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Neuropsychological deficits in adults age 60 and above with attention deficit hyperactivity disorder

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ABSTRACT

Objective: Neuropsychological deficits are of major importance in ADHD, yet no previous studies have assessed clinically referred samples of older adults. The authors compared older adults with ADHD (60–75 years) with both younger adults with ADHD (18–45 years) and older healthy controls with regard to various neuropsychological deficits.
Methods: Well-established tests were used to investigate working memory, inhibition, switching, planning, fluency, and speed of processing. Self-ratings of executive functioning and delay-related behaviors were also included. Both variable-oriented and person-oriented analyses were conducted.
Results: Older adults with ADHD differed from controls with regard to working memory, inhibition, switching, and delay-related behaviors. In comparison to younger adults with ADHD, they performed at a similar level with regard to working memory and planning, but significantly better with regard to inhibition, switching, fluency, speed of processing, and delay aversion. Despite several significant group differences relative to controls, person-oriented analyses demonstrated that a majority of older adults with ADHD performed within the average range on each test and 20% showed no clear deficit within any neuropsychological domain.
Conclusions: The results are in line with models of heterogeneity that have identified different neuropsychological subtypes in ADHD as well as a subgroup of patients without any clear neuropsychological deficits. For older adults with ADHD, it will be important to assess their functioning across time as normal aging is related to memory decline and these patients could therefore end up with severe deficits as they grow older, which in turn could have serious negative effects on daily life functioning.

1. Introduction

Neuropsychological deficits have been shown to be of major importance in attention deficit hyperactivity disorder (ADHD) in both childhood [1] and adulthood [2]. However, no previous studies have addressed this issue in a clinically referred sample of individuals with ADHD above 60 years of age. The overall aim of the present study was therefore to investigate neuropsychological deficits among older adults with ADHD and compare them to both healthy controls in the same age range and younger adults with ADHD. More specifically, the present study focused on deficits in executive functions (i.e., working memory, inhibition, switching, and planning), delay-related behaviors (i.e., the tendency to choose smaller immediate rewards over larger rewards that involve waiting), verbal fluency, and speed of processing. Studying neuropsychological deficits in older adults with ADHD should be considered an important topic, as we know from previous research that ADHD persists into older adulthood with prevalence rates of 2.8–3.3% [3,4]. Older ADHD patients have also been shown to have similar impairments as younger adults with ADHD such as higher rates of comorbid depression, anxiety and perceived somatic health [5], as well as lower educational levels, higher rates of divorce, and more loneliness [6].

With regard to neuropsychological functioning, studies of younger adults have shown that ADHD is associated with deficits in executive functioning such as working memory, inhibition and switching [2,7]. In line with the dual pathway model [8], links have

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also been found between ADHD and delay-related behaviors [9,10], although results are more inconsistent compared to those found for executive functioning [11]. Only one previous study [12] has investigated neuropsychological functioning in older adults with ADHD, and this study used a population-based sample and a lower cut-off for ADHD symptom levels (i.e., 4 symptoms of hyperactivity/impulsivity or inattention) than what is used in the DSM-5 [13]. The result of this study showed a significant group difference only for working memory, which did not remain significant when controlling for comorbid depression. More studies are clearly needed, especially as the sample included few cases in the ADHD group ($n = 23$), more complex executive functions such as switching and planning were not included, and this study did not report measures of diagnostic sensitivity (i.e., the proportion of correctly classified ADHD patients based on the neuropsychological measures) and specificity (i.e. the proportion of correctly classified controls). In studies of younger adults with ADHD, the sensitivity of neuropsychological measures has proven to be relatively poor [11,14] – a fact being interpreted as support for models of heterogeneity that argue that individuals with ADHD vary substantially with regard to their neuropsychological deficits [1,15]. One population-based study using a dimensional measure of ADHD symptoms rather than investigating group differences, showed that associations between symptom severity and neuropsychological functioning were less consistent among older compared to middle-aged adults [16]. This points to the importance of comparing older adults with ADHD not only to healthy controls but also to younger adults with ADHD.

