can be found in previous publications (Koolschijn and Geurts 2016; Lever and Geurts 2015). In short, to confirm the clinical ASC diagnosis, the autistic adults needed to score above the cut-off (> 7) on the Dutch Autism Diagnostic Observation Schedule (ADOS-NL; De Bildt and de Jonge 2008) and/or score above the cut off (> 26) on the Dutch Autism-spectrum Quotient (AQ-NL; Hoekstra et al. 2008). Exclusion criteria: (1) a self-reported history of neurological disorders (e.g., epilepsy, stroke), schizophrenia or having experienced more than one psychosis; (2) current alcohol or drugs dependency; (3) an estimated IQ below 80 based on the Vocabulary and Matrix Reasoning subtests of the Dutch Wechsler Adult Intelligence Scale 3th edition (WAIS-III-NL; Uterwijk 2000; administered in this study); (4) an MMSE score < 26 (to ensure that all participants scored ≥ 26 in line with the study design). For the comparison group (controls), additional exclusion criteria were: (1) a clinical

diagnosis of ASC and/or ADHD; (2) ASC or schizophrenia in close family members; and (3) an AQ score > 32.

Materials

MMSE-NL (Kok and Verhey 2002)

This test (duration 5 to 10 min) consists of 30 items addressing five cognitive domains: orientation (10 items), memory (6 items), attention (5 items), language (8 items) and visuo-construction (1 item). The internal consistency of the total MMSE-scores ranges from .54 to .96 (Cronbach’s alpha). The test-retest reliability for the original MMSE after a month ranges from $r = .38$ to $.84$ (Tombaugh and McIntyre 1992). While there is no published reliability data available for the MMSE-NL, it can discern the difference between healthy elderly participants and dementia patients (Wind et al. 1997).

MoCA-NL (Dautzenberg and de Jonghe 2004)

The MoCA (duration 10 to 15 min) consists of 30 items that cover six cognitive domains: orientation (6 points), memory (5 points), attention/working memory (5 points), language (6 points), visuo-construction (4 points) and executive functioning (4 points). The test-retest reliability of the original MoCA after approximately a month is high, $r = .92$, and the internal consistency is good, yielding a Cronbach alpha of .83 (Nasreddine et al. 2005). The MoCA-NL test-retest reliability ranges from good (ICC = .64) to excellent (ICC = .82, Bruijnen et al. 2020). The MoCA-NL has proven to be a valid instrument for distinguishing typical ageing, Mild Cognitive Impairment (MCI), and dementia (Thissen et al. 2010). For both the MMSE-NL and the MoCA-NL, the maximum score is 30. Scores below 26 indicate cognitive impairment (Crum et al. 1993; Nasreddine et al. 2005). Please note that Powell and colleagues used a lower score as the cut-off, but, to answer our main question regarding enhanced sensitivity of the MoCA-NL, we followed the official guidelines.

Procedure

Study protocols were approved by the local ethical committee of the department of Psychology of the University of Amsterdam (2011-PN-1952, 2013-PN-2668). All participants were briefed about the purpose of the study, provided written informed consent, and received compensation for their travel expenses. Most controls received additional compensation (max €20). A large battery of neuropsychological

Table 1 Means (Standard Deviations) and of the Demographic and Clinical Scores of the ASC and COM Group and Test Statistics of the MMSE-NL and MoCA-NL

	ASC ^a (n=51)	COM ^b (n=49)	Test-statistic	Bayes Factor
Age	51.46 (12.61)	50.14 (11.93)	$t(98) = .54, p = .59, d = .11$	–
Gender	35 M/ 16 F	32 M/ 17 F	Fisher's test, $p = .83$	–
Educational Level ^a	1/16/34	1/11/37	Fisher's test, $p = .72$	–
Estimated IQ	116.31 (16.21)	111.59 (15.78)	$t(98) = 1.48, p = .14, d = 2.09$	–
Diagnosis ^b	6/28/17	–	–	–
Age of Diagnosis ^c	45.89 (13.84)	–	–	–
AQ-NL total score	36.22 (6.52)	12.94 (5.89)	$t(98) = 18.71, p < .001, d = 3.75$	–
ADOS-NL total score	7.94 (3.31)	–	–	–
MMSE-NL total score	29.18 (.95)	28.98 (1.11)	$t(98) = -.95, p = .34, d = .29$	$BF_{01} = 3.17, BF_{10} = 0.316$
MMSE-NL < 26	0	0	–	–
MoCA-NL total score	27.80 (2.10)	27.94 (1.71)	$t(98) = .71, p = .48, d = .10$	$BF_{01} = 3.80, BF_{10} = 0.034$
MoCA-NL < 26 (%)	8 (15.68)	4 (8.16)	Fisher's test, $p = .20$	–

