Verbal Episodic Memory Deficits in Adults With ADHD: The Role of Strategy Utilization

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Abstract: Amongst individuals with Attention Deficit Hyperactivity Disorder (ADHD) an impairment in verbal episodic memory (VEM) has consistently been found. This impairment has been located at the encoding stage, but its underlying cognitive mechanisms are poorly understood. The aim of this thesis was therefore to study whether spontaneous strategy use, a compensatory mechanism strongly related to executive functions that are known to be impaired in ADHD, could explain the observed VEM deficiency in adults with ADHD. To test this, 274 English-speaking participants were recruited from a crowdsourcing website resulting in a final sample of 65 adults with ADHD and 209 neurotypical controls. As part of an online test battery, the participants completed a word list learning task and were given an open-ended strategy questionnaire to measure strategy use during each trial. The adults with ADHD recalled less words than the controls on the word list learning task. This performance difference increased over the three trials, indicating that the adults with ADHD benefited less from repeated learning trials. Spontaneous use of manipulation strategies was associated with superior word recall and was equally effective in both groups. However, the adults with ADHD employed strategies less often than the neurotypical controls, and this difference in strategy employment explained a small part of the variance between the two groups´ word-list learning performance. Further studies should seek for other cognitive factors that contribute to this pervasive deficit in encoding of verbal materials.
Keywords: Verbal Episodic Memory, ADHD, Strategy, Adult

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ÅBO AKADEMI – FAKULTETEN FÖR HUMANIORA, PSYKOLOGI OCH TEOLOGI

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Titel: Strategianvändningens Roll i Nedsatt Verbal Episodisk Minne hos Vuxna med ADHD
Handledare: Matti Laine
Abstrakt: Nedsatt Verbal Episodisk Minne (VEM) hos vuxna med Attention Deficit Hyperactivity Disorder (ADHD) har observerats i flera studier. Nedsättningen anses uppkomma vid inkodningsfasen av minneslagring, men de kognitiva mekanismerna som förklarar nedsättningen är inte välundersökta. Målet med denna studie var att undersöka ifall användningen av spontana minnesstrategier, vilka är associerade med exekutiva funktioner som är nedsatta i ADHD, kunde delvis förklara varför vuxna med ADHD presterar sämre på uppgifter som mäter VEM. För att undersöka detta, rekryterades sammanlagt 274 vuxna, engelskspråkiga deltagare från en crowdsourcing nätsida varav 65 hörde till ADHD gruppen och 209 till kontrollgruppen. Som en del av ett bredare testbatteri fick deltagarna lära sig en ordlista och fritt rapportera de strategier de använde sig av i för att komma ihåg orden från ordlistan efter varje försök. De vuxna med ADHD kom ihåg färre ord än kontrollgruppen och denna prestationsskillnad blev större med varje försök, vilket tyder på att vuxna med ADHD drog mindre nytta av de upprepade försöken. Användningen av spontana manipulationsstrategier var associerat med bättre prestation på ordlista uppgiften för båda grupperna. Dock använde vuxna med ADHD färre strategier än kontrollgruppen, och detta förklarade en liten del av prestationsskillnaden på ordlista uppgiften mellan grupperna. Fortsatta studier bör undersöka vilka andra kognitiva faktorer underligger den ihållbara nedsättningen hos vuxna med ADHD i inkodningen av verbalt material
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Verbal Episodic Memory Deficits in Adults With ADHD: The Role of Strategy Utilization

ADHD (attention deficit hyperactivity disorder) is a common neurodevelopmental disorder characterized by deficits in attentional regulation, impulsivity, and hyperactivity (Faraone et al., 2021) ADHD is primarily considered a childhood disorder and prevalent in approximately 5-11% of children (Francés et al., 2022). However, ADHD persists into adulthood in 50% of cases (Lara et al., 2009). In adults, ADHD has been shown to be associated with many factors negatively impacting quality of life, such as poorer academic performance, occupational difficulties, and less satisfaction with one's social life (Biederman et al., 2006; Holst & Thorell, 2020; Sedgwick-Müller et al., 2022).

Although ADHD is a commonly diagnosed and well-studied disorder, the complexity and heterogeneity of symptoms have yet to be completely explained by one theoretical model (Luo et al., 2019). However, several cognitive domains have been shown to be impaired in ADHD, such as executive functions (EFs), working memory, processing speed, response inhibition, and verbal episodic memory (VEM) (Hervey et al., 2004; Schoechlin & Engel, 2005). Taken together, these cognitive deficits form the complex symptomatology in ADHD.

Due to the complexity of the disorder, the mechanisms underlying specific cognitive impairments in ADHD remain unclear. One such impairment is the commonly found deficiency in VEM in adults with ADHD (Fuermaier et al., 2013; Lundervold et al., 2019; Orban et al., 2022; Skodzik et al., 2017). The aim of the current study was to examine whether spontaneous utilization of memory strategies, a skill associated with EFs that are impaired in ADHD, could explain why adults with ADHD consistently show poorer performance on VEM tasks.

Executive Functions in ADHD

There is no consensus in the literature regarding the exact definition of EFs. However, the most cited model of EFs is the one proposed by Miyake et al. (2000; Baggetta & Alexander, 2016). This model divides EFs into three more basic components: 1) Shifting between tasks or mental sets, 2) updating and monitoring working memory representations, and 3) inhibition of prominent or prepotent responses. These components are thought to be separable but interdependent and work together to accomplish complex cognitive tasks such as goal-directed planning as well as processing and manipulating information (Miyake et al., 2000).

Deficits in EFs have received much attention in ADHD research and have been proposed to be one of the core deficits responsible for ADHD symptomology (Barkley, 1997). According to the model by Barkley (1997), the primary symptoms of ADHD can be explained by deficient EFs. Other theoretical models of ADHD have also been proposed, highlighting deficient motivational pathways or dysfunctions in cognitive energy management (Sergeant et al., 1999; Sonuga-Barke, 2005). Regardless of theoretical model, EFs continue to be consistently identified as deficient in ADHD (Wilcutt et al., 2005), being a central part of ADHD symptomatology.

Verbal Episodic Memory in ADHD

Human memory relies on several different functional components. These components, such as short-term/working memory (WM) and long-term memory, are commonly categorized depending on which stage of processing they are responsible for and in which way the information is stored in long-term memory. Long-term memory can be divided into explicit and implicit memory. Explicit memory refers to our memory of things we can recall, such as people, events, and facts, while implicit memory refers to our memory of skills and procedures (Squire & Zola, 1996). Explicit memory can further be divided into memory of personal events and facts which are bound in time and place (episodic memory) and knowledge which is not bound to time and place (semantic memory). Furthermore, episodic memory is often divided into different categories, such as memory for verbal information and memory for visual information (Scott & Schoenberg, 2011). In the present study, I focused on the verbal component of episodic memory, as it has consistently been found to be deficient in adults with ADHD.

For verbal information to be successfully stored in long-term memory, it must first be successfully held and manipulated in WM and fed into long-term memory. However, WM has a limited storage capacity (Cowan, 2010). A person can only hold a certain amount of information in their WM before it is overloaded (Baddeley, 2003). If WM is overloaded, information will not be successfully manipulated and therefore will not be fed into long-term memory storage.

VEM can be probed with various verbal materials such as digits, words, sentences, or longer texts. Importantly, the memoranda must be long enough to exceed WM capacity, thus ensuring the engagement of long-term memory in encoding and recall. Commonly employed clinical test measures of VEM include the California Verbal Learning Test (CVLT; Delis et al., 2016) the Rey Auditory Verbal Learning Test (RAVLT; Schmidt, 1996) or the Wechsler

Memory Scale – 4th ed. (WMS-IV;(Wechsler, 2012). In the present study, I utilized an experimental 18-item word list learning (WLL) task taken from Waris et al. (2021).

Evidence for pervasive VEM deficits in adults with ADHD is based on several studies (Fuermaier et al., 2013; Lundervold et al., 2019; Orban et al., 2022; Skodzik et al., 2017). Skodzik et al. (2017) provided perhaps the most important meta-analytical evidence of a VEM deficit in adults with ADHD. Their meta-analysis of 19 studies with 831 ADHD participants and 771 neurotypical controls showed that adults with ADHD perform less well than neurotypical controls on measures of verbal delayed free recall. Moreover, the ADHD-related impairments did not extend to the visual long-term memory domain. These findings, therefore, suggest that the episodic memory deficit in ADHD is specific to verbal information.