In order to address the limitations of the previous studies described above, the aim of the present study was to investigate a range of different neuropsychological deficits in a clinically referred sample of older adults (60–75 years of age) with ADHD, healthy controls of the same age, and younger adults (age 18–45 years of age) with ADHD. We complemented our study of mean group differences with person-oriented analyses to allow for the identification of neuropsychological subgroups.

2. Method

2.1. Participants and procedure

The study included 158 participants in three groups:

- older adults (60–75 years of age) diagnosed with ADHD ($n = 44$);
- healthy controls of the same age ($n = 58$);
- younger adults (18–45 years of age) with ADHD ($n = 56$).

Adults with ADHD were recruited from outpatient psychiatric units in Stockholm specialized in neuropsychiatric disorders and they all met the full diagnostic criteria according to DSM-5 [13] as assessed by trained psychologists/psychiatrists. The diagnostic assessment included a detailed anamnesis, and standardized rating instruments. Information was collected from both the patient him-/herself and a significant other (i.e., a partner, parent, or sibling). As patients were recruited from several different clinics, not all participants were assessed using exactly the same instruments. All patients in the younger ADHD group and 18% of the patients in the older ADHD group were assessed using the second version of the Diagnostic Interview for ADHD in Adults (DIVA 2.0; [17]). This semi-structured clinical interview includes assessment of ADHD symptoms and impairment in five areas of functioning (i.e., education, work, family, social/relationships, and self-confidence) in childhood and at the present time. With regard to standardized rating instruments, childhood ADHD symptom levels were assessed using the Childhood Symptom Scale [18], the Brown Attention Deficit Disorder Rating Scale (Brown ADD-RS; [19]) or the Wender Utah Rating Scale (WURS; [20]). ADHD symptom levels in adulthood were assessed using the 18-item version of the Adult ADHD Self-Report Scale (ASRS; [21]). Comorbid symptoms were assessed using the Mini International Neuropsychiatric Interview (M.I.N.I.; [22]). If comorbid symptoms were identified during this structured interview, it was complemented with one or several standardized rating instruments, depending on the identified symptoms. Finally, current symptom levels were also assessed within the present study using self-ratings on the ASRS [21] and all participants were found to meet the symptom criteria for ADHD according to DSM-5 [13].

Exclusion criteria for both clinical groups were:

- an IQ score < .70 on the Wechsler Adult Intelligence Scale (WAIS-IV [23]);
- ongoing substance-related disorders;
- the presence of a serious neurological disorder such as Parkinson's disease, amyotrophic lateral sclerosis (ALS), multiple sclerosis (MS), or dementia.

Among the older adults, we also collected information about several aspects that are relatively common among older adults, as they could affect cognitive performance and therefore would need to be taken into consideration in the analyses:

- a score of < 24 on the Mini Mental State Examination (MMSE [24]), which is indicative of cognitive decline;
- ongoing (i.e., during testing) migraine/severe headache, chronic or acute pain, severe physical disabilities, or seriously impaired vision after correction;
- current use of neuroleptic, sedative, anxiolytic, or antiepileptic drugs.

None of the participants (i.e., healthy controls or ADHD patients) who had agreed to participate in the study were found to have problems related to the aspects mentioned above. Among older adults with ADHD, 22 patients were on stimulant medication, but withdrew the medication for at least 24 hours prior to testing. One patient was on non-stimulant medication (i.e., Atomoxetine). In the younger ADHD group, 38 patients were on stimulant medication, and 20 of these patients withdrew the medication for 24 hours. The remaining 18 patients were on medication during testing. However, results were very similar for both the variable- and person-oriented analyses when excluding these patients.

Healthy controls were recruited through local health care clinics and local organizations for senior citizens. Exclusion criteria were the same as described above as well as the presence of any psychiatric disorder. The controls did not differ significantly from the older ADHD group on the MMSE, $t = .88$, *ns*. Participants provided written informed consent after receiving a complete description of the study and the local ethics committee approved the study. All participants received approximately 70 Euros for taking part in the study.

