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Latent Profile Analysis of Working Memory Performance in a Sample of Children with
ADHD

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Abstract

The current study used latent profile analysis (LPA) to ascertain distinct groups of children with ADHD ($N = 701$) in terms of performance on working memory (WM) tasks that tapped visuospatial sketchpad, spatial central executive, and verbal central executive functions. It compared the WM performances of these classes with a clinical comparison group ($N = 59$). The participants' age ranged from 7 to 16 years (586 males, 71 females). The results of the LPA supported three classes. For all three WM tasks, class 1 ($N = 196$) had more difficulties than classes 2 ($N = 394$) and 3 ($N = 111$), and the clinical comparison group. Class 2 had more difficulties than class 3 and the clinical comparison group, and there was no difference between class 3 and the clinical comparison group. Class 1 had lower IQ and academic abilities, and relatively more individuals with depressive disorders. The implications of the findings for understanding ADHD and its treatment are discussed.

Key Words: ADHD, Working Memory, Latent Profile Analysis, Children and Adolescents

Latent Profile Analysis of Working Memory Performance in a Sample of Children with ADHD

Working Memory (WM) involves the ability to maintain and manipulate information over brief periods of time without reliance on external aids or cues (Baddeley, 2000). The results of studies of WM in children with Attention-Deficit/Hyperactivity Disorder (ADHD; DSM-IV-TR, American Psychiatric Association (APA), 2000; DSM-5, APA, 2013) have shown a high degree of heterogeneity in WM performance among children with ADHD. For a group of children and adolescents (henceforth referred to as children) with ADHD, the current study used latent profile analysis (LPA) to identify more homogenous ADHD groups with similar within group WM profiles. To date this or related procedures have not been applied to this area of research.

Baddeley (2000) has proposed a WM model that has featured extensively in ADHD research (Martinussen, Hayden, Hogg-Johnson, & Tannock, 2005; Walshaw, Alloy & Sabb 2010; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005a). In this model, WM is conceptualized as comprising two limited-capacity short-term memory components called the phonological loop (responsible for temporary storage and rehearsal of phonological or verbal information, such as remembering a series of digits) and visuospatial sketchpad (responsible for the temporary storage and rehearsal of visuospatial information, such as remembering a series of locations), and a central executive (CE). The CE is involved when higher levels of processing within WM are needed. The CE oversees and coordinates the phonological loop and the visuospatial sketchpad, and also influences their interactions with long-term memory. Although

Baddeley's model proposes a modality-general CE, some ADHD WM studies have differentiated CE into verbal and spatial processes (e.g., Martinussen et al., 2005).

According to the DSM-IV-TR (APA, 2000) there are three types of ADHD: the predominantly inattentive type (mainly inattention symptoms), predominantly hyperactive-impulsive type (mainly hyperactive-impulsive symptoms), and the combined type (both sets of symptoms). DSM-5 (APA, 2013) has the same symptoms for ADHD as in DSM-IV-TR, but the different types are viewed as "presentation specifiers." Most previous studies have however, grouped all ADHD types or presentation specifiers together when examining WM. Although an earlier qualitative review by Pennington and Ozonoff (1996) concluded that there was no robust evidence of WM impairments in ADHD, more recent qualitative meta-analysis reviews of WM have concluded that there is support for difficulties in the phonological loop, the visuospatial sketchpad, and the CE components of WM (Martinussen et al. 2005; Walshaw et al. 2010; Willcutt et al. 2005a). However, these reviews showed differences in the effect sizes across the different WM components. Martinussen et al. (2005) reported that the overall effect sizes for the visuospatial sketchpad (Cohen's effect size or $d = 0.85$) and the spatial CE ($d = 1.06$) were larger than those obtained for the phonological loop ($d = 0.47$) and the verbal CE ($d = 0.43$). Willcutt et al. (2005a) reported larger effect size for spatial WM ($d = .63$, number of studies = 11) than for verbal WM ($d = .55$, number of studies = 8). A larger effect size for spatial WM ($d = .77$, number of studies = 7) than verbal WM ($d = .63$, number of studies = 8) has also been reported by Walshaw et al. (2010). Another major finding in all three reviews was that there was considerable heterogeneity among children with ADHD in performance of various WM components, with many of them not having

difficulties. Given this, it would be useful to identify more homogenous groups of children with ADHD in terms of their WM performance. A method well suited for such evaluation is latent profile analysis (LPA).

LPA estimation uses distributional assumptions to find distinct classes or groups of individuals . Within each class, the variables are assumed to be independent (conditional independence.). This assumption is called local independence. LPA assumes that any association between observed variables is accounted for only by the presence of the latent class. Expressed differently, latent classes are reasons for the correlation among the variables or if one removes the effect of latent class membership on the data, all that remains is randomness. It has been argued that this criterion leads to the most natural and useful groups (Lazarsfeld & Henry, 1968; Goodman, 1994).

LPA postulates a discrete latent variable to define class membership. The number of categories in the latent variable that defines class membership, which results from the LPA, represents the number of different classes or types. Individuals are grouped into their most likely class based on their observed symptoms so that individuals within a class are more similar than individuals between classes. When LPA is applied to ADHD individuals with different WM scores, it will reveal distinct classes of individuals in terms of their WM performance. **Given the conditional independence** assumption in LPA models, these classes will be independent of the correlations between the WM observed indicators, and thus LPA can potentially reveal classes that are and are not modality specific (if they exist).