ASC = Autism Spectrum Condition, COM = Comparison Group, AQ = Autism-spectrum Quotient, ADOS = Autism Diagnostic Observation Schedule. MMSE = Mini-Mental State Examination, MoCA = Montreal Cognitive Assessment. Cohen's d effect size

^aLow/middle/high

^bThe numbers between brackets indicate a DSM-IV or DSM-5 diagnosis of Autism/Asperger/Pervasive Developmental Disorder Not Otherwise Specified

^cOne participant was diagnosed when 11 years old, all others were diagnosed after the age of 22

tests was administered in three sessions at the university (Session 1: ADOS-NL, MMSE-NL and WAIS-III-NL; Session 3: MoCA-NL; Time-interval between Session 1 and 3 is 0 to 22 months ($M = 5$ months, $SD = 5$ months)). Data were collected between March 2012 and July 2014.³

Statistical Analyses

Because the scores of the MoCA-NL and MMSE-NL were not normally distributed, data was analysed with parametric and non-parametric tests. Only parametric tests results are reported unless test results differed. A significance level of $p < .05$ was applied. Additionally, we used Bayesian statistics with a prior of one to determine the robustness of the effects. Because we anticipated to observe null effects, it was important to determine if the data were indeed best explained by the null hypotheses, or whether the statistical method was insensitive. The Bayes factor (BF_{01}) shows evidence in favour of the null hypothesis H_0 , rather than the alternative hypothesis H_1 . $BF_{01} < 3$ indicates anecdotal evidence for H_0 over H_1 , between 3 and 10 substantial evidence, 10–30 strong evidence and > 30 very strong evidence. BF_{10} shows evidence in favour of H_1 over H_0 . Bayesian analyses were conducted in JASP 0.11.1, all other analyses

were calculated using SPSS 24. To avoid inconsistencies, all results were validated using Statcheck (Rife et al. 2016).

Results

Demographic and clinical characteristics (age, gender, educational level, scores on the AQ-NL and ADOS-NL), and test statistics are shown in Table 1.

Can the MoCA-NL Detect Cognitive Impairment, When the MMSE-NL Does Not?

The first goal was to test if people who score within the normal range on the MMSE-NL show cognitive impairment on the MoCA-NL. A McNemar's test determined that there was a significant difference in the proportion of people who scored under the cut-off score for the MMSE-NL (none of the participants) in comparison with the MoCA-NL for autistic adults only, $p < .01$, but not for the comparison group, $p = .13$. Possible time effects were ruled out as the time interval between tests did not differentially predict the MoCA-NL scores, for autistic adults ($\beta = -.003, p = .14$) or non-autistic adults ($\beta = .006, p = .06$).

³ Note that both the MMSE-NL and MoCA-NL were reported upon in previous studies (i.e., Lever and Geurts 2015; Koolschijn and Geurts 2016) as these were used as inclusion criteria for these studies' main focus (i.e., cognitive profiling and neuroimaging).

Table 2 Regression Analyses' Statistics for the Shortened and Regular MoCA-NL

		β	p	adj R^2	F	$p - F$ model
Shortened MoCA-NL ^a	Estimated IQ	.42	< .01	.16	18.92	<.01
	Age	-.07	.60	.01	.70	.40
	Diagnosis	-.15	.11	.02	2.62	.11
	Age-x-diagnosis	.00	.97	<.01	.00	.98
Regular MoCA-NL	Estimated IQ	.37	<.01	.13	15.03	<.01
	Age	-.39	<.01	.08	10.12	<.01
	Diagnosis	-.11	.23	.01	1.46	.23
	Age-x-diagnosis	.15	.26	.01	1.30	.26

Note that the Bayes Factor is not reported here because we solely tested the strength of hypothesized predictors for the post-hoc tests (see text for further explanation)

^aShortened MoCA is without the delayed recall items, as was done by Powell et al. (2017)

Do Autistic Adults Perform Different on the MMSE-NL and MoCA-NL than the Comparison Group?

There was neither a difference between autistic adults and the comparison group in MMSE-NL and MoCA-NL scores nor on the number of individuals scoring below the cut-off. Bayesian analyses indicated substantial evidence in favour of the former null finding, indicating that it was more than three times more likely that the data derived from H_0 as from H_1 (see Table 1).