Descriptive statistics are presented in Table 1. The two groups including older adults did not differ with regard to age, $t = 0.53$, *ns*, and the three groups did not differ regarding male–female ratio, $\chi^2 = 0.41$, *ns*, or general intellectual functioning (assessed using the Block Design Subtest from the WAIS-IV [23]), $F = 2.17$, *ns*. However, significant group differences were found for educational level, $F = 55.35$, $P < .001$, with the healthy controls showing the highest educational level and the younger adults with ADHD the lowest.

2.2. Measures of neuropsychological deficits

We used neuropsychological tests from the Delis-Kaplan Executive System (D-KEFS; [25]) and the WAIS-IV [23]. Raw scores

Table 1
Descriptive data for background variables, ADHD symptom levels, comorbid diagnoses, and general intellectual functioning.

	ADHD older adults (n = 44) M (SD)	ADHD younger adults (n = 56) M (SD)	Healthy older controls (n = 58) M (SD)
Background variables			
Age (years)	65.09 (3.52)	26.86 (5.93)	65.52 (4.40)
Gender (% men)	43.2%	42.9%	48.3%
Educational level (%)			
Min requirement (≤ 9 years)	9.1	38.8	4.9
High school	29.5	55.1	21.3
University/college	61.4	6.1	73.8
ADHD symptom levels			
Hyperactivity/impulsivity	3.13 (0.73)	3.49 (0.70)	1.97 (0.49)
Inattention	3.48 (0.68)	3.81 (0.54)	2.26 (0.50)
Comorbid diagnoses (%)			
Depression	31.8	17.8	0
Anxiety disorders	15.9	5.3	0
Bipolar disorder	6.8	5.3	0
Social phobia	0	1.7	0
Panic disorder	0	3.5	0
Personality disorders	0	7.0	0
Autism spectrum disorders	2.2	0	0
General intellectual functioning			
WAIS - block design task	10.05 (2.60)	9.46 (2.75)	10.61 (3.04)
Mini-Mental State Examination	28.47 (1.40)	n.a.	28.72 (1.24)

n.a.: not available.

were converted into scaled scores (i.e., age-adjusted scores) to allow for comparison between participants of different ages. *Working memory* was measured using the backward and sequencing condition from the Digit Span Test and the Letter-Number Sequencing Test, both taken from the WAIS-IV. *Inhibition* was investigated using completion time on the third subtest (i.e., interference trial) of the Color-Word Interference Test from the D-KEFS. Switching was measured using the fourth subtest (i.e., shifting trial) from the Color Word Interference Test and planning was assessed using the total achievement score from the Tower Test, both from the D-KEFS. Verbal fluency was measured using mean number of words for letter and semantic fluency. Speed of processing was measured using the mean reaction time for Trial 1 (i.e., naming colors) and Trial 2 (i.e., reading words) from the Color-Word Interference Test from the D-KEFS. Finally, we used two self-rating instruments. Delay-related behaviors were measured using the 10-item "Quick Delay Questionnaire" (QDQ; [10,26]) and working memory and inhibition were measured using the Adult Executive Functioning Inventory (ADEXI; [27]). The ADEXI has the advantage of focusing specifically on working memory and inhibition, whereas most other rating instruments targeting executive functioning also include items that are more or less identical to the symptom criteria for ADHD [27,28]. Although neuropsychological tests have the advantage of not being influenced by rater bias, they often have poorer ecological validity compared to ratings [29,30]. A reason for this could be that ratings and test have been argued to capture partly different constructs [29]. By including both tests and ratings, the present study were able to get a more complete assessment of the participants' neuropsychological deficits.