Existing findings for WM in general indicate that older age (for review, see Best & Miller, 2010), higher IQ (for a review see Fry & Hale, 2000), and better reading ability

(Gathercole, Alloway, Willis, & Adams, 2006) are positively associated with better WM. Also, males generally have better visuospatial ability than females (Duff & Hampson, 2001). WM difficulties are also associated positively with Oppositional Defiant Disorder (ODD; Rhodes, Park, Seth, & Coghill, 2012), depressive disorders (Franklin et al., 2010; Matthews, Coghill, & Rhodes, 2008), and anxiety disorders (Vance, Ferrin, Winther, & Gomez, 2013). These findings raise the possibility that these factors may confound the performance on WM tasks in children with ADHD. On the other hand, it is conceivable that these variables are substantial to the performance of children with ADHD on WM tasks.

Based on archival data, the current study used LPA to examine the WM profiles of children with ADHD. To date, no study has examined the WM difficulties of children with ADHD using LPA. We defined WM in terms of the visuo-spatial sketchpad, verbal WM (phonological loop plus verbal CE), and (spatial) CE. The phonological loop by itself was not included as this information was not available in the data set used.

Appropriate tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB; www.camcog.com) were used for measuring visuo-spatial sketchpad and spatial CE. The Digit Span (DS) scale score from the Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV; Wechsler, 2003) was used as a measure of verbal WM. Using the classes to which individuals with ADHD were allocated, this study then compared the WM performance of these classes and a clinical comparison group for the visuo-spatial sketchpad, verbal WM, and spatial CE measures. We then examined the external validity of these groups by comparing them on other measures of the visuo-spatial sketchpad and spatial CE (also from the CANTAB). Following this, we compared

these classes and the clinical comparison group for attention problems and overall psychological problems, and examined the frequencies of the different ADHD types in the different LPA classes. We then compared the classes and the clinical comparison group for age, sex, IQ, reading ability, arithmetic ability, Oppositional Defiant Disorder and/or Conduct Disorder (ODD/CD), anxiety disorders, and depressive disorders. Based on the findings from these analyses, we compared the groups, controlling for appropriate covariates (revealed by the previous analyses), on all the WM tasks. Since past reviews have concluded that most, but not all, children with ADHD will have difficulties in all components of WM, with more difficulties in the phonological loop and spatial CE (Martinussen et al. 2005; Walshaw et al. 2010; Willcutt et al. 2005a), we expected to find at least the following three classes: (1) difficulties in all the WM components, (2) relatively more difficulties in the phonological loop and spatial CE compared to verbal WM, and (3) no difficulties in all the WM components.

Method

Participants

The data for all participants was collected archivally from the Academic Child Psychiatry Unit (ACPU) of the Royal Children's Hospital (RCH), Melbourne, Australia. The ACPU is an out-patient psychiatric unit that provides services for children and adolescents with behavioral, emotional, and learning problems. Referrals are generally from other medical services, schools, and social, and welfare organizations. The study was approved by the RCH ethics committee as part of our group's comprehensive examination of executive function in children and adolescents with ADHD including comorbid disorders. Each legal guardian and participant provided informed written

consent for any data provided by them to be used in future ethics approved research studies. This is a standard part of the ACPU assessment procedure. For the current study, we used the records of children, aged between 7 and 16 years, referred between 2004 and 2010, with full-scale IQ (FSIQ) of 80 and above. Two groups were formed: those with an ADHD diagnosis and those without any DSM-IV-TR disorder, including ADHD (henceforth referred to as the clinical comparison group). There was a total of 760 participants. All children with ADHD were naive with respect to stimulant and other psychoactive medications at the time of testing. The clinical comparison group was formed to enable comparison with the ADHD classes.

In total, there were 701 children with ADHD, comprising 77.6% males. The overall mean age of ADHD participants was 10.89 years ($SD = 2.77$). The clinical comparison group comprised 59 children, comprising 76.3% males. The overall mean age of clinical comparison participants was 11.07 years ($SD = 4.05$). The percentages of paternal employment status were as follows: employed = 78.2%, home duties = 2.1%, pensioner/retired = 5.7%, unemployed = 8.8%, other/unknown = 5.2%. The percentages of paternal highest education level were as follows: tertiary = 15.5%, high school/some years in secondary school or equivalent = 63.0%, technical certificate or equivalent = 18.3%, primary school = 2.5%, and no schooling = 0.7%. Thus, most fathers of participants were employed, and more than two-third of participants had fathers who had attended at least secondary school. In terms of parental relationship, about 50% of parents in both groups were living together and 43% were separated or divorced.

Measures

The measures included in this study were the Anxiety Disorders Interview

Schedule for Children (ADISC-IV; Silverman & Albano, 1996), the Cambridge Neuropsychological Test Automated Battery (CANTAB), the Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV, Wechsler, 2003), the Wide Range Achievement Test 3 (WRAT-3; Wilkinson, 1993), the Child Behavior Checklist (CBCL), and the Teacher Report Form (TRF; Achenbach & Rescorla, 2001).

Anxiety Disorders Interview Schedule for Children (Silverman & Albano, 1996).