The VEM deficit observed in adults with ADHD raises the question whether it is a primary symptom of ADHD, or perhaps a secondary symptom due to insufficient encoding processes related to other neurocognitive deficits. Several studies have addressed this question. Both Skodzik et al. (2017) and Fuermaier et al. (2013) found that adults with ADHD showed deficiencies in the encoding phase, while no differences between adults with ADHD and neurotypical controls were found when measuring retention or recall. A study by Lundervold et al. (2019) provided some explanation as to why specifically the encoding phase of VEM seems to be affected in adults with an ADHD diagnosis. Their results showed that WM and inhibition, both key components in EFs (Miyake et al., 2000), partially explain the poorer performance on verbal memory tasks.

Taken together, these studies show consistent VEM deficits in adults with ADHD. The studies also suggest that ineffective encoding processes due to executive dysfunction might explain poorer VEM performance.

Mnemonic Strategy Use in ADHD

Using strategies when trying to memorize information aids the capacity of WM (Willcutt et al., 2005). Thereby, mnemonic strategies such as grouping the memoranda or creating associations can help in encoding to-be-remembered materials into long-term memory. The levels of processing framework proposed by Craik and Lockhart (1972) provides an explanation for why mnemonic strategies might aid encoding of information. The framework posits that the level at which information is encoded will affect how well it is stored in long-term memory. In other words, if information is manipulated on a deeper level in WM (e.g., creating semantic associations), it will be stored more effectively. The existing

literature regarding strategies supports this framework. Mnemonic strategy use is associated with better recall performance (Camp et al., 1983; Gross & Rebok, 2011; Waris et al., 2021) and aids storage of information over time (Boltwood & Blick, 1970). Additionally, strategies which require a deeper level of processing improve encoding and storage of the to-be-remembered material (Boltwood & Blick, 1970; Camp et al., 1983).

EFs represent higher-level cognitive processes which are needed for the organization and execution of complex thoughts. Therefore, it can be assumed that EFs are associated with the utilization of strategies that are called for when performing demanding or novel cognitive tasks. Effective utilization of strategies has been shown to be positively correlated with EF processing (Comoldi et al., 1999; Garner, 2009), confirming that well-functioning EFs are an important factor contributing to the effective utilization of cognitive strategies.

As deficits in executive functioning are a central component of ADHD symptomatology (Barkley, 1997), it seems logical to assume that those with an ADHD diagnosis would be less effective at utilizing cognitive strategies. Both children and adults with ADHD do, in fact, show deficits in effectively utilizing or selecting cognitive strategies when presented with spatial memory tasks, as well as tasks that require strategic planning, when compared to neurotypical controls (Kofman et al., 2008; Young et al., 2006). More importantly, children with ADHD have shown deficiencies in effective strategy utilization during VEM tasks (Comoldi et al., 1999; Egeland et al., 2010). Although the relationship between strategy use and VEM has been studied in children with ADHD, not much is known regarding strategy use in adults with ADHD. One smaller-scale study by Roth et al. (2004) found that adults with ADHD used a semantic organizational strategy less often than neurotypical controls and showed poorer performance during a verbal learning and memory task. Roth et al. (2004) also found that the performance difference between the groups was not mediated by semantic organizational strategy use.

However, more research regarding the role of strategy use in impaired VEM in adults with ADHD is needed. The existence of EF deficits in ADHD, the central role of EFs in strategy utilization, and the relationship between strategy use and higher memory performance raise the possibility that impaired strategy utilization and selection could play a role in abnormal VEM performance in adults with ADHD.

Aims of the study

The primary aims of the present study were twofold. The first aim was to replicate the previous findings of a VEM deficit in adults with ADHD by comparing adults with ADHD

vs. a neurotypical control group on a word list learning task. The second aim was to examine whether impaired spontaneous strategy utilization could account for VEM performance deficits in adults with ADHD.

Based on the motivations detailed above, the following hypothesis were put forth:

1. Adults with ADHD show impairment on a VEM task compared to neurotypical controls.
2. Adults with ADHD exhibit impairments in spontaneous use of memory strategies in a VEM task as compared to neurotypical controls. These impairments should be seen in frequency and/or efficacy of strategy use.

Method

The present data stem from a larger online study that focused primarily on the performance of adults with ADHD vs. neurotypical controls on the novel video gaming task Executive Performance in Everyday Living (EPELI; Jylkkä et al., 2023). The larger study aimed to examine the capability of the video game to quantitively measure goal-directed behavior and prospective memory in a more life-like setting.

The present study focuses on a verbal memory task that was included in the test battery of the larger study, namely a Word List Learning (WLL) task. For this task, both objective memory performances and open-ended strategy reports collected for each task block were available.

Procedure

The study received approval from the Ethics Board of the Departments of Psychology and Logopedics at the Åbo Akademi University in Turku, Finland. Recruitment of participants was performed anonymously by Jylkkä et al. (2023a) via the crowdsourcing site Prolific (https://www.prolific.com/) and the participants received monetary compensation via the site for their participation in the study.

In total, the study consisted of three stages: two prescreening studies and the primary study which consisted of five sessions performed over five separate days. The data were gathered between August and December in 2021.

Prescreening studies

During the first prescreening study, the participants were asked to report whether they had been diagnosed with ADHD or ADD by a clinical professional as well as fill out part A of the ASRS (Adult ADHD Self-Report Scale; Kessler et al., 2005). A total of 12 446

participants completed the first prescreening, out of which 1517 participants were invited to complete the second prescreening.

During the second prescreening, participants were asked to complete questionnaires which gathered information about the participants age, gender, income, education, medical history, eyesight and color vision, alcohol use, nicotine use and use of other psychoactive substances. The participants were also asked to complete the ASRS part B to further assess ADHD symptoms as well as the DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure – Adult (Bravo et al., 2018) to assess overall mental health. For further information see Jylkkä et al. (2023b)

Based on the data gathered from the second prescreening study, participants were invited to the primary study if they met the following criteria: Normal or corrected-to-normal vision; no color blindness; no neurodevelopmental disorders; no neurological illness that affects the participant´s current life; never being diagnosed with severe depression, bipolar disorder, psychosis, or schizophrenia across their lifespan; and no self-reported substance-abuse problem. Participants were also excluded from the primary study if they reported suicidality or had a sum score of 3 or more in the depression, mania, and anxiety domains on the DSM symptom measure. Furthermore, participants were excluded from the analysis if they had taken ADHD medication within 24 hours of completing the WLL-task or if they had any missing values in any of the study variables. After all necessary participants were excluded, the data from 274 participants was used in the study. The ADHD group and the control group did not significantly differ on gender distribution ($\chi^2 = 4.79$, $p = .091$), years of education (t (270) = -.64, $p = .162$), age (t (272) = -.06, $p = .086$) or performance on an a fluid intelligence test (t (268) = -1.49, $p = .121$), namely the 16-item International Cognitive Ability Resource (ICAR-16; Condon & Revelle, 2014). However, the control group was significantly larger than the ADHD group and female gender was overrepresented in both groups. Further information regarding background characteristics of the sample can be found in Table 1.

Table 1

Background characteristics in the two groups

	ADHD Group	Control Group	Total
Sample (*n*)	65	209	274
Gender (F/M/O)	43/21/0	157/52/1	200/73/1
ICAR-16 (*M, SD*)	7.3 (3.96)	8.05 (3.55)	7.87 (3.66)
Education (years) (*M, SD*)	16.22 (3.87)	16.51 (2.98)	16.44 (3.21)
Age (years) (*M*, *SD*)	31.8 (8.70)	31.87 (8.71)	31.85 (8.51)

Note: 4 missing values for ICAR-16 and 2 missing values for years of education. F = Female, M = Male, O = other.

Primary study

The participants who received an invitation to the primary study completed tasks during five separate sessions. All the participants completed the EPELI game during the first session. The presentation order of the remaining tasks was counterbalanced between the participants. Each session was performed on separate weekdays with a minimum 12-hour interval in-between the sessions. The WLL task was completed during one of these five sessions.

Measures

Word List Learning Task

The experimental WLL task was initially developed by Waris, Fellman et al. (2021) as a measurement of verbal episodic memory and learning. During the WLL task, participants were given a list of 18 common nouns, presented altogether three times in a randomized order. The words in the list were displayed for one second each, followed by a one-second blank screen interval.