2.3. Statistical analyses

Analyses were performed using SPSS, version 21.01, with $P < .05$ (2-tailed) considered as statistically significant. No outliers were detected using the outlier labeling rule [31]. First, group differences for the dimensional measures were investigated using analyses of variances (ANOVAs) for dimensional variables. Post hoc analyses (paired comparisons) were used to compare older adults with ADHD with either the healthy controls or the younger ADHD group. Effect sizes for the post hoc analyses were investigated using Cohen's d and the size of the effects was interpreted in line with recommendations where .30 is considered a small effect, .50 a medium effect, and .80 a large effect [32]. We also re-ran these analyses controlling for comorbid depression or anxiety disorders. Second, logistic regression analyses were used to obtain information about independent effects of the different neuropsychological variables, as well as estimates of diagnostic sensitivity and specificity. Only the older adults with ADHD and the older controls were included in this analysis. Third, person-oriented analyses were conducted. Performance on each test was categorized as being average/above average (scaled score ≥ 8), mildly deficient (scaled score of 4–7, i.e., ≥ 1 SD below the mean) or severely deficient (scaled score ≤ 3, i.e., ≥ 2 SD below the mean) relative to available norms [23,25]. Only the tests were included in the person-oriented analyses as norms were not available for the ratings. Finally, chi-square analyses were used to investigate whether there were significant group differences for the categorical variables and Venn diagrams were used to illustrate the overlap between the different categories.

3. Results

3.1. Group differences in neuropsychological functioning

For working memory, older adults with ADHD performed at a significantly lower level compared to healthy controls for all measures (Table 2). Older adults with ADHD rated themselves as having less severe working memory deficits compared to younger adults with ADHD, but group differences between the two ADHD groups were not significant for the laboratory tests.

For inhibition and switching, significant effects of group were found for all three measures. Post hoc analyses revealed that older adults with ADHD performed worse compared to healthy controls, but better compared to younger adults with ADHD. No significant group effects were found for the Tower Task measuring planning. For both verbal fluency and speed in naming colors, older adults with ADHD did not differ significantly from healthy controls, but they performed better compared to younger adults with ADHD. In

Table 2
Results of the ANOVAs, post hoc analyses, and effects sizes (d) for the comparison between the older ADHD group (1), the younger ADHD group (2), and older healthy controls (3) with regard to neuropsychological functioning.

	ADHD older adults (n = 44) M (SD)	ADHD younger adults (n = 56) M (SD)	Healthy older controls (n = 58) M (SD)	ANOVA F	Post hoc comparisons (effect sizes)		ANCOVA (Depression) F	ANCOVA (Anxiety) F
					1 vs 2 (d)	1 vs 3 (d)		
Working memory								
Digit span (backward)	9.18 (2.88)	9.21 (2.58)	10.50 (2.99)	3.87*	ns (.01)	1 < 3 (.45)	2.59****	3.62*
Digit span (sequencing)	8.32 (2.10)	7.71 (2.27)	10.60 (2.12)	27.27***	ns (.28)	1 < 3 (1.08)	23.83***	25.60***
Letter-number sequencing	8.39 (1.67)	8.66 (2.52)	10.47 (2.23)	14.17***	ns (.12)	1 < 3 (1.04)	13.32***	13.73***
ADEXI rating: working memory subscale[a]	3.04 (0.88)	3.40 (0.79)	1.84 (0.53)	67.38***	1 < 2 (.43)	1 > 3 (1.71)	59.53***	67.61***
Inhibitory Control								
Color word test–time inhibition trial	10.77 (3.58)	8.88 (3.16)	12.33 (2.35)	21.92***	1 > 2 (.56)	1 < 3 (.53)	15.65***	17.19***
ADEXI rating: inhibitory control subscale[a]	3.09 (0.73)	3.49 (0.83)	2.01 (0.64)	60.77***	1 < 2 (.50)	1 > 3 (1.55)	69.50***	58.82***
Switching								
Color Word Test–time switching trial	11.16 (2.13)	8.98 (2.50)	12.54 (1.78)	36.96***	1 > 2 (.93)	1 < 3 (.71)	35.00***	35.92***
Planning								
Tower Test	10.95 (3.38)	10.36 (2.86)	11.29 (2.16)	1.43	ns (.19)	ns (.12)	1.27	1.56
Verbal fluency								
Letter fluency–correct number of items	12.91 (3.82)	11.04 (3.87)	12.91 (3.85)	4.64*	1 > 2 (.48)	ns (.00)	4.51*	4.49*
Category fluency–correct number of items	13.00 (3.92)	11.38 (4.22)	14.09 (3.47)	7.22***	1 > 2 (.40)	ns (.30)	7.30***	6.91***
Speed of processing								
Color word task–time for naming colors	10.20 (3.37)	6.59 (3.34)	10.91 (2.10)	31.45***	1 > 2 (1.27)	ns (.26)	33.96***	34.09***
Color word task–time for reading words	8.91 (2.98)	7.23 (3.52)	10.79 (2.06)	19.34***	1 > 2 (.51)	1 < 3 (.75)	19.25***	21.16***
Delay-related behaviors[a]								
QDQ rating: delay aversion subscale[a]	3.50 (0.85)	3.80 (0.88)	2.36 (0.67)	50.71***	1 < 2 (.34)	1 > 3 (1.52)	43.48***	46.86***
QDQ rating: delay discounting subscale[a]	2.77 (0.71)	2.76 (0.76)	2.02 (0.58)	22.70***	ns (.01)	1 > 3 (1.70)	15.07***	19.90***