The ADISC-IV is a semi-structured interview, based on the DSM-IV diagnostic system. Although ADISC-IV has been designed primarily to facilitate the diagnosis of the major anxiety and depressive disorders, it can also be used for diagnosing other major childhood disorders, including ADHD. Although the diagnosis of ADHD requires the presence of cross-situational symptoms, in this study diagnosis was based on parent interviews alone. There is support for the concurrent validity of the ADISC-IV ADHD module based on parent interviews (Jarrett, Wolff, & Ollendick, 2007). The ADISC-IV guidelines for diagnosis are that the child be given a diagnosis of all disorders meeting the diagnostic criteria. Disorders are diagnosed categorically (either present or absent). The scores of ADISC-IV have sound psychometric properties, including excellent test-retest reliability over a 7 to 14-day interval (Silverman, Saavedra, & Pina, 2001). Kappa values for interview with parents ranged from 0.65 to 1.00 ([Silverman et al., 2001](#)). For the current study, there was adequate inter-rater reliability for the diagnoses made between the research assistants (who collected the data) and their supervisors (who supervised the data collection), and between research assistants (kappa values generally more than .88, and ranged from .82 to .95). Clinical diagnosis for all disorders in the study was based on parent interview using the ADISC-IV. In addition to ADHD

(including ADHD subtypes), the major depressive disorders, anxiety disorders, ODD and CD were diagnosed.

Cambridge Neuropsychological Test Automated Battery (CANTAB). The CANTAB (www.camcog.com) was used for measuring the visuo-spatial sketchpad and spatial CE. The CANTAB comprises a number of neuropsychological tasks that are well standardized and validated. All tasks are computerized and performed using a touch-screen (Rhodes et al., 2004). These tasks have been extensively used with children and patient populations in the assessment of executive functions (Gau & Chang, 2010; Rhodes, Coghill, & Matthews, 2006; Walshaw et al., 2010). The specific tasks used in the current study were the Spatial Span (SS), Spatial Working Memory (SWM), and Delayed Matching to Sample (DMtS) tests. The test-retest reliabilities of these measures are satisfactory (Lowe & Rabbitt, 1998)

The Spatial Span (SS) task, used in the LPA, measures the visuospatial sketchpad. The visuospatial sketchpad is responsible for the temporary storage and rehearsal of visuo-spatial information such as remembering a series of locations. The SS task begins with nine white boxes presented in fixed locations on the screen. Following this, the boxes change color, one after the other, in a set sequence, and this ends in a tone. Upon the presentation of this tone, the individual is instructed to point to the boxes in the order in which they changed color. Thus, the SS task requires both maintenance and retrieval of stored information. The test begins with 2-box problems and gradually increases to 9-box problems. The key variable is span length, which is the longest sequence successfully recalled within three attempts. Previous studies have shown that children with ADHD have lower scores than typically developing controls on this task (Gau & Chang, 2010).

The meta-analysis by Walshaw et al. (2010) indicated that three out of three studies found significant difficulties for children with ADHD in SS, with an overall d effect size of 0.94.

The Spatial Working Memory (SWM) task measures the spatial CE of WM. The CE involves higher levels of processing in WM that oversee and coordinate the phonological loop and the visuo-spatial sketchpad. The SWM task is a self-ordered task in which individuals are asked to search through a number of colored boxes presented on the screen to find blue tokens hidden inside. Each box has only one token per trial. The SWM task, which assesses WM for spatial stimuli, requires both maintenance and manipulation of information in WM. This means that both mnemonic and executive functioning are used to work towards a goal. An efficient strategy to accomplish this task requires following a predetermined search sequence, beginning with a particular box and, when a token is found, returning to start a new sequence with that same box (Owen et al., 1990). While this score is related to spatial CE, it also measures executive planning and problem solving. The score in this task used in the LPA was the total number of between search errors, or searching an empty box that has already been searched in a previous attempt. Higher scores reflect poorer functioning. Previous studies have shown that children with ADHD have higher scores than controls on this task (Gau & Chang, 2010; Rhodes et al., 2004; Walshaw et al., 2010). The meta-analysis by Walshaw et al. (2010) indicated that five out of seven studies found significant difficulties for children with ADHD in SWM, with an overall d effect size of .77. The SWM also provides a strategy score, which is the number of search sequences starting from the same box in both 6- and 8-box problems in the SWM task. For this task, higher scores mean less efficient strategy

(i.e. many sequences starting from different boxes in a trial). The SWM-strategy score was used for external validation of the LPA classes.

Another CANTAB task used for external validation of the LPA classes was the Delayed Matching to Sample (DMtS) task. In this task, subjects are asked to remember patterns presented on a touch-sensitive screen for 4.5 seconds. Each trial begins with a presentation of the target stimuli that has four shapes that differ in color and form. At the end of presentation interval, four choice patterns appear under the target pattern, with one being identical to the target. The subject is required touch the identical choice pattern. If subjects make an incorrect response, they are required to continue to choose until the target stimulus is selected. In the “simultaneous condition”, the target pattern remains on screen with the choice pattern. For the delayed condition the target disappears from the screen before the choice patterns are presented. There are three delayed conditions or intervals: 0, 4, and 12 seconds. The simultaneous and delayed conditions are presented in a pseudo-random order, with 20 test trials for each of the four conditions. Although the DMtS measures an individual’s ability to remember complex visual stimuli, performance of this task requires visuo-spatial processing. This is because as the simultaneous and delayed trials are presented in a pseudo-random order, the subject will not know if the target will disappear. Thus, for optimum performance for each trial, including the simultaneous trials, the subject would need to use visuo-spatial processing skills in anticipation that the target stimulus could disappear. Thus, scores for DMtS, including that from the simultaneous condition, can be seen as a measure of the visuo-spatial sketchpad as performance of this task requires the temporary storage of and rehearsal of visuo-spatial information. Previous studies have shown that children with ADHD have

lower scores than controls on this task (Rhodes et al., 2004). For this study, the measure used was the percentage of correct responses in the simultaneous condition. This score can be seen as a measure of the visuo-spatial sketchpad.

Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV, Wechsler, 2003). The WISC-IV comprises 13 subtests and has a measure of an individual's overall IQ, FSIQ, and also scores for Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Processing Speed Index (PSI), and Working Memory Index (WMI). It is also possible to compute a General Ability Index (GAI), an overall measure of IQ that is less sensitive to the influence of working memory and processing speed (Raiford, Weiss, Rolfhus, & Coalson, 2005). The test as whole and all the sub-tests have excellent reliability (internal consistency and test-retest) and validity (Williams, Weiss, & Rolfhus, 2003).

Among the WISC-IV subscales is the Digit Span (DS). The DS task has two sections. The first section requires an individual to recall digit strings presented orally (digit forward), and the second section requires the individual to recall digits presented orally in a backward sequence (digit backward). Generally, performance on the digit forward is considered a measure of phonological loop, whereas performance on the digit backward is considered a measure of verbal CE. As separate digit forward and digit backward scores were not available, the total digit span score was used in the current study in the LPA. The combined score was interpreted as a measure of verbal WM (combination of the phonological loop, as measured by the digit forward score, and the verbal CE, as measured by the digit backward score). For the verbal WM as measured by

WISC-4 Digit Span test, the meta-analysis by Walshaw et al. (2010) indicated a *d* effect size of 0.66 across four studies.

Wide Range Achievement Test-3 (WRAT-3; Wilkinson, 1993). Reading and arithmetic abilities were measured using the WRAT-3. The WRAT-3's reading test has letters and individual words that the individual has to name or pronounce. This test has sound reliability and validity (Wilkinson, 1993). The arithmetic test has two parts. The first part requires simple counting, reading number symbols, and solving verbally presented simple arithmetic problems. The second part is a paper and pencil task that requires the individual to calculate up to 40 arithmetic problems. This test has sound reliability and validity (Wilkinson, 1993).

CBCL and TRF (Achenbach & Rescorla, 2001). The CBCL is completed by parents and has 113 items, while the TRF has 120 items for teacher completion. Both are used to rate children between 4 and 18 years of age. Respondents indicate the degree or frequency of each behavior described in the item on a scale of 0 (not true), 1 (somewhat or sometimes true), or 2 (very true or often true). The standard rating period is six months for the CBCL and two months for the TRF. Both have comparable measures and scales, including scales for attention problems and other psychological problems. The *T* scores for these scales were used as measures of attention problems and overall psychological problems, respectively. All scales of the CBCL and TRF, including the attention problems and overall psychological problems scales, have excellent psychometric properties, and are summarized in Achenbach and Rescorla (2001).

Procedure

Each participant and their parents were interviewed separately in testing sessions

over two consecutive days. Breaks were provided as needed. Parental consent forms were completed prior to the assessment. The data collected covered a comprehensive demographic, medical (primarily neurological and endocrinological), educational, psychological, familial, and social assessment of the child and their family based on information obtained from parents and children. Standard procedures were used for the administration of all measures, including the ADISC-IV, CBCL, TRF, WISC-IV, WRAT-3, and the CANTAB tasks. Where necessary, researchers read the items to participants who then completed their responses. Approximately 95% of the parent ADISC-IV interviews involved mothers only, and the rest involved fathers only or both fathers and mothers together. Clinical diagnosis, based on the ADISC-IV, was determined by two consultant child and adolescent psychiatrists who independently reviewed these data. The inter-rater reliability for diagnoses of the two psychiatrists was high ($\kappa = .90$).

All psychological tasks were administered by research assistants, who were advanced masters or doctoral students in clinical psychology, and under the supervision of registered clinical psychologists. The research assistants were provided with extensive supervised training and practice by the psychologists prior to them collecting data. This training for the ADISC-IV included observations of it being administered by the registered psychologists. The research assistants commenced administering the ADISC-IV once they had attained competence in its administration, as assessed by the registered psychologists.

Statistical analysis for LPA

The SS, SWM-error, and DS scores of all children in the ADHD group were subjected to LPA. All statistical analyses were conducted using Mplus Version 6.12 (Muthén & Muthén, 2010), and the analyses used robust maximum likelihood estimation. In this analysis, we used 500 random starting values to ensure the validity of each class solution. The number of latent classes (groups) was established as follows. Beginning with a single latent class, additional classes were added in sequence, until a model was found that met optimal selection criteria. In this study, the optimal number of classes was determined using the Bayesian Information Criterion (BIC), the sample-size Adjusted BIC (ABIC), the Lo-Mendell-Rubin likelihood ratio test (LRT), and the Adjusted LRT (ALRT). Lower BIC and ABIC values indicate a better model. The LRT and the ALRT test a model with K classes versus a model with $K-1$ classes. A significant p -value indicates that the model with K classes is better than the model with $K-1$ classes. Usually, a non-significant p -value indicates that the model with K classes is not an improvement over the model with $K-1$ classes. Although, entropy generally is not used to determine the model with the optimal number of classes (Lubke & Muthén, 2007), it is useful as it provides a summary of classification accuracy (whether individuals are classified neatly into one and only one category). Entropy varies from 0 to 1, with values closer to 1 indicating less classification errors.