After the entire list was presented, the participants were given a simple arithmetical distractor task to complete. The distractor task was designed to engage the participants' WM to a degree that any of the words from the to-be-remembered list would be cleared from their WM. This ensured that any of the words recalled in the next phase of the test were recalled from VEM, not WM.

Once the distractor task was completed, the participants were shown a screen with 18 blank boxes and given the instruction to recall as many words as possible from the previously presented list by typing them into the blank boxes. The number of words recalled was

subsequently used as the primary dependent measure. The participants were given 1 point for each word recalled, resulting in a possible maximum of 18 points and a minimum of 0.

Once the participants had recalled as many words as they could, they were asked to report which mnemonic strategies they used when presented with the word list. The participants were given the following open-ended question: "Please describe in as much detail as possible how you solved the previous word list task (not the math task). That is, how did you try to memorize the words". After the participants had completed describing their choice of strategy, they continued with the next trial that had an identical structure. Thus, each of the three WLL task trials included a presentation of the same to-be-remembered words, the distractor task, recall phase, and the open strategy report.

Strategy Descriptions

The open-ended strategy descriptions provided by the participants resulted in three separate variables that were scored by two independent raters. The three variables were the primary strategy type the participant reported, the number of specific strategy details given, and the total number of strategy types reported. For the purposes of this study, only the first variable (primary strategy type) was used in the analysis.

The independent raters classified the descriptions into 7 different strategy types presented in the Appendix. The strategy types were further grouped into three broader categories following Waris et al. (2021) and Fellman et al. (2020).

The first category, no strategy use, included descriptions with no indications of strategy employment. The second category, maintenance strategies, included the primary strategy types rehearsal/repetition and selective focus, as they do not entail any manipulation of the memoranda. Rather, the participants simply attempted to keep the words in mind by actively rehearsing them or disregarding a portion of the items. The third category, manipulation strategies, included grouping, association, visualization of objects and/or locations, and other strategy. All these primary strategy types involved some kind of manipulation of the to-be-remembered items to support the encoding of the word list into verbal episodic memory.

Statistical analysis

To test the two hypotheses, I performed statistical analyses using IBM SPSS Statistics 29.0.

The first hypothesis stated that the ADHD group would perform worse on the WLL task than the neurotypical control group. To examine, this, I performed a two-way mixed

model ANOVA with group (ADHD, control) and trial (1-3) as the independent variables and number of correctly recalled words as the dependent variable. To ensure that the assumptions for the ANOVA model were fulfilled, I produced Q-Q plots and visually checked that both groups' performances on all three trials were normally distributed. I observed a violation of sphericity and corrected it using the Huynh-Feldt correction. The assumption of equal variances was also violated. However, Field (2009) notes if the variance ratio of the dependent variable is under 2, equal variances can be assumed. The variance ratios of the first and second trial were under the critical value of 2. However, the third trial slightly exceeded the critical value with its variance ratio of 2.13. As this was only a slight violation, I opted to continue with the two-way mixed model ANOVA.

The second hypothesis stated that adults with ADHD will exhibit problems in spontaneous use of memory strategies when compared to neurotypical controls. This hypothesis consists of two parts, namely a group difference in frequency of strategy use and/or in efficacy of strategy use. To test the first part of this hypothesis, I first performed a one-way ANOVA with group (ADHD, control) as the independent variable and the number of trials in which a strategy was used (0-3) as the dependent variable. All assumptions for the one-way ANOVA were fulfilled, except the assumption of equal variances. However, the variance ratio between the groups was under the critical cutoff value of 2 suggested by Field (2009).

To examine frequency of strategy use in the two groups in more detail, three separate Chi-square analyses were conducted, one for each trial. Frequency of strategy use was measured by categorizing the participants into strategy users (irrespective of strategy type) and non-users in each trial. The distribution of this dichotomous variable in the ADHD vs. control group was then compared. The assumptions for the Chi-square analysis were fulfilled as no cells had an expected frequency below 5.

Because the results gave indications of a group difference in the frequency of strategy use, a follow-up analysis of covariance (ANCOVA) examined to what extent this finding was related to the group difference in actual memory performance. Here group (ADHD, control) served as the independent variable, frequency of strategy use over the three trials (0-3) as a covariate, and the summative score of word recall across all three trials as the dependent variable. The aim was to find out to what extent the inclusion of this strategy-related covariate would weaken the main effect for group, thereby estimating to what extent it could explain the group difference in word recall. In other words, I wanted to see the role of

frequency of strategy in the group difference in word recall, and how much of that difference is related to other factors.

To test the second part of the hypothesis, that is, whether the ADHD group use strategies less effectively than the neurotypical control group, I conducted three separate two-way ANOVAs, one for each trial. The independent variables in the analysis were group (ADHD, control) and self-reported strategy type (no strategy, maintenance strategy, manipulation strategy). Word recall performance for that particular trial served as the dependent variable. Levene's test was significant in the second and third trial. However, the variance ratios for each group were again under the critical cutoff value of 2 suggested by Field (2009). Thus, the analysis was performed as no other assumptions were violated.

Before running any of the analyses, the data was checked for extreme outliers by separately checking performance on the WLL task for each group and each trial. Extreme outliers were defined as a value outside of the 3rd quartile + 3* interquartile range or 1st quartile -3*interquartile range. However, no such cases were found.

Results

Hypothesis 1: Adults with ADHD Show impaired Verbal Episodic Memory Performance Compared to the Control Group

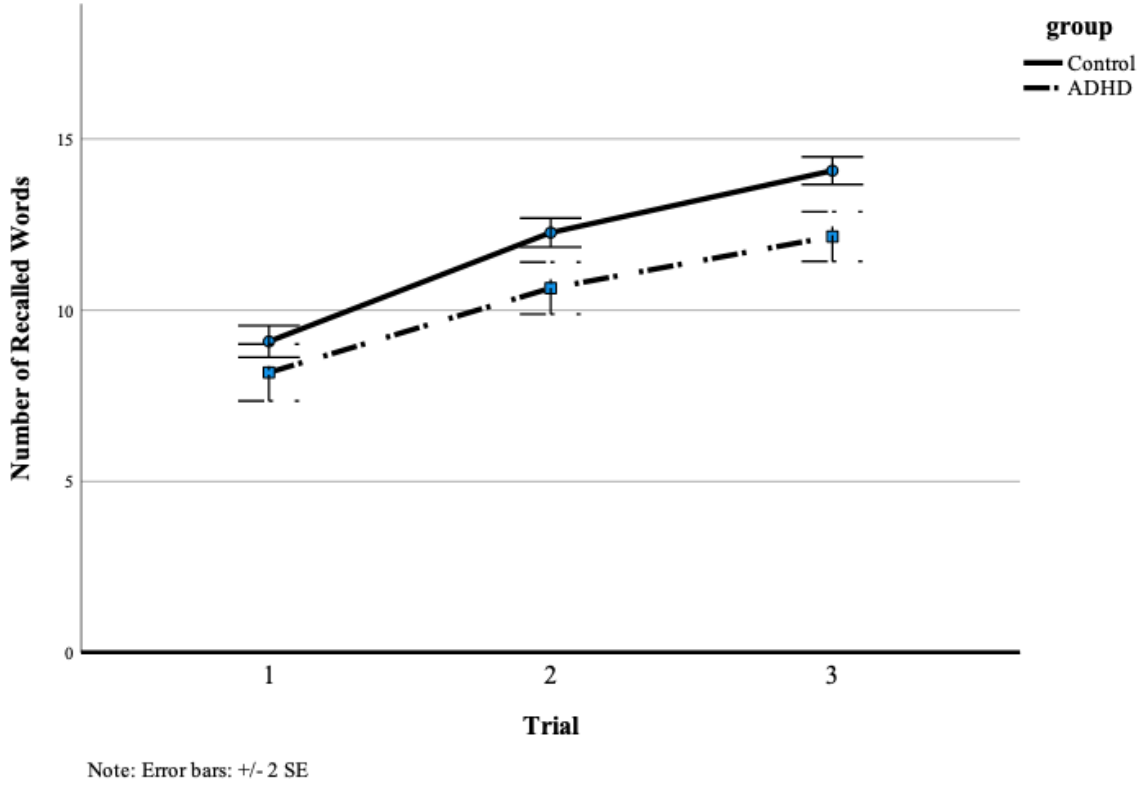
The two-way mixed model ANOVA with group and trial as independent variables and the number of recalled words as the dependent variable showed a significant main effect of group ($F[1,273] = 13.30$, $p = <.001$, $\eta_p^2 = .047$), with the neurotypical control group recalling more words on the WLL task than the ADHD group. As expected, there was also a significant main effect of trial *(*$F[2, 273] = 459.40$, $p <.001$, $\eta_p^2 = .628$), with the overall task performance increasing over the repeated learning trials. Moreover, the trial x group interaction was statistically significant ($F[1,273] = 6.11$, $p = .003$, $\eta_p^2 = .022$), indicating that the difference in word recall performance between the two groups grew over the three trials (see Figure 1).