ns: non-significant.
[a] In contrast to the laboratory measures, higher scores indicate larger deficits for the questionnaire data.
* $P < .05$.
*** $P < .001$.
**** $P < .10$.

addition, the older adults with ADHD performed better compared to younger adults with ADHD on the task measuring speed in reading words. In comparison with controls, older adults with ADHD rated themselves as having higher problem levels with regard to both measures of delay-related behavior, but lower compared to younger ADHD patients for delay aversion. Finally, we re-ran all analyses controlling for ongoing comorbid depression or anxiety disorders. As shown in Table 2 (last two columns), all significant group differences remained, except for the Digit Span Task for which the main effect and the post hoc comparison between the older ADHD patients and controls was only marginally significant (i.e., $P < .10$) when controlling for depression.

3.2. Sensitivity and specificity

The results of the logistic regression analysis (Table 3) showed that a model including all laboratory measures was significant, $\chi^2 = 49.72$, $P < .001$, and the following two working memory tasks had a significant effect: digit span sequencing, Wald = 6.60, $P < .01$, and the number-letter sequencing task, Wald = 11.00, $P < .001$. The number of correctly classified individuals in the ADHD group (i.e., sensitivity) was 76.7 and the number of correctly classified individuals among the controls (i.e., specificity) was 86.0. When entering the self-ratings in the second step, the sensitivity was increased to 88.4 and the specificity to 91.2.

Table 3
Results of the logistic regression analysis.

	Sensitivity	Specificity	Total correctly classified
ADHD older adults versus healthy controls[a]			
Step 1. Only laboratory measures	76.7	86.0	82.0
Step 2. Laboratory measures + ratings	88.4	91.2	90.0

[a] Only laboratory measures for which there was a significant group difference between older adults with ADHD and healthy controls in the ANOVAs were included in this analysis.

3.3. Person-oriented analyses

The person-oriented analyses (Table 4) showed that a majority of the individuals in both the younger and older ADHD group performed within the average range for most of the tasks. In the chi-square analyses used to investigate group differences for the categorical variables, we used a dichotomized measure (i.e., deficit or no deficit) as the number of participants with severe deficits was too small for several of the variables if also distinguishing between mild and severe deficits. The results showed that the two ADHD groups showed similar levels of impairment in working memory, planning, and verbal fluency, all $\chi^2 < 2.65$, *ns*. However, for inhibition, switching and speed of processing, older ADHD patients were less impaired compared to younger ADHD patients, all $\chi^2 > 5.56$, $P < .05$. Thus, except for verbal fluency, these finding were the same as those found in the variable-oriented analyses. For the comparison between older ADHD patients and controls, the chi-square analyses showed the same results as the variable-oriented analyses with significant group differences for working memory, verbal fluency, and speed of processing, all $\chi^2 > 3.91$, $P < .05$. However, unlike the variables oriented analyses, the ADHD patients differed from controls also with regard to planning, $\chi^2 = 6.25$, $P < .05$, whereas no significant differences were found for inhibition and switching, both $\chi^2 < 1.53$, *ns*.