Results

Identification of the Optimum Number of Classes in the LPA

We computed models with 1 to 5 classes. Table 1 provides the BIC, ABIC, LRT, ALRT and entropy for these models. Both the BIC and ABIC decreased sequentially from the 1- to 2- to 3-class. The BIC value for the 4-class model was higher than that of

the 3-class model, and the ABIC value for the 4-class was only negligibly higher than the 3-class model ($\Delta\text{ABIC} = 6.764$). Both the BIC and ABIC were negligibly higher in the 5-class model than the 4-class model. Also, the LRT and ALRT values for the 2- and 3-class LPA solutions were significant at $p = .001$, whereas these values were significant for the 4-class model at $p = .05$. These values were not significant for the 5-class model. Collectively, these findings are not supportive of the 5-class model. Accordingly, it is not necessary to test models with more classes. Although there was support for both the 3- and 4-class models, the improvement of the 4-class model over the 3-class model was negligible and mixed (given its higher BIC value). The overall classification accuracy (entropy) for the 3-class model was 0.744, whereas it was 0.644 for the 4-class model. For the 3-class model, the percentage of individuals correctly classified were 86.0% for class 1, 89.9% for class 2, and 89.9% for class 3. For the 4-class model, the percentage of individuals correctly classified were 78.2% for class 1, 81.9% for class 2, 83.6% for class 3, and 72.3% for class 4. These findings indicate greater parsimony for the 3-class model than the 4-class model. Thus, the 3-class model was accepted in the current study. Classes 1, 2, and 3 consisted 28.0% ($N = 196$), 56.2% ($N = 394$), and 15.8% ($N = 111$) of the sample, respectively.

Comparison of the Working Memory Measures in the Model in Three Classes and the Clinical Comparison Group

With Mplus, it is possible to obtain, for each individual, the most probable class to which the individual belongs. Table 2 shows the mean scores of the three WM measures used in the LPA in the classes in the 3-class model. It also includes the mean scores for the clinical comparison group. Table 2 also includes the results of 1-way

ANOVAs and group comparisons across classes 1, 2, 3, and clinical comparison participants for the WM scores used in the LPA. As shown, the groups differed for SS, SWM-error, and DS. Class 1 had lower SS and DS and higher SWM-error scores than class 2, class 3, and clinical comparison groups. Also, class 2 had lower SS and DS and higher SWM-error scores than class 3 and clinical comparison groups. There was no difference for SS, SWM-error, and DS between the average and clinical comparison groups.

Table 3 shows the effect sizes for significant comparisons of the working memory measures in three classes and the clinical comparison group. Based on Cohen's (1992) guidelines for interpreting *d* effect sizes (small $\leq .20$, medium $\geq .50$, and large $\geq .80$); for SS, the effect sizes for the differences in the analyses for class 1 with class 2, class 3, and clinical comparison groups were all large. The effect sizes for the differences for the moderate deficit group with the average and clinical comparison groups were also large. For SWM-error, the effect sizes for the differences for class 1 with class 2, class 3, and clinical comparison groups were all large, and the effect sizes for the differences for class 2 with class 3 and class 2 with clinical comparison group were large and medium, respectively. For DS, the effect sizes for the differences for class 1 with class 2 was small, and the effect sizes were medium for the differences for class 1 with class 3 and the clinical comparison group. The effect sizes were small for the differences for class 2 with class 3 and the clinical comparison group.

Overall, the findings indicate no difference between the clinical comparison group and class 3 for all components of WM: visuo-spatial sketchpad, verbal WM, and spatial CE. Relative to the clinical comparison group and class 3, class 1 and 2 had scores

reflecting lower abilities in all three components of WM, with class 1 having scores reflecting lower abilities than class 2. Thus, class 1 can be considered an ADHD high-WM deficit group, class 2 can be considered an ADHD moderate-WM deficit group, and class 3 can be considered an ADHD average-WM group. For convenience, these groups are referred to as high deficit, moderate deficit, and average WM groups, respectively.

Comparison of the Groups for CBCL and TRF Attention Problems and Total Scores

Although individuals in the clinical comparison group had no clinical diagnoses, including ADHD, it is possible that they could have had notable or sub-threshold clinical psychological problems, including attention problems, as they were all referred for behavior and/or emotional and/or learning problems. As this could impact the interpretation of our findings when the ADHD groups are compared to the clinical comparison group, we examined the differences between the ADHD and clinical comparison groups for CBCL and TRF *T* scores of the attention problems scale and total scale.