Subsequent tests of simple main effects indicated further that the neurotypical control group performed significantly better than the ADHD group in the second trial ($M_{diff} = 1.62$, $p < .001$) and in the third trial ($M_{diff} = 1.92$, $p < .001$). However, the difference between the two groups in the first trial failed to reach statistical significance ($M_{diff} = 0.91$, $p = .057$).

In sum, these results support the first hypothesis, according to which participants with ADHD will show impaired performance on the WLL task compared to neurotypical controls.

Figure 1

Participants' average scores on the word list learning task across three trials



Hypothesis 2: Adults With ADHD Show Impairments in Spontaneous Use of Memory Strategies

Frequency of Spontaneous Strategy Use

The one-way ANOVA with group as the independent variable and the number of trials (0-3) in which a strategy was used as the dependent variable showed a significant difference between the two groups, (F[1,273] = 6.13, p = .014, η_p^2 = .022). This was due to the fact that the ADHD group used strategies less frequently (M = 2.43, SD = .98) than the neurotypical control group (M = 2.71, SD = .718).

The subsequent Chi-square analyses compared the proportions of strategy users vs. non-users in the two groups separately for each trial. There was a statistically significant difference in the proportion of strategy users in the two groups during the second trial (X^2[2] = 8.89, p = .003) but not during the first (p = .206) or the third trial. Nevertheless, the third trial showed a trend in the same direction as the second trial (p = .061), that is, less frequent strategy use in the ADHD group (See Table 2).

As a reference point for the following analysis, I compared the two groups with a one-way ANOVA by using the summative word recall score over the three trials as the dependent variable. As expected based on the initial analysis described above (Hypothesis 1), there was a significant group difference (F[1,273] = 13.30, $p < .001$, $\eta_p^2 = .047$). Thus, on the summative word recall score, the neurotypical control group showed better performance (M = 35.44, SD = 7.84) than the adults in the ADHD group (M = 30.98, SD = 10.69). In the next analysis, the total number of trials in which a strategy was used was included in the model as a covariate. The results showed that with the covariate, the group difference remained significant, but was slightly smaller (F[1,273] = 10.06, $p = .002$, $\eta_p^2 = .036$). Thus, despite taking into account the frequency of strategy use, the groups still differed in their word recall. Additionally, the effect of the covariate on the summative word recall score was significant (F[1,273] = 11.44, $p < .001$, $\eta_p^2 = .041$).

These results provide support to the first part of hypothesis 2, which predicted that the adults in the ADHD group will use strategies less frequently than the neurotypical control group. Additionally, frequency of strategy use explained some of the difference in memory performance between the two groups. However, even when frequency of strategy use was controlled for, the group difference in memory performance remained clearly significant, indicating that other factors are also in play.

Table 2

Trial-wise frequency of strategy use in adults with ADHD vs. neurotypical controls

		Self-reported strategy use					
		Trial 1		Trial 2		Trial 3	
		N	%	N	%	N	%
Group	ADHD	54	83.1%	52	80%	52	80%
	Control	186	89%	194	92.8%	186	89%

Efficacy of Spontaneous Strategy Use

To study the second part of hypothesis 2, I performed three separate two-way ANOVAs, one for each trial, to investigate possible differences in the efficacy of strategy use (the magnitude of performance advantage when using a strategy) between the two groups. The independent variables in the analysis were group and strategy type. The latter one was divided into no strategy, maintenance strategy and manipulation strategy. The dependent

variable was the word recall performance on the trial. A group difference in efficacy of strategy use would surface up as a statistically significant group x strategy type interaction, so that the difference between no strategy vs. maintenance and/or manipulation strategy users would be smaller in the ADHD group than in the control group. Descriptive statistics from the three two-way ANOVAs can be found in Table 3.

In the first trial, a significant main effect of strategy use on the number of correct responses was observed (F [2,273] = 7.75, $p < .001$, $\eta_p^2 = .055$). Main effect of group (F [1,273] = .389, $p = .533$, $\eta_p^2 = .001$) and the interaction term between group and strategy type (F [2,273] = .97, $p = .393$, $\eta_p^2 = .01$) were non-significant. Simple main effects tests of strategy type revealed that during the first trial, there was no overall difference in efficacy when utilizing a maintenance strategy over no strategy ($p = .36$). However, using a manipulation strategy was more effective than using no strategy ($M_{diff} = 2.23$, $p = .001$) or a maintenance strategy ($M_{diff} = 1.61$, $p = .001$).

In the second trial, I found significant main effects of strategy use (F [2,273] = 9.04, $p < .001$, $\eta_p^2 = .04$) and group (F [1,273] = 4.46, $p = .036$, $\eta_p^2 = .016$). Thus, strategy use was associated with better performance on the WLL task and the participants in the neurotypical control group averaged a higher word recall than the adults with ADHD. In line with the results from the first trial, the interaction term between group and strategy type was non-significant (F [2,273] = .43, $p = .648$, $\eta_p^2 = .003$). Simple main effects tests of strategy type revealed that during the second trial, there was no overall difference in efficacy when utilizing a maintenance strategy over no strategy ($p = .60$). However, using a manipulation strategy was more effective than using no strategy ($M_{diff} = 2.04$, $p = .001$) or a maintenance strategy ($M_{diff} = 1.69$, $p < .001$).

In the third trial, the results showed a significant main effect of strategy use (F [2,273] = 5.21, $p = .006$, $\eta_p^2 = .037$) and group (F [1,273] = 13.26, $p < .001$, $\eta_p^2 = .047$). In line with the results from the second trial, strategy use was associated with higher performance on the WLL task, and the neurotypical control group averaged a higher word recall than the adults with ADHD. In line with the results from the first and second trial, the interaction term between group and strategy type was non-significant (F [2,273] = .15, $p = .859$, $\eta_p^2 = .001$). Simple main effects tests of strategy type revealed that during the third trial, there was no overall difference in efficacy when utilizing a maintenance strategy over no strategy ($p = .34$). However, using a manipulation strategy was more effective than using no strategy ($M_{diff} = 1.66$, $p = .004$) or a maintenance strategy ($M_{diff} = 1.02$, $p = .05$).

Table 3

Average word recall performance as a function of group and strategy type in the three trials.

		Trial 1	Trial 2	Trial 3
Group	Strategy type	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Control	No Strategy	7.04 (2.51)	10.40 (1.99)	12.61 (3.03)
	Maintenance	8.04 (2.65)	10.96 (2.47)	13.61 (2.53)
	Manipulation	10.13 (3.26)	12.96 (2.81)	14.44 (2.35)
ADHD	No Strategy	7.55 (4.61)	9.85 (3.44)	11.23 (4.75)
	Maintenance	7.79 (3.51)	10.00 (3.95)	11.50 (3.65)
	Manipulation	8.92 (3.64)	11.38 (3.55)	12.71 (3.71)
Total	No Strategy	7.21 (3.27)	10.14 (2.72)	12.11 (3.73)
	Maintenance	7.97 (2.91)	10.7 (2.95)	13.07 (2.97)
	Manipulation	9.91 (3.35)	12.66 (3.01)	14.08 (2.77)

Discussion

This study set out to examine whether the verbal episodic memory (VEM) deficit in adult ADHD would be related to impaired use of self-generated mnemonic strategies. Although ADHD is characterized by several neurocognitive deficits including difficulties with attentional regulation, impulsivity, and hyperactivity (Faraone et al., 2021), a deficient long-term memory system is generally not seen as characteristic of the diagnosis. Nevertheless, in adults with ADHD, impaired VEM has been observed in several studies (Fuermaier et al., 2013; Lundervold et al., 2019; Orban et al., 2022; Skodzik et al., 2017). The study addressed the cognitive mechanisms underlying deficient VEM performance in adults with ADHD by focusing on spontaneous mnemonic strategy use. Self-generated mnemonics represent a compensatory mechanism strongly associated with EFs, being important at the encoding phase of memory formation where the ADHD-related VEM deficit

has been located. To test whether impairments in spontaneous strategy use could be related to poorer VEM performance in adults with ADHD, a sample of 64 participants with ADHD and 209 neurotypical participants were examined with a word list learning (WLL) task.