Next, a Venn diagram was used to illustrate the overlap between different neuropsychological deficits. Verbal fluency and planning were not included as group differences between older adults with ADHD and healthy controls had not been found for these measures. In addition, the measures for inhibition and switching were combined as these are highly related constructs and they had shown a similar pattern of results in the previous

Table 4
Table presenting the percentage of older ADHD patients with severe, mild or no deficit in neuropsychological functioning.

	ADHD - older adults			ADHD - younger adults		
	Severe deficit (1–3)	Mild deficit (4–7)	No deficit (8 ≥)	Severe deficit (1–3)	Mild deficit (4–7)	No deficit (8 ≥)
Working memory						
Digit span (backward)	2.3	29.5	68.2	0.0	32.1	67.9
Digit span (sequencing)	0.0	45.5	54.5	3.8	48.1	48.1
Letter-number sequencing	2.3	20.5	77.3	2.0	24.0	74.0
Inhibitory Control						
Color word test–time inhibition trial	2.4	4.8	92.9	9.8	19.6	70.6
Switching						
Color word test–time switching trial	0.0	6.8	93.2	4.2	20.8	75.0
Planning						
Tower test	2.3	13.6	84.1	0.0	16.1	83.9
Verbal fluency						
Letter fluency–correct number of items	0.0	6.8	93.2	1.8	16.1	82.1
Category fluency–correct number of items	0.0	11.4	88.6	3.6	12.5	83.9
Speed of processing						
Color word task–time for naming colors	6.8	11.4	81.8	21.4	37.5	41.1
Color word task–time for reading words	6.8	20.5	72.7	18.2	27.3	54.5

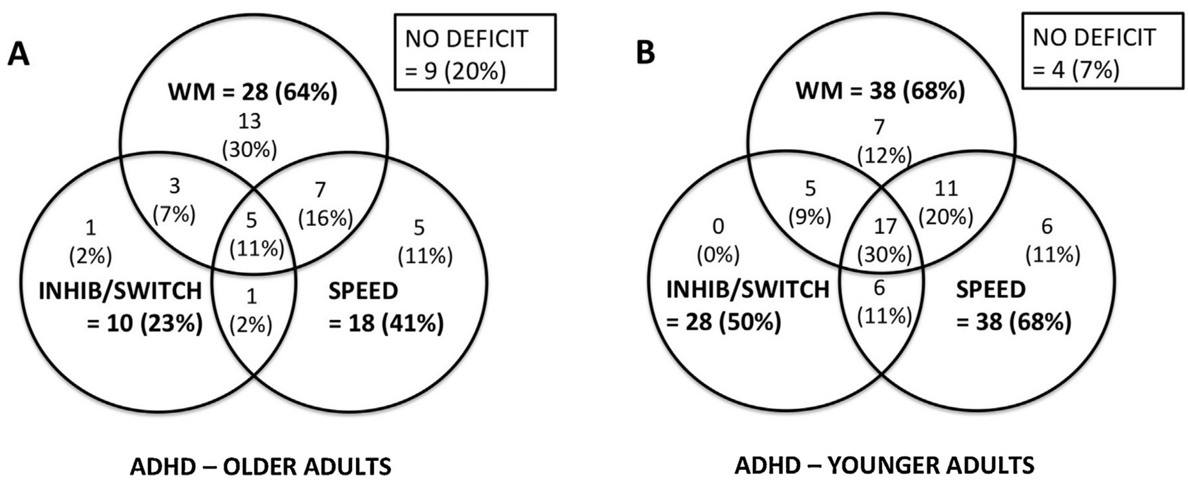

Fig. 1. Venn diagram showing the number of older (A) and younger (B) adults with ADHD who had impaired performance with regard to the three domains: working memory (WM), inhibition/switching (INHIB/SWITCH), and speed of processing (SPEED).

analyses. Thus, the overlap between the following three domains was investigated: working memory, inhibition/switching, and speed of processing. As shown in Fig. 1, 20% of older ADHD patients did not have a deficit within any domain, 43% had impaired performance within a single domain, and 36% showed impairment in multiple domains. The corresponding numbers for the younger adults with ADHD was 7% without deficits, 23% with single deficits, and 70% with multiple deficits. The Venn diagram also illustrates that working memory (64%) was the most common impairment among older adults with ADHD, whereas both working memory and speed (each one 68%) was most common among younger adults with ADHD. A larger proportion of the younger adults (30%), compared to the older adults with ADHD (11%), had impairment in all three domains.