Table 4 shows the mean scores for the CBCL and TRF (a subset of the sample, *N*s for high deficit = 131, moderate deficit = 254, average = 60, clinical comparison = 32) scores for the attention problems and total scale scores in the three ADHD groups and the clinical comparison group. It also includes the results of 1-way ANOVAs for comparisons between these groups. For both CBCL and TRF attention problems and total *T* scores, there was no difference between the ADHD groups, and all these groups had significantly higher scores than the clinical comparison group. The effect sizes for these differences were either medium or large (*d* values ranging from .76 to 2.58). Also, as indicated in Table 4, *T* scores for CBCL and TRF total scores for all ADHD groups were

in the clinical range, while they were in the non-clinical range for the clinical comparison group. The *T* scores for CBCL and TRF attention problem score for all ADHD groups were in the clinical and borderline clinical range, respectively, and in the normal range for the clinical comparison group. However, for both the CBCL and TRF scores, the later groups differed from the normative sample used in the standardization of these measures (*d* values ranging from .22 to .81). Collectively, these findings indicate that although the clinical comparison group had scores in the normal range, they had higher scores than the normative population for attention problems and overall psychological problems.

External Validity of the Classes

Based on the classes to which the participants were assigned, differences in the mean SWM-strategy and DMtS percentage of correct responses in the simultaneous condition were tested using 1-way ANOVAs. The results of the 1-way ANOVAs are shown in Table 2. It demonstrates significant group differences for both measures, whereby the high deficit group had higher or lower scores (as the case may be) than the moderate deficit, average, and clinical comparison groups. The moderate deficit group had higher or lower scores (as the case may be) than the average and clinical comparison groups, and there was no difference between the average and clinical comparison groups.

As shown in Table 3, for SWM-strategy, effect sizes for the differences for the high deficit group with the moderate deficit group were small, and the differences for the high deficit group with the average, and clinical comparison groups were both medium. The effect sizes for the differences for the moderate deficit group with the average and clinical comparison groups were both small. For the DMtS, effect sizes for the differences for the high group with the moderate deficit, average, and clinical comparison

groups were all large. The effect sizes for the differences for the moderate deficit group with the average and clinical comparison groups were medium and large, respectively. The findings for the SWM-strategy and DMtS measures are supportive of the external validity of the LPA classes.

Class Differences for ADHD Types

The frequencies of percentages of individuals in the three ADHD groups (classes) for the different ADHD types were computed using the classes to which each individual was allocated. The percentages of ADHD combined type, inattentive type, and hyperactive-impulsive type in the high deficit class were 28.3%, 28.1%, and 20.4%, respectively. They were 56.3%, 56.8%, and 57.1%, respectively, for the moderate deficit group; and 15.5%, 15.15, and 22.4%, respectively, for the average group. The results of a 3 (class) by 3 (ADHD type) chi-square analysis was not significant, $\chi^2(4) = 2.46$, *ns*, thereby indicating no difference in the frequencies of different ADHD types across the three ADHD groups (classes).

Comparison of Classes and Clinical Comparison Group for Age, Sex, IQ, Reading, Arithmetic, and Psychopathology

Table 5 shows the mean scores for age, IQ (FSIQ, VCI, PRI, PSI, WMI, and GAI), reading, and arithmetic in the three ADHD groups and the clinical comparison group. It also includes the results of 1-way ANOVAs for comparisons across these groups. As shown, the groups differed for all measures, except age.

For all the IQ measures, except PSI, the high deficit group had lower scores than moderate deficit group. For the PSI, there was no difference. For all IQ measures, the high deficit group had lower scores than the average class and clinical comparison

groups. Also, the moderate deficit group had lower scores than the average and clinical comparison groups, and there was no difference between the average and the clinical comparison group. The effect sizes for differences between the high deficit and moderate deficit groups for all IQ scores were small (d values ranging from .30 to .40).

With the exception of FSIQ, the difference between the high deficit and average groups for the VCI, PRI, and the GAI were medium (d values ranging from .54 to .74). The difference for FSIQ was large. For the FSIQ and the GAI, the differences between the high deficit and the clinical comparison groups were large (d values .94 and .89, respectively). The differences between the high deficit and the clinical comparison groups for VCI and PRI were both medium (d values .57 and .60, respectively). The effect sizes for differences between the moderate deficit and average groups for all FSIQ, VCI, PRI, and the GAI were small (d values ranging from .17 to .46). For the FSIQ and the GAI, the differences between the moderate deficit and average groups were medium (d values .57 and .54, respectively). The differences between the moderate deficit and average groups for VCI and PRI were both small (d values .26 and .31, respectively). All differences for the PSI and WMI were small (d values $< .50$).

For reading, the high deficit group had lower scores than all the other groups, and the moderate deficit group had lower scores than the clinical comparison group. The effect sizes for all differences were either small or medium (d values ranging from .32 to .53). For arithmetic, the high deficit group had lower scores than the average group and the clinical comparison group. Also, the moderate deficit group had lower scores than the clinical comparison group. The effect sizes for all differences, except the difference between the moderate deficit and average groups, were large (d values ranging from .92

to 2.24). The effect size for the difference between the moderate deficit and average groups was medium ($d = 0.78$).

For sex, a 2 (sex) x 4 (group: high deficit, moderate deficit, average, and clinical comparison) chi-square analysis indicated no significant effect, $\lambda^2(3) = 0.97$, *ns*. The percentages of males in the high deficit, moderate deficit, average, and clinical comparison groups were 78.6%, 77.2%, 77.7%, and 76.3%, respectively. For employment, a 2 (employed, all others) x 4 (group: high deficit, moderate deficit, average, and clinical comparison) chi-square analysis also indicated no significant effect, $\lambda^2(3) = 0.50$, *ns*. The percentages of employed in the high deficit, moderate deficit, average, and clinical comparison groups were 80.3%, 78.4%, 78.3%, and 76.2%, respectively.