Hypothesis 1: Verbal Episodic Memory is Impaired in Adult ADHD

In line with previous studies (Fuermaier et al., 2013; Lundervold et al., 2019; Orban et al., 2022; Skodzik et al., 2017), the present sample of adults with ADHD showed impairment on the WLL task when compared to neurotypical controls. Thus, the first hypothesis on impaired VEM performance in adults with ADHD was confirmed. Additionally, an interaction effect between group and trial was observed, as the adults with ADHD benefited less from the repeated learning trials, further exacerbating their deficit. The ADHD group performed significantly worse than the controls on the second and the third trial, while the group difference was close to significant on the first trial.

The increasing performance difference between the two groups suggests a verbal learning impairment in the adult ADHD group. This concurs with previous evidence showing impaired learning in adults with ADHD during verbal list-learning tasks when compared with neurotypical controls (Woods et al., 2002). A previous study on children with ADHD (Kaplan et al., 1998) found similar results and suggested that the observed learning deficit could be attributed to attentional difficulties. Based on their meta-analysis, Skodzik et al. (2017) similarly argued that the primary source for the VEM impairment in adult ADHD lies in an encoding deficiency, not a deficiency in retention or recall. This conclusion further motivates the present focus at spontaneous strategies, as they are relevant especially for the encoding phase of VEM.

Hypothesis 2: Adults with ADHD have problems in Spontaneous Memory Strategy Use

After the existence of a VEM deficit in the present sample of adults with ADHD was confirmed, possible group differences in the frequency and efficacy of spontaneous strategy use were examined, as these could underlie the VEM impairment. The results revealed that the adults with ADHD did use strategies less frequently than the neurotypical control group. When frequency of strategy use was statistically controlled in an ANCOVA model, the group difference in VEM performance diminished somewhat, suggesting that the frequency of strategy use explained some of the performance difference between the ADHD group and the neurotypical control group. At the same time, a significant group difference still remained, indicating that there are other major factors that underlie the VEM deficit.

Furthermore, the results suggested that in line with previous mnemonic strategy studies, strategy use was associated with superior memory performance (Camp et al., 1983; Gross & Rebok, 2011; Waris et al., 2021). In line with the levels of processing framework that claims that deeper mental processing of information is associated with better memory performance (Craik & Lockhart, 1972), this advantage was seen in the users of the more cognitively engaging manipulation strategies. Manipulation strategy use was associated with similar performance advantages in both groups, suggesting that adults with ADHD were not less effective in employing such strategies. Thus, the impairment in spontaneous strategies in the adult ADHD group concerned only the frequency of strategy use, not the efficacy when they chose to employ a manipulation strategy.

Why Adults with ADHD Employed Strategies Less Often?

The question then remains why adults with ADHD employed strategies less often. As this study dealt with spontaneous strategy use, it is not possible to know to what extent this is a matter of individual choice or an inability of at least some adults with ADHD to fully utilize self-generated strategies. Strategy-related studies in children would point to the second alternative, as children with ADHD have not benefited from strategy instructions during a memory task (Comoldi et al., 1999; Kofman et al., 2008). However, children are not fully comparable to adults whose cognitive systems have matured.

If less frequent strategy use in adult ADHD reflects a deficit, it could stem from their well-documented problems with EF. One of the studies mentioned above (Comoldi et al., 1999) found that although children with ADHD did not benefit from receiving strategy instructions, they did benefit from receiving assistance during the task. Receiving metacognitive support during the task could possibly aid attentional regulation and, therefore, heighten the likelihood of strategy employment. In line with this, Skodzik et al. (2017) suggested that the encoding deficiency during VEM tasks found in adult ADHD populations could be due to insufficient attention being allocated to the phonological loop of WM. This, in turn, could lead to insufficient manipulation and encoding of the presented material, which involves possible strategy implementation as well. This claim is backed up by evidence from a study by Lundervold et al. (2019), which found that WM and inhibition in part accounted for poorer performance on VEM tasks in adults with ADHD. In addition, neurophysiological studies on adult ADHD have provided evidence for attentional dysfunction affecting encoding in the visual WM (Kim et al., 2014; Ortega et al., 2020; Zhao et al., 2020). However, the studies discussed above did not address WM functions during an episodic

memory task. Attentional regulation and WM are two key components of EFs (Miyake et al., 2000). As EFs are deficient in ADHD, it is plausible that they in part explain why adults with ADHD employ strategies less frequently. It remains to be seen whether the hypothesis on poor attentional allocation to the phonological loop could account for the significant group difference in WLL performance that remained after taking the less frequent strategy use in the ADHD group into account.

Strengths and Limitations of The Study

Some strengths and limitations regarding the present study setting, sample and measures are worth mentioning. Firstly, the participants engaged in the experiment remotely via an online website, and there is no information regarding the setting in which they completed the task. Thus, the participants' performance on the WLL task could have been affected by distractors in their environment. Nevertheless, participants tend to show only slight differences in performance when participating in experiments online, as opposed to a laboratory setting (Germine et al., 2012; Luna et al., 2021; Nussenbaum et al., 2020). Furthermore, possible distractors were counteracted by instructing the participants to perform the tasks in a calm setting, and by applying outlier exclusion criteria to the sample. Furthermore, the online format also resulted in a relatively large sample size, which further strengthens the results from the statistical analyses.

Secondly, the non-random participant selection via an online platform could have biased the samples. Indeed, the ADHD sample contained characteristics which are not representative of the population. Out of the 73 participants with an ADHD diagnosis, 43 were female. As ADHD has been shown to be more prevalent among males (Faheem et al., 2022), the male to female ratio in the present ADHD group was uncommon. Additionally, many of the participants in the ADHD sample did not actively take medication, and those who had taken medication within 24 hours were removed from the study. The limited use of ADHD-related medication could reflect a prevalence of milder symptomatology's in the ADHD sample, which in turn could have attenuated the group differences in WLL performance and strategy employment. In other words, one should exert caution in generalizing the present results to the whole population of adults with ADHD.

Finally, the open-ended strategy questionnaires which required the participants to report which strategies they used rely on the participants' ability to verbally describe their chosen strategies in an accurate fashion. It is possible that the participants varied in the degree they were aware of the strategies they employed, as well as in the degree to which

they chose to report their strategy use in detail. However, the open-ended strategy questionnaires also provided more information about strategies than what could be obtained with indirect measures of strategies, such as clustering of semantically or phonologically related words in recall. As many strategy types are difficult to deduce from objective performance features, they would go unnoticed if subjective strategy questionnaires would not be used.

Conclusions and Future Directions

This study provides further evidence of a VEM deficiency in adults with ADHD when compared to neurotypical controls. This impairment appears to have cumulative effects, as adults with ADHD benefited less from repeated learning trials during a VEM task than their neurotypical controls did.

Regarding strategy use in the VEM task, adults with ADHD were able to utilize advantageous manipulation strategies as efficiently as the neurotypical control group. However, they did not employ strategies as often. This explained some of the group difference found between the two groups, but a large portion of the variance remained unexplained. Strategy use therefore only partly explains the VEM deficit found in ADHD. Deficient strategy employment by the ADHD group as well as the unexplained variance of the group difference may be attributed to the well-documented EF deficit in ADHD. More specifically, as Skodzik et al. (2017) hypothesized, attentional allocation to the phonological loop during encoding might explain deficient VEM performance by adults with ADHD. In addition, neurophysiological evidence of attentional dysregulation during the encoding phase of visual WM (Kim et al., 2014; Ortega et al., 2020; Zhao et al., 2020) further motivates focusing on EFs, and specifically attentional allocation during VEM tasks. Therefore, future studies regarding VEM in adults with ADHD should turn their attention to the components of EF during the encoding phase of VEM formation to uncover the cognitive mechanisms underlying the deficit. In addition, future studies focusing on the neural correlates of WM attentional allocation during VEM tasks could advance our understanding of the VEM deficit observed in adults with ADHD. Better insights into the mechanisms of this deficit could also help in designing treatments for this pervasive cognitive problem.