4. Discussion

The aim of this study was to investigate to what extent older adults with clinically referred ADHD differ from healthy controls or younger adults with ADHD regarding neuropsychological functioning. The results showed that older adults with ADHD differed from controls in working memory, inhibition and speed of processing. In comparison to younger adults with ADHD, they performed at a similar level for working memory and planning, but significantly better with regard to inhibition, switching, fluency, speed of processing, and delay aversion. Despite several significant group differences relative to controls, person-oriented analyses showed that a majority of older adults with ADHD performed within the average range when studying each measure separately and 20% did not have a clear deficit within any neuropsychological domain.

4.1. Variable-oriented analyses

As this is the first study investigating neuropsychological functioning in clinically referred older ADHD patients, a direct comparison with previous findings is not possible. However, it is interesting to note that our results are only partly in line with the study by Semejin et al. [12] as they only found a significant group effect for working memory in relation to healthy controls. The most likely reasons for these inconsistencies are probably that the previous study included a small sample size ($n = 23$), a population-based sample, as well as the fact that 39% the participants only had symptomatic ADHD (i.e., high symptom levels, but not meeting the full symptom criteria for the disorder). Thus, our study contributes with new valuable information demonstrating that clinically referred older ADHD patients differ significantly from controls with regard to most neuropsychological functions. However, when comparing older adults with ADHD with younger adults with the same diagnosis, older adults appear to be less impaired with regard to inhibitory control, switching, fluency, speed of processing, as well as self-rated delay aversion.

For delay aversion, the significant difference between younger and older ADHD patients could possibly be explained as a result of general age effects (i.e., that younger individuals in general are more delay averse compared to older individuals). In support for this interpretation, studies using age effects on temporal discounting task in normally developing samples have shown that younger adults have a tendency to choose immediate rewards more often compared to older adults [33,34]. However, as reviewed by Drobetz et al. [35], there are some inconsistencies in previous research depending on the age of the participants and the type of discounting task that have been used. The results of the present study were also somewhat inconsistent as the older and younger patients with ADHD differed only with regard to the delay aversion and not delay discounting. In order to explain why older individuals might be less delay averse compared to younger individuals, Li et al. [34] found support for the hypothesis that older adults have higher levels of crystallized intelligence but lower levels of fluid intelligence and that delay-related behaviors are more dependent on crystallized intelligence.

For the neuropsychological test, it is important to note that these comparisons were made using scaled scores, which means that younger ADHD patients were more impaired compared to older adults with ADHD relative to norms. As an example, a raw score of 73 would result in a scaled score of 10 for an individual age 70–79 years, but a scaled score of 4 for an individual in the age range 20–29 years. Conclusively, the older adults with ADHD were not performing better than the younger patients with ADHD in absolute terms, but they were less impaired compared to what can be expected of people their age.

With regard to comorbidity, it should be noted that the previous study by Semejin et al. referred to above showed that the significant effect for the Digit Span Task disappeared when controlling for comorbid depression [12]. In the present study, the effect on the same task changed from significant to marginally significant when controlling for depression. The differences between this previous study and our study as described above (i.e., sample size, type of sample, and symptom severity) could possibly explain why comorbid depression did not influence the results as much in the present study. More importantly, the present study demonstrated that older adults with ADHD differed significantly from controls on two additional measures of working memory even when controlling for either depression or anxiety disorder. Thus, our more in-depth evaluation of group difference in working memory showed that there were significant differences between older adults with ADHD and controls, whereas younger and older adults with ADHD had the same level of impairment relative to norms.