The percentages of those with ODD/CD in the high deficit, moderate deficit, and average groups were 76.5%, 74.6%, and 71.2%, respectively. The percentages of those with anxiety disorders (Separation Anxiety, Social Phobia, Specific Phobia, Panic, Agoraphobia, Generalized Anxiety, Obsessive Compulsive and/or Post-Traumatic Stress disorders) in these groups were 76.0%, 74.6%, and 70.3%, respectively; and the percentages of those with depressive disorders (Dysthymic or/and Major Depressive disorders) in these groups were 64.8%, 54.3%, and 47.3%, respectively. Separate 3 (group: high deficit, moderate deficit, and average) x 2 (presence/absence of a disorder) chi-square analyses were conducted for each disorder. There was no significant group difference for ODD/CD, $\chi^2(2) = 1.08$, *ns*, and anxiety disorders, $\chi^2(2) = 1.27$, *ns*. The analysis involving depressive disorders was significant, $\lambda^2(2) = 9.67$, $p < .01$, thereby indicating differential associations between classes and depressive disorders. The

standardized adjusted residuals statistic was used to evaluate these associations more closely. The high deficit group had more individuals with depressive disorders (z for standardized adjusted residuals = 2.9, $p < .01$), and the average group had fewer individuals with depressive (standardized adjusted residuals = 2.0, $p < .05$) than that expected by chance.

Comparison of All Working Memory Measures in Three Classes and the Clinical Comparison Group Controlling for Covariates

Since the groups differed for IQ, reading, arithmetic, and depressive disorders we compared the ADHD groups and the clinical comparison group on WM measures (SS, SWM-error, DS, SWM-strategy, and DMtS) controlling for the effects of these variables. The total and attention problems scores for CBCL and TRF were not used as covariates as they included items comparable to the ADHD symptoms. For all comparisons, we used 1-way ANCOVAs. Since the DS scores were derived from the same measure used to compute the FSIQ, the inclusion of FSIQ as a covariate when comparing the groups for DS could confound the results. Also, the FSIQ is influenced by WM. Consequently, the GAI was used as the covariate as it does not include the DS and is minimally influenced by WM (Williams et al., 2003).

Table 6 shows the estimate marginal mean scores for SS, SWM-error, DS, SWM-strategy, and DMtS. It also includes the results of the 1-way ANCOVAs and group comparisons between these groups. Group differences were the same as those without covariates (Table 2). With few exceptions, the magnitude of the effect sizes for group differences were also the same. For SWM-error, the effect sizes for the differences for the high deficit and moderate deficit group were large with no covariates and medium with

covariates. For SWM-strategy, the effect sizes for the differences for the high deficit group and the clinical comparison group were medium with no covariates and small with covariates. The effect sizes for the differences for the moderate deficit group and the average group were small with no covariates and medium with covariates. For the DMtS, the effect sizes for the differences for the high deficit group and the moderate deficit group was medium without covariates and large with covariates. Given these findings, it can be taken that the covariates had minimal influence on group differences.

Discussion

The current study used LPA to examine the WM performance of children with ADHD for measures tapping the visuo-spatial sketchpad, spatial CE, and verbal WM (phonological loop plus verbal CE). The visuo-spatial sketchpad, spatial CE, and verbal WM were measured using CANTAB spatial span score (SS), the between search errors in 6- and 8-box problems of the CANTAB spatial working memory tasks (SWM-error), and the total score of the digit span (DS) subtest of WISC-4. The LPA supported three classes. These classes and a clinical comparison group with no specific diagnoses were compared for SS, SWM-error, and DS. There were group differences for SS, SWM-error, and DS. For all three measures class 1 had more difficulties than classes 2 and 3 and the clinical comparison group. Class 2 had more difficulties than class 3 and the clinical comparison group and there was no difference between class 3 and the clinical comparison group. The effect sizes for differences involving SS, SWM-error, and DS were either large or medium. Virtually, all these differences were also evident when the comparisons controlled for IQ (as indexed by the GAI), reading ability, arithmetic ability, and depressive disorders. Since the ADHD groups had comparable attention problems

and had scores in the clinical or borderline clinical levels, and the clinical comparison group had attention problems scores in the normative level, classes 1, 2, and 3 can be considered high deficit, moderate deficit, and average WM groups. There was support for the external validity of these groups. More specifically, for SWM-strategy (a measure of spatial CE) and the DMtS (a measure of visuo-spatial sketchpad), the high deficit group had more difficulties than the moderate deficit, average, and control groups. The moderate deficit group had more difficulties than the average and control groups and there was no difference between the average and control groups. Overall, we found two of the three classes that we expected: high deficit and average. We did not find a class with relatively more difficulties in phonological loop and spatial CE, compared to verbal WM. This suggests that children with ADHD who experience WM difficulties can be expected to have difficulties with all WM components (although not at comparable levels, as discussed below), rather than difficulties with separate components.