Swedish Summary

ADHD (attention deficit hyperactivity disorder) är en vanlig neuropsykiatrisk funktionsnedsättning som kännetecknas av nedsättningar i reglering av uppmärksamhet, impulsivitet och hyperaktivitet (Faraone et al., 2021). ADHD beaktas oftast som en barndomsrelaterad funktionsnedsättning, men i 50% av fallen fortsätter den in i vuxenålder (Lara m.fl., 2009). Ett flertal kognitiva förmågor har visats vara nedsatta i ADHD. Till exempel, exekutiva funktioner (EF), arbetsminne, bearbetning av information, inhiberingsförmåga och verbalt episodiskt minne (VEM) (Hervey m.fl., 2004; Schoechlin & Engel, 2005).

Nedsättningen i VEM hos vuxna med ADHD har observerats i ett flertal studier (Fuermaier m.fl., 2013; Lundervold m.fl., 2019; Orban m.fl., 2022; Skodzik m.fl., 2017). Dock har det förblivit oklart vilka specifika kognitiva mekanismer bidrar till denna nedsättning. Syftet med denna studie är därmed att undersöka ifall spontan användning av minnesstrategier, en färdighet som är nära kopplat till EF, kunde förklara varför vuxna med ADHD konsekvent presterar sämre på uppgifter som mäter VEM.

EF kan delas in i tre komponenter: 1) Att skifta uppmärksamheten mellan uppgifter eller mentala föreställningar, 2) uppdatering av innehåll i arbetsminnet, och 3) inhiberingsförmåga (Miyake m.fl., 2000). Dessa tre komponenter anses viktiga för att kunna utföra komplexa kognitiva uppgifter, som att planera för och åstadkomma mål samt för att bearbeta och manipulera information (Miyake m.fl., 2000). Forskning i ADHD har riktat mycket uppmärksamhet mot nedsatta EF och de har föreslagits vara i kärnan av symptombilden i ADHD (Barkley, 1997). Enligt Barkleys (1997) modell, kan symptomen i ADHD förklaras utifrån nedsatta EF. En del andra teoretiska har även föreslagits (Sergeant m.fl., 1999; Sonuga-Barke, 2005). Oavsett vilken teoretisk modell man ser på, identifieras ändå nedsatta EF konsekvent i ADHD (Wilcutt m.fl., 2005), och kan därför beaktas som en central del av ADHD symptombilden.

VEM är en komponent av episodiskt minne, som i sin tur är en del av långtidsminne. Episodiskt minne kan definieras som minnet av händelser och fakta som är bundet i tid och plats (Squire & Zola, 1996). Episodiskt minne innehåller ett flertal olika kategorier, bland annat minnen av verbal information och minnen av visuell information (Schoenberg & Scott, 2011). För att information skall lagras i långtidsminne krävs det att informationen först bearbetas i arbetsminne (Cowan, 2010). Kapaciteten av arbetsminnet är begränsat, vilket innebär att en människa kan endast hålla en viss mängd information i arbetsminnet före det

överbelastas (Baddeley, 2003). Ifall arbetsminnet överbelastas, kommer en del av den informationen som bearbetats i arbetsminne inte att lagras i långtidsminnet.

I denna studie fokuserar jag på den komponenten av episodiskt minne som berör verbalt lagrad information, eftersom det är denna komponent som i ett flertal studier observerats vara nedsatt i ADHD (Fuermaier m.fl., 2013; Lundervold m.fl., 2019; Orban m.fl., 2022; Skodzik m.fl., 2017). Av dessa studier framstår Skodzik med flera (2017) som den studien som bidragit mest till forskningsfältet. I deras meta-analys av 19 studier med 831 vuxna med ADHD och 771 kontroller fann de att vuxna med ADHD presterar sämre på uppgifter som mäter VEM. Utöver detta fann de att denna prestationsskillnad inte överfördes till den visuella domänen av episodiskt minne, och därmed verkar nedsättningen hos vuxna med ADHD vara specifikt i den verbala domänen av episodiskt minne.

Nedsättningen i VEM hos vuxna med ADHD väcker frågan vare sig nedsättningen är ett primärt symtom i ADHD eller om det är ett sekundärt symtom som uppkommer tack vare nedsatt inkodning av information som är relaterat till andra neurokognitiva nedsättningar. Både Skodzik med flera (2017) och Fuermaier med flera (2013) fann i sina studier att vuxna med ADHD visade nedsättningar i inkodningsfasen av minneslagring. Däremot presterade vuxna med ADHD och kontrollgrupperna lika väl i lagrings- och återkallningsfasen. Lundervolds (2019) studie bidrog med resultat som delvis förklarade den nedsatta inkodningsförmågan som observerades hos vuxna med ADHD. I deras studie fann de att nedsatt arbetsminne och inhiberingsförmågan, vilka är båda viktiga komponenter av EF (Miyake m.fl., 2000), förklarade delvis vuxna med ADHD:s nedsatta prestation på VEM uppgifter. Utgående från dessa studier, är det möjligt att vuxna med ADHD:s nedsättning i VEM beror på ineffektiva inkodningsprocesser som kan förklaras av exekutiv dysfunktion.

Användningen av minnesstrategier då man försöker memorera information utökar kapaciteten av arbetsminnet (McNamara & Scott, 2001; Unsworth & Spillers, 2010). Exempelvis, minnesstrategier som att försöka gruppera information eller skapa associationer mellan informationen som skall memoreras stöder inkodningen av information i långtidsminnet. Craik and Lockharts (1972) ramverk stöder detta påstående. De föreslår att desto mera information bearbetas i arbetsminnet, desto större är sannolikheten att informationen lagras i långtidsminnet. Utöver detta har ett flertal studier hittat associationer mellan användningen av minnesstrategier och bättre prestation på minnesuppgifter (Camp m.fl., 1983; Gross & Rebok, 2011; Waris m.fl., 2021). Dessutom har användningen av minnesstrategier visats vara positivt korrelerade med EF (Comoldi m.fl., 1999; Garner, 2009). Eftersom nedsatta EF är en central komponent av ADHD symtombilden (Barkley

1997) kan det vara att de som har en ADHD diagnos också har en nedsatt förmåga att använda sig av minnesstrategier. Det finns evidens för att barn med ADHD skulle använda minnesstrategier mindre effektivt än kontroller (Comoldi m.fl., 1999; Egeland m.fl., 010). Dock saknas det stark evidens för att detta skulle vara läget även hos vuxna. En småskalig studie av Roth med flera (2004) fann att vuxna med ADHD använde en semantisk organisationsstrategi mindre ofta än kontroller. Studien fann ändå ingen evidens för att sämre prestation på VEM uppgiften skulle medieras av användningen av minnesstrategier. Likväl behövs det mera forskning kring minnestrategianvändnings roll i försämrad VEM prestation hos vuxna med ADHD. Nedsatta EF hos vuxna med ADHD tillsammans med centrala rollen av EF i användningen av minnesstrategier och förhållandet mellan strategianvändning och förbättrad prestation på minnesuppgifter vidare motiverar forskningen av detta ämne.

Målet av denna studie är tudelad. Första målet är att replikera tidigare fynd som funnit att vuxna med ADHD presterar sämre på VEM uppgifter, genom att jämföra prestationerna av vuxna med ADHD och en kontrollgrupp i inlärningen av en ordlista. Andra målet var att undersöka vare sig nedsatt spontan användning av minnesstrategier kunde förklara denna försämrade prestation av vuxna med ADHD i inlärningen av en ordlista.

Baserat på dessa mål lades följande hypoteserna fram:

1. Vuxna med ADHD kommer att prestera sämre på en VEM uppgift än kontrollgruppen
2. Vuxna med ADHD kommer att uppvisa nedsättningar i spontana användningen av minnesstrategier på en VEM uppgift jämfört med kontrollgruppen. Dessa Nedsättningar kommer att gälla frekvensen och/eller effektiviteten av strategianvändning

Metod

Denna studie använde data som samlades in i samband med en online-studie, som huvudsakligen undersökte hur vuxna med ADHD presterade på en nyutvecklad videospels uppgift Executive Performance in Everyday Living (EPELI; Jylkkä m.fl., 2023) jämfört med en kontrollgrupp. I föreliggande studie fokuserar jag på inlärningen av en ordlista som var inkluderad i testbatteriet, nämligen Word List Learning Task (WLL).