Can We Replicate the Findings of Powell et al. (2017)?

To test whether we could replicate the results of Powell et al. (2017), identical predictors for the regression analyses were used; estimated IQ (ASC range: 86–155, controls range: 80–141), age (mean-centered), diagnosis and age-by-diagnosis interaction. Because Powell and colleagues excluded the delayed recall items (consisting of a maximum of 5 points), the regression analysis was run twice; once to mimic Powell and once with the regular MoCA-NL (Table 2).

When excluding the delayed recall items from the regression analyses (similar to Powell et al. 2017), we found that estimated IQ was a significant positive predictor. However, neither age and diagnosis nor their interaction did explain a significant part of the variance. When using the regular MoCA-NL total score as the outcome, both estimated IQ and age were significant predictors, whereas diagnosis and the age-by-diagnosis interaction were not. Given the lack of an interaction effect, no follow-up analyses were conducted. However, the strength of the predictors when following Powell's post-hoc tests was explored using Bayesian statistics in the next section.

How Strong are the Effects of Age and IQ as Predictors? An Exploratory Bayesian Analysis

We were interested in how strong the hypothesized predictors would be and explored this using Bayesian regression analyses. We, therefore, analysed the strength of the hypothesized predictors' effects (by Powell et al. 2017) per group compared to the null hypothesis. First, for the shortened MoCA-NL, there was extremely strong evidence for IQ as a predictor in the ASC group [BF10 = 300.66], whereas there was only anecdotal evidence for IQ as a predictor in the comparison group [BF10 = 1.77]. Regarding age, there was anecdotal evidence against age as predictor in both the ASC group [BF01 = 2.99] and the comparison group [BF01 = 2.91]. These findings suggest that IQ but not age contributed to the shortened MoCA-NL scores in both groups.

Second, for the regular MoCA-NL there was strong evidence for IQ as a predictor in the ASC group [BF10 = 24.76], whereas there was only anecdotal evidence for IQ as a predictor in the comparison group [BF10 = 2.04]. However, there was anecdotal evidence against age in the ASC group [BF01 = 1.59] and strong evidence for age as a predictor in the comparison group [BF10 = 26.38]. These findings suggest that while IQ seemed to predict the regular MoCA-NL scores for both groups, age only predicted regular MoCA-NL scores in the comparison group.

Discussion

The first goal was to examine performance on two commonly used cognitive screeners to test if autistic adults who do not show cognitive impairments on the MMSE-NL score below the cut-off score on the MoCA-NL. Results showed that some autistic adults did score below the cut-off score of the MoCA-NL but did not score below the cut-off on

the MMSE-NL. Also, there was slightly more variance on the MoCA-NL, suggesting that subtle cognitive dysfunctions may be detected earlier by the MoCA-NL than the MMSE-NL. This fits well with the known better psychometric properties of the MoCA (Hsu et al. 2015; Wu et al. 2014; Hoops et al. 2009). Moreover, the enhanced performance of the MoCA can be explained by the fact that the MoCA focuses on a broader spectrum of cognitive domains than the MMSE, including executive functions and visuospatial ability. These cognitive domains are of special relevance for autistic adults as below-average executive functions and above-average visuospatial abilities are commonly observed in autistic people. When measuring the effects of cognitive ageing in autistic adults, these cognitive domains need to be included (Lever and Geurts 2015). Furthermore, in the cognitive domains that are similar on the MMSE, the MoCA has a larger number of delayed-recall items and a longer delay, which makes it a more difficult task with higher rate of lower-scoring participants. Therefore, when screening autistic older adults for cognitive dysfunctions, the MoCA seems the preferred option. Moreover, based on our findings, we see no reason to adjust the advised used cut-off for the general population. Powell et al. (2017) used a different cut-off score off <21 for autistic adults to account for possible lower scores due to executive dysfunctioning. Using a similar cut-off score as Powell, all of the autistic adults in our sample would score in the normal range. However, we found no evidence that autistic adults scored structurally different than the comparison group on the MoCA-NL, which suggests that adjusting the cut-off score is not necessary.