The study showed that the percentages of children with ADHD in the high deficit, moderate deficit, and average WM groups were 28.0%, 56.2%, and 15.8%, respectively. Since there was no difference between the average and clinical comparison groups, the findings suggest that close to 84% of children with ADHD may show concurrent WM difficulties with temporary storage and rehearsal of visuo-spatial information (as indexed by their low performance on the SS task that taps the visuo-spatial sketchpad), and with higher level processing that requires overseeing and coordinating temporary storage and rehearsal of verbal and visuo-spatial information and also their interactions with long-term memory (as indexed by their low performance on the SWM-error and DS tasks that tap the spatial CE and verbal WM, respectively). However, the findings for verbal WM

need to be viewed with some caution. This is because the LPA used the total DS score, which comprises both forward and backward DS scores, and the forward DS has often been viewed as a measure of the phonological loop. Bearing this possibility in mind, our conclusion is consistent with meta-analysis reviews of WM difficulties in ADHD (Martinussen et al. 2005; Walshaw et al. 2010; Willcutt et al. 2005a). These reviews concluded that there is support for difficulties in the visuo-spatial sketchpad, CE of WM, and phonological loop. However, it needs to be noted that as close to 16% of children with ADHD did not show WM difficulties (at least as compared to the clinical comparison group); therefore, arguably, WM difficulties may not be the primary deficit in ADHD, in that it does not characterize all children with ADHD. However, there is need for caution with this proposition as we used only one task per WM component. It could be possible that other WM tasks may show different findings.

The current study also showed more differences between the clinical comparison group and the WM deficit groups for the visuo-spatial sketchpad and spatial CE than for verbal WM. The effect sizes for the differences for both the high and moderate deficit groups with the clinical comparison group were large for both the visuo-spatial sketchpad and the spatial CE. Although the effect size for the difference between the high deficit and clinical comparison groups for verbal WM was large, the effect size for the verbal WM was medium for the difference between the moderate deficit and clinical comparison groups. Collectively, these findings suggest more difficulties in temporary storage, rehearsal, and higher level processing of visuo-spatial information than verbal information. These findings are somewhat consistent with existent literature suggesting

greater difficulties for spatial than verbal WM (Martinussen et al., 2005; Willcutt et al., 2005a).

With respect to the characteristics of the ADHD WM groups, the findings indicated no difference in the frequencies of different ADHD types, ODD/CD, and anxiety disorders between them. The ADHD and clinical comparison groups showed no difference for age. The groups differed for all IQ measures, reading ability, and arithmetic ability. For all the IQ measures, the high deficit group had lower scores than moderate deficit, average, and clinical comparison groups. Also, the moderate deficit group had lower scores than the average and clinical comparison groups, and there was no difference between the average and the clinical comparison groups. All differences were of a large or medium effect size. For reading, the high deficit group had lower scores than all the other groups, and the moderate deficit group had lower scores than the clinical comparison group. The effect sizes for all differences were either small or medium. For arithmetic, the high deficit group had lower scores than the average and clinical comparison groups. Also, the moderate deficit group had lower scores than the clinical control group. The effect sizes for all differences were mostly large. The findings also showed that the ADHD groups were differentially associated with depressive disorders, with more individuals in the high deficit group than the moderate deficit and average groups. Taken together, these findings suggest that generally more WM difficulties among ADHD children are associated with lower IQ, lower academic abilities, and increased depression. This argument is conceivable as there are data showing that low IQ (for a review see Fry & Hale, 2000), low academic abilities

(Gathercole et al., 2006) and depressive disorders (Matthews et al, 2008, Franklin et al, 2010) are positively associated with poor WM performance.

The findings in this study have implications for training and treatment of children with ADHD. As around 84% of children with ADHD may have WM difficulties, it could be argued that many ADHD children may need training to improve their WM. Although, there is evidence that such programs could improve WM, IQ, and behavioral inhibition of children with ADHD (Holmes et al., 2010; Klingberg, Forssberg, & Westerberg, 2002), a recent meta-analysis on a wide range of WM training programs concluded that such training programs provided only near-transfer, short-term effects (Melby-Lervåg & Hulme, 2012). Also, as the findings in the current study demonstrated that more WM difficulties among ADHD children were associated with lower academic abilities and more depression, it seems prudent that children with ADHD and WM difficulties be screened for these problems, and provided with appropriate evidence-based interventions for them.

Several limitations need consideration when interpreting the findings of this study. First, although a clinical diagnosis of ADHD requires the presence of cross-situational symptoms, in the current study, clinical diagnosis of ADHD was based on parent interviews alone. Thus, the findings may not be applicable to ADHD as defined by the DSM-IV-TR. However, as teachers rated the attention problems of children with ADHD to be at the borderline clinical range it is conceivable that many of them would have high levels of ADHD-related behaviors at their schools. Second, children in the clinical comparison group were those referred for clinical evaluation because of psychological problems, but who did not qualify for diagnosis of any DSM-IV disorder.

Therefore, it is conceivable that many in this group may have had sub-threshold levels of clinical symptoms for one or more disorders, including ADHD. If so, it is plausible that many individuals in the clinical comparison group may also have had difficulties in WM. We suspect that this is likely as the attention problems and total *T* scores for CBCL and TRF for this group were higher than for the normative population. Third, the children with ADHD in this study were highly comorbid for anxiety disorders, depressive disorders, and ODD/CD. Although there were no differential associations between the