Deltagare rekryterades till studien anonymt av Jylkkä med flera (2023a) via crowdsourcing nätsidan Prolific (https://www.prolific.com/) och deltagarna fick monetär belöning för sitt deltagande i studien. Studien bestod totalt av tre olika faser: två förhandsgranskningar och den primära studien som bestod av fem sessioner utspritt över fem

dagar. I förhandsgranskningarna fick deltagarna besvara frågor angående bland annat ADHD diagnos, demografisk information, mental hälsa och syn. Efter första förhandsgranskningen bjöds in 1517 deltagare till andra förhandsgranskningen. Efter den andra förhandsgranskningen och efter att alla deltagare som hade tagit ADHD medicinering inom 24 timmar eller saknade något värde i en test variabel togs bort, kvarstod 274 deltagare. Av de 274 deltagarna som deltog i studien tillhörde 65 ADHD gruppen och 209 kontrollgruppen. Grupperna skiljde sig inte mycket åt från varandra gällande ålder, utbildning eller prestation på ett intelligenstest. Däremot var kontrollgruppen signifikant större än ADHD gruppen, och kvinnokön var överrepresenterat i båda grupperna.

WLL uppgiften som användes för att mäta VEM och inlärning i föreliggande studie utvecklades av Waris, Fellman med flera (2021). I WLL uppgiften presenterades deltagarna med en lista av 18 vanliga substantiv sammanlagt 3 gånger i randomiserad ordning. Efter att listan hade presenterats i sin helhet, fick deltagarna utföra en enkel matematisk distraktionsuppgift vars mening var att engagera deltagarnas arbetsminne så att orden från listan inte kunde återkallas från arbetsminnet. Efter att distraktionsuppgiften avslutades, fick deltagarna återkalla så många ord från listan som de kunde. Efter att detta var avklarat, fick deltagarna fritt beskriva hurudana strategier de använde sig av för att komma ihåg ordlistan, ifall de använde sig av en strategi. Deltagarnas strategibeskrivningar delades in i 7 olika strategityper av två oberoende bedömare. Strategityperna grupperades vidare in i 3 bredare kategorier utifrån Waris med flera (2021) och Fellman med flera (2020). Första kategorin, ingen strategi, inkluderade beskrivningar av strategier som indikerade att deltagaren inte hade använt sig av en strategi. Den andra kategorin, upprätthållande strategier, inkluderade strategier då deltagarna hade försökt upprepa orden i arbetsminnet eller selektivt rikta deras uppmärksamhet till någon av orden. Den tredje kategorin, manipuleringsstrategier, inkluderade strategier då deltagarna hade grupperat, associerat eller visualiserat orden i ordlistan. Även övriga strategier som inte kunde kategoriseras inkluderades i denna kategori.

Statistiska analyserna gjordes med IBM SPSS Statistics 29.0. För att undersöka ifall ADHD gruppen presterade sämre på WLL uppgiften än kontrollgruppen, utförde jag en tvåvägs blandad ANOVA med grupp (ADHD, kontroll) och försök (1–3) som oberoende variabler och poäng på WLL uppgiften som beroende variabel. Utöver detta utförde jag en envägs ANOVA med grupp (ADHD, kontroll) som oberoende variabel och mängden försök i vilka strategier användes (0–3) som beroende variabel för att undersöka ifall ADHD gruppen använder strategier mindre frekvent än kontrollgruppen. För att vidare undersöka frekvensen av strategianvändning hos ADHD gruppen utförde jag 3 skilda Chi-kvadrat analyser, en för

varje försök på WLL uppgiften. Detta mätte jag genom att dela in deltagare i två grupper, nämligen de som använde strategier (oavsett strategityp) och de som inte använde strategier för varje försök. Eftersom resultaten tydde på en gruppskillnad i frekvensen av strategianvändning, utförde jag en kovariansanalys (ANCOVA) för att undersöka i vilken utsträckning denna gruppskillnad var associerat med gruppskillnaden i minnesprestation. I denna analys var grupp (ADHD, kontroll) oberoende variabeln och frekvensen av strategianvändning i alla försök sammanlagt (0–3) kovariaten medan summan av alla tre försök på WLL uppgiften var beroende variabeln. Slutligen ville jag undersöka vare sig ADHD gruppen använde strategier mindre effektivt än kontrollgruppen. Detta gjorde jag genom att utföra tre skilda tvåvägs ANOVAN, en för varje försök på WLL uppgiften. Oberoendevariabeln i analyserna var grupp (ADHD, kontroll) och självrapporterad strategityp (ingen strategi, upprätthållande strategi, manipulerings strategi). Prestation på WLL uppgiften var beroende variabeln för varsitt försök. Antaganden för samtliga analyser undersöktes och korrigerades vid behov.

Resultat

Resultaten från första analysen antydde att ADHD gruppen presterade signifikant sämre på WLL uppgiften än kontrollgruppen. Dessutom fanns det en effekt av försök på WLL uppgiften, vilket innebär att båda gruppernas prestationer ökade i takt med försöken. Även en interaktionseffekt hittades vilket antyder att skillnaden i prestationer på WLL uppgiften mellan de två grupperna växte över de tre försöken.

Analyserna som undersökte skillnader i strategianvändning hos ADHD gruppen och kontrollgruppen visade att ADHD gruppen använde signifikant färre strategier än kontrollgruppen på WLL uppgiften. Då de tre försöken analyserades skilt, observerade jag endast en skillnad i frekvens av strategianvändning i vid andra försökstillfället, men inte i första eller tredje försökstillfället. Kovariansanalysen som jag utförde till följd av dessa resultat visade att skillnader i frekvensen av strategianvändning förklarade en del av gruppskillnaden i prestation på WLL uppgiften, men en stor del av variansen förblev oförklarad.

Möjliga skillnader i effektiviteten av strategianvändning mellan grupperna undersökte jag med tre separata analyser, ett för varje försök. Resultaten från första försöket antydde att strategianvändning förbättrade båda gruppernas prestationer på WLL uppgiften. Dock fann jag ingen signifikant gruppskillnaden beträffande prestation på WLL uppgiften eller

interaktionseffekt mellan grupp och strategityp. Vid andra försökstillfället observerade jag en signifikant huvudeffekt av strategianvändning och grupp. Strategianvändning förbättrade prestationen på WLL uppgiften och ADHD gruppen presterade sämre än kontrollgruppen. Däremot var interaktionstermen mellan grupp och strategianvändning icke-signifikant. Likt andra försöket, presterade ADHD gruppen signifikant sämre än kontrollgruppen på WLL uppgiften och strategianvändning förbättrade signifikant prestation på WLL uppgiften på tredje försöket. Även på tredje försöket var interaktionstermen mellan grupp och strategianvändning icke-signifikant.

Utöver dessa resultat utfördes analyser av enkla huvudeffekter för att belysa associationen mellan tre strategityper och prestation på WLL uppgiften. Resultaten från alla tre försök antydde att användningen av en manipulationsstrategi var effektivare än att använda en upprätthållande strategi eller ingen strategi för båda grupperna. Däremot var det inte effektivare att använda en upprätthållande strategi jämfört med ingen strategi alls.

Diskussion

Syftet med denna studie var att undersöka ifall en nedsättning i VEM hos vuxna med ADHD kunde delvis förklaras av en nedsatt förmåga i användningen av spontana minnesstrategier. I likhet med tidigare studier fann jag att vuxna med ADHD presterade sämre på WLL uppgiften jämfört med kontrollgruppen. Detta resultat bekräftade således studiens första hypotes och replikerade tidigare studier som också funnit en nedsättning i VEM hos vuxna med ADHD (Fuermaier m.fl., 2013; Lundervold m.fl., 2019; Orban m.fl., 2022; Skodzik m.fl., 2017). Utöver detta observerade jag en interaktionseffekt mellan grupp och försök, vilket innebär att ADHD gruppen fick mindre nytta av upprepade försök på WLL uppgiften jämfört med kontrollgruppen. En tidigare studie fann också att vuxna med ADHD visade nedsatta inlärningsförmågor på en VEM uppgift jämfört med en kontrollgrupp (Woods m.fl., 2002). Skodzik med flera (2017), baserat på deras meta-analys, resonerade att VEM nedsättningen i vuxna med ADHD kunde bero på problem vid inkodningsfasen av minneslagring. Således motiverar den observerade interaktionseffekten och Skodzik med fleras (2017) resonemang att fokusera på spontan minnesstrategianvändning, eftersom de är involverade vid inkodningsfasen av VEM.