4.2. Person-oriented analyses

The need for more person-oriented research in ADHD samples has been emphasized [15]. This type of analysis identifies the proportion of patients scoring within the "abnormal" range rather than just comparing mean values between groups as in variable-oriented analyses. In the present study, we also had the advantage of using well-established tests with norms rather than more arbitrary cut-offs (e.g., the 90th percentile of the controls) and our findings can thus more easily be transferred to a clinical setting.

Interestingly, we were able to demonstrate that when using person-oriented analyses, the main conclusions from the variable-oriented analyses were at least partially altered. Whereas the ANOVAs showed significant group differences between older adults with ADHD and healthy older controls on several measures, the person-oriented analyses showed that a majority of the older adults with ADHD performed within the average range relative to norms on each tasks and that 20% did not have deficits within any neuropsychological domain. Thus, the overall results of the present study are in line with current models of heterogeneity in which different neuropsychological subgroups can be identified, but that there is also a subgroup without any clear deficits. As emphasized by for example Nigg et al. [15], these subtypes can then be compared with regard to external correlates, etiology, or treatment response. The results of the present study indicate that working memory deficits appear to be the most prominent among older adults with ADHD. This is important to acknowledge, as many everyday tasks (e.g., decision-making, problem-solving, or integration and reorganization of information) require high working memory skills [36]. We also know from previous research that normal aging is associated with memory decline, with only a small decline taking place between the ages 40–65 years, but a steep continuous decline thereafter [37]. For the subgroup of older adults with ADHD and working memory deficits identified in the present study, additional decline due to the normal aging process is likely to have serious consequences for the patients' ability to cope with the hassles of daily life.

4.3. Limitations

We recognize some limitations. First, although the sample size of the present study was larger than that of previous studies of older adults with ADHD, it was still small in comparison with previous ADHD studies including younger participants. The reason for this is that the number of patients with ADHD in this age group still is limited, probably due to difficulties for health care professionals in recognizing the disorder in older adults. However, it will most likely grow substantially as an increasing number of adults have been diagnosed with ADHD during the last decades. Individuals in this age group are also more likely to suffer from severe physical and mental disabilities, which means that they are less likely to participate in studies. Taken together, this could suggest that our sample might be somewhat less severely affected compared to older adults with ADHD in general. However, our sample is likely to better reflect the ADHD population compared to previous studies of older adults as they have used population-based samples and/or included individuals not meeting the full diagnostic criteria. As we wanted to capture the neuropsychological heterogeneity of ADHD, we chose to include a relatively large number of different neuropsychological functions, but this meant that we could not include multiple tests for each function. When choosing what tasks to include, we were limited in the way that we could only include tasks for which standardized scores were available for older adults as we were interested in comparing to what extent older and younger adults with ADHD differed from one another relative to norms. We feel that it would have been especially valuable to include tasks assessing spatial working memory, reaction time variability, and reward processing, as well as additional tasks assessing inhibitory control. Ratings of emotion regulation would also have been valuable to include as several previous studies of children have found strong links between ADHD and deficient emotion regulation [38].

4.4. Conclusions and future directions

Conclusively, the findings of the present study supports current models of heterogeneity in which ADHD is regarded as a disorder related to a range of different neuropsychological deficits, but that there is also a subgroup of ADHD patients without clear neuropsychological deficits [1,15]. Identifying neuropsychological subgroups within the ADHD population might therefore be of major importance as this could identify patients being at particularly high risk of poor functioning in daily life. Regarding future research, longitudinal follow-ups of older adults with ADHD will be of major importance, as we do not know how specific neuropsychological deficits in older adults with ADHD interact with either normal or abnormal cognitive decline. In addition, it would be of great value to further examine to what extent neuropsychological deficits among older adults with ADHD affect their daily life functioning and quality of life. Here, an important aspect will be to conduct further research on how information obtained from neuropsychological tests and rating should best be combined in order to get a more complete view of the patients' difficulties.

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Disclosure of interest

The authors declare that they have no competing interest.

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