The second goal was to test if we could replicate previous findings in this larger sample, namely that (1) autistic adults and controls have similar MoCA scores, (2) IQ does not predict MoCA scores, and (3) older autistics adults show more progressive impairment than controls (Powell et al. 2017). We replicated the first finding (1), but, in contrast, we found that (2) IQ was a significant predictor for the shortened and regular MoCA-NL, with lower IQ scores being associated with lower MoCA-NL scores. This is in line with prior research demonstrating an association between IQ and MoCA performance in patients with MCI, Alzheimer's dementia and in the general population (Alves et al. 2013). Moreover, we found that (3) when following Powell and colleagues in dismissing the delayed recall items, age had no effect on MoCA-NL scores. Interestingly, when we included the memory items (i.e. regular MoCA-NL) age *did* predict MoCA-NL scores with higher age being related to lower MoCA-NL scores. Given that the first symptom for the presence of MCI often is memory impairment (Petersen 2000); excluding memory-related items in an able and relatively young sample might diminish the possibility to detect milder cognitive changes. Our results based on a larger

(but still modest) sample size that contradicts Powell's findings together with our Bayesian explorations showing evidence against age as predictor for the MoCA-NL in autistic adults suggests that chance is a potential explanatory factor for the findings reported in Powell et al. (2017).

Our study was not without caveats. First, results are based on a smart (estimated IQ $M = 116.3$) and highly educated sample of autistic adults and findings may not be applicable to a cognitively less able or lower educated population. Second, the age of diagnosis was relatively high, with nearly all adults (except for one) receiving their diagnosis in adulthood by a multidisciplinary team of experienced clinicians. Note that adult samples with a large portion of women and higher intelligence often receive their diagnosis later in life (Brugha et al. 2011), possibly through the development and use of compensatory mechanisms to overt ASC-difficulties (for a detailed discussion of this topic see Koolschijn and Geurts 2016). Third, our results are cross-sectional and we, therefore, cannot make inferences regarding the predictive value of these cognitive screeners over time.

In conclusion, this study was the first to examine the performance of individuals with ASC on two frequently used cognitive screeners. We conclude that there is no difference in performance between people with and without an ASC on the MMSE-NL or MoCA-NL. However, similar to prior findings based on comparisons between the MMSE and MoCA, the MoCA-NL was more sensitive to detect cognitive dysfunctioning, potentially proving better clinical utility as a screener for this population.

Author Contributions All authors contributed to the study conception and design. Material preparation and data collection were performed by AGL and CK. The first draft of the manuscript was written by IG and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval Study protocols were approved by the local ethical committee of the department of Psychology of the University of Amsterdam (2011-PN-1952, 2013-PN-2668).