Resultaten från denna studie antydde att vuxna med ADHD använde strategier mera sällan än kontrollgruppen. Ytterligare antydde resultaten från kovariansanalysen att denna skillnad i frekvens av strategianvändning förklarade delvis den observerade gruppskillnaden i

prestation på WLL uppgiften. Dock förblev en stor del av variansen oförklarad, vilket tyder på att även andra faktorer än frekvensen av spontan strategianvändning påverkar gruppskillnaden. I linje med tidigare studier (Camp m.fl., 1983; Gross & Rebok, 2011; Waris m.fl., 2021), var strategianvändning associerat med bättre prestation på WLL uppgiften. I linje med Craik & Lockharts (1972) nivåer av bearbetning ramverk var mera krävande strategier (manipulationsstrategier) associerat med bättre prestation på WLL uppgiften. Båda grupperna lyckades dra nytta av strategier lika mycket. Med andra ord använde ADHD gruppen färre strategier, men när de valde att använda en strategi, kunde de använda den lika effektivt som kontrollgruppen.

Resultaten väcker frågan kring varför vuxna med ADHD använder strategier mindre frekvent än kontrollgruppen. Det är möjligt att denna nedsättning är ett resultat av de väldokumenterade problemen med EF i ADHD. En studie fann att barn med ADHD inte drog nytta av att få instruktioner kring strategianvändning, men då de fick hjälp under uppgiften presterade de lika väl som kontrollgruppen (Comoldi m.fl., 1999). Det är möjligt att den metakognitiva stöden som de fick under uppgiften stödde uppmärksamhetsreglering och således också strategianvändning. Skodzik med flera (2017) argumenterade i linje med de ovannämnda resultaten, att nedsättningen i inkodningsfasen av VEM hos vuxna med ADHD kunde bero på att uppmärksamhet bristfälligt fördelas till fonologiska loopen i arbetsminne. Detta i sin tur kunde leda till att materialet som skall föras in i långtidsminnet inte manipuleras eller inkodas godtyckligt, vilket skulle även försvåra strategianvändning. Evidens för att arbetsminne och inhibering delvis förklarar VEM nedsättningen hos vuxna med ADHD vidare motiverar denna hypotes (Lundervold m.fl., 2019). Utöver detta finns det neurofysiologisk evidens på vuxna med ADHD som visar att nedsatt uppmärksamhetsreglering påverkade inkodning i visuellt arbetsminne (Kim m.fl., 2014; Ortega m.fl., 2020; Zhao m.fl., 2020).

Denna studie utfördes med en online-format vilket för med sig både styrkor och svagheter. Online-formatet bidrog till att omgivningen i vilken deltagarna utförde experimentet inte kunde kontrolleras. Dock motiveras online-formatet med att deltagarna instruerades i förhand att utföra uppgifterna i lugna utrymmen för att minimera distraktioner. Utöver detta tenderar deltagare att endast visa små skillnader i prestation i online-experiment jämfört med experiment utförda i laboratorium (Germine m.fl., 2012; Luna m.fl., 2021; Nussenbaum m.fl., 2020). Rekryteringen av deltagarna gjordes inte heller slumpmässigt vilket kan ha påverkat resultaten. Detta bidrog ändå till en relativt stor sampelstorlek vilket stärker resultaten från de statistiska analyserna. Därutöver var samplet i studien icke-

representativ av populationen eftersom kvinnor med ADHD var överrepresenterade. Dessutom tog flera av deltagarna inte regelbundet medicin för deras ADHD och de som hade tagit medicin inom 24h exkluderades från studien. Detta kan tyda på att ADHD samplet hade lindrigare symptom än populationen som helhet. Slutligen kan de öppna strategirapporterings frågeformulären ha påverkat i vilken utsträckning deltagarna rapporterade sina strategier. Däremot gav de öppna frågeformulären mera nyanserad information kring deltagarnas strategianvändning än indirekta mått på strategianvändning.

Resultaten från denna studie replikerar tidigare fynd gällande nedsatt VEM hos vuxna med ADHD. Därutöver bidrar denna studie med information kring strategianvändningens roll i nedsättningen. Även om frekvensen av strategianvändning kunde förklara en del av den observerade gruppskillnaden i VEM mellan vuxna med ADHD och kontroller, förblev en stor del av variansen oförklarad. Framtida studier kunde fokusera på komponenter av EF som är verksamma under inkodningsfasen av VEM för att avslöja de kognitiva mekanismer som ligger bakom nedsättningen och därmed bidra till utvecklingen av behandlingar för denna kognitiva nedsättning.

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Appendix

Instructions for coding the primary strategy type in participants' open strategy reports after each trial.

Code for strategy type	Type	Examples
0	**No explicit strategy use** • No strategy • No clear evidence of strategy use • Repetition of instructions or own action sequence • Response unrelated to strategy use, • comments on understanding instructions, or comments on task difficulty • Guessing, intuition, instinct, familiarity, 'gut feeling'	• "No system" • "I tried" • "I tried to keep up with the list but found it quite difficult" • "Just tried to concentrate on the words" • "I memorized the words mentally" • "I memorized all the words" • "Tried to apply a strategy/mnemonic"(with no description as to what the strategy/mnemonics would have been)
1	**Rehearsal / Repetition** • Rehearsing items verbally, nonverbally or visuomotorically • *E.g. repeating, speaking in head, saying in mind, yelling the tasks, rehearsing quietly*	• "I repeated the words" • "I rehearsed the words in my mind" • "Said aloud all the items in the list in order to keep them in memory"
2	**Grouping** • Grouping items together • *E.g. chunking, pairing, memorizing in groups, remembering in chunks, thinking*	• "I memorized the words in chunks" • "I grouped the words in pairs" • "I remembered the words in groups" • "grouped together in my mind words that rhymed"

	in pairs, dividing into subsets, subdividing into sets, splitting into shorter sequences	
3	**Association** • - Associating the objects/actions with something outside the stimuli	• "I tried to associate each word with something that I have at home"
4	**Visualization of objects and/or locations** • • Linking tasks with some visual/visuospatial representations in mind • • *E.g. visualizing objects in mind, forming spatial images, visualizing objects in their locations*	• "Built a mental image of the words in my mind" • "Visualized the words as they were shown" • "I was picturing the words in my head"
5	**Selective focus** • Focusing on only some of the tasks or keywords for the tasks	• "I focused on remembering only a subset of the words and disregarded the rest" • "Just concentrated on the easy words as the task was quite difficult" • "Focused on the words I had previously forgotten" • "Fixated only on the first 4 words"
6	**Other strategy**	• "Made up a story based on the words to remember them better" • "I tried to match the words to those I saw previously"

Adapted from Laine et al. (2023)

PRESSMEDDELANDE

Nedsättningar i språkligt minne hos vuxna med ADHD kan delvis bero på att de använder färre minnesstrategier

Varför har vuxna med ADHD ofta problem med språkligt minne? Resultaten från en pro-gradu avhandling vid Åbo Akademi tyder på att en orsak kan ligga i minnestrategier som vuxna med ADHD visade sig använda mera sällan än de som inte har en ADHD diagnos. De hade dock lika stor nytta av strategier som kontrollgruppen då de valde att använda en strategi.

Även om strategianvändningen spelar en roll i det sviktande språkliga minnet hos vuxna med ADHD, verkade den förklara endast en del av denna minnesproblematik. Det är sannolikt att de observerade problemen med språkligt minne härstammar även från de välkända symtomen av ADHD, dvs. nedsatt reglering av uppmärksamhet som kan påverka bearbetningen av språkligt material då det ska lagras i minnet.

Datat samlades in genom en nätbaserad testningsplattform där deltagarna fick lära sig en lista ord och rapportera vilka minnesstrategier de hade använt sig av. Totalt deltog 274 engelskspråkiga deltagare från Storbritannien varav 65 hörde till ADHD gruppen och 209 till kontrollgruppen.

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