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

- Abbott, P., Happé, F. G., & Charlton, R. A. (2018). Exploratory study of executive function abilities across the adult lifespan in individuals receiving an ASD diagnosis in adulthood. *Journal of Autism and Developmental Disorders*, 48(12), 4193–4206.
- Alves, L., Simões, M. R., Martins, C., Freitas, S., & Santana, I. (2013). Premorbid IQ influence on screening tests' scores in healthy patients and patients with cognitive impairment. *Journal of Geriatric Psychiatry and Neurology*, 26(2), 117–126.
- Bowler, D. M. (2006). *Autism Spectrum disorder. Psychological theory and research*. Chichester: Wiley.
- Brugha, T. S., McManus, S., Bankart, J., Scott, F., Purdon, S., Smith, J., et al. (2011). Epidemiology of autism spectrum disorders in adults in the community in England. *Archives of General Psychiatry*, 68(5), 459–465.
- Bruijnen, C. J., Dijkstra, B. A., Walvoort, S. J., Budy, M. J., Beurmanjer, H., De Jong, C. A., & Kessels, R. P. (2020). Psychometric properties of the Montreal Cognitive Assessment (MoCA) in healthy participants aged 18–70. *International Journal of Psychiatry in Clinical Practice*, 24, 293–300.
- Crum, R., Anthony, J., Bassett, S., & Folstein, M. (1993). Population-based norms for the Mini-Mental State Examination by age and educational level. *JAMA: The Journal of the American Medical Association*, 269(18), 2386–2391.
- Dautzenberg, P. L. J., de Jonghe, J. F. M. (2004). *Montreal Cognitive Assessment: afname- en scoringinstructies*.
- Daids, R. C., Groen, Y., Berg, I. J., Tucha, O. M., & van Balkom, I. D. (2016). Executive functions in older adults with autism spectrum disorder: Objective performance and subjective complaints. *Journal of Autism and Developmental Disorders*, 46(9), 2859–2873.
- De Bildt, A., & de Jonge, M. V. (2008). *Autisme Diagnostisch Observatie Schema*. Amsterdam: Hogrefe.
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-Mental State": A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12(3), 189–198.
- Hand, B. N., Angell, A. M., Harris, L., & Carpenter, L. A. (2019). Prevalence of physical and mental health conditions in Medicare-enrolled, autistic older adults. *Autism*, 24(3), 755–764.
- Happé, F., & Frith, U. (2006). The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 36, 5–25.
- Hoekstra, R. A., Bartels, M., Cath, D. C., & Boomsma, D. I. (2008). Factor structure, reliability and criterion validity of the autism-spectrum quotient (AQ): A study in Dutch population and patient groups. *Journal of Autism and Developmental Disorders*, 38(8), 1555–1566.
- Hoops, S., Nazem, S., Siderowf, A. D., Duda, J. E., Xie, S. X., Stern, M. B., & Weintraub, D. (2009). Validity of the MoCA and MMSE in the detection of MCI and dementia in Parkinson disease. *Neurology*, 73(21), 1738–1745.
- Hsu, J. L., Fan, Y. C., Huang, Y. L., Wang, J., Chen, W. H., Chiu, H. C., & Bai, C. H. (2015). Improved predictive ability of the Montreal Cognitive Assessment for diagnosing dementia in a community-based study. *Alzheimer's Research & Therapy*, 7(1), 1–8.
- Kok, R. M., & Verhey, F. R. J. (2002). *Dutch translation of the Mini Mental State Examination*.
- Koolschijn, P. C. M., & Geurts, H. M. (2016). Gray matter characteristics in mid and old aged adults with ASD. *Journal of Autism and Developmental Disorders*, 46(8), 2666–2678.
- Lever, A. G., & Geurts, H. M. (2015). Age-related differences in cognition across the adult lifespan in autism spectrum disorder. *Autism Research*, 9(6), 666–676.
- Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., et al. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, 53(4), 695–699.
- Ozonoff, S., Cook, I., Coon, H., Dawson, G., Joseph, R. M., Klin, A., et al. (2004). Performance on Cambridge neuropsychological test automated battery subtests sensitive to frontal lobe function in people with autistic disorder: Evidence from the collaborative programs of excellence in autism network. *Journal of Autism and Developmental Disorders*, 34(2), 139–150.
- Petersen, R. C. (2000). Mild cognitive impairment: Transition between aging and Alzheimer's disease. *Neurologia*, 15(3), 93–101.
- Powell, P. S., Klinger, L. G., & Klinger, M. R. (2017). Patterns of age-related cognitive differences in adults with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 47(10), 3204–3219.
- Rife, S. C., Nuijten, M. B., Epskamp, S. (2016). *Statcheck: Extract statistics from articles and recompute p-values* [web application]. Retrieved from <http://statcheck.io>.
- Thissen, A. J., Van Bergen, F., De Jonghe, J. F., Kessels, R. P., & Dautzenberg, P. L. (2010). Applicability and validity of the Dutch version of the Montreal Cognitive Assessment (MoCA-d) in diagnosing MCI. *Tijdschrift voor Gerontologie en Geriatrie*, 41(6), 231–240.
- Tombaugh, T. N., & McIntyre, N. J. (1992). The Mini-Mental State Examination: A comprehensive review. *Journal of the American Geriatrics Society*, 40(9), 922–935.
- Uterwijk, J. (2000). *WAIS-III Nederlandstalige bewerking. Technische handleiding*. Lisse: Swets & Zeitlinger.
- van Heijst, B. F., & Geurts, H. M. (2015). Quality of life in autism across the lifespan: A meta-analysis. *Autism*, 19(2), 158–167.
- Walsh, M. J., Baxter, L. C., Smith, C. J., & Braden, B. B. (2019). Age group differences in executive network functional connectivity and relationships with social behavior in men with autism spectrum disorder. *Research in Autism Spectrum Disorders*, 63, 63–77.
- Wind, A. W., Schellevis, F. G., Van Staveren, G., Scholten, R. J., Jonker, C., & Van Eijk, J. T. M. (1997). Limitations of the Mini-Mental State Examination in diagnosing dementia in general practice. *International Journal of Geriatric Psychiatry*, 12(1), 101–108.
- Wu, C., Dagg, P., & Molgat, C. (2014). A pilot study to measure cognitive impairment in patients with severe schizophrenia with the Montreal Cognitive Assessment (MoCA). *Schizophrenia Research*, 158(1), 151–155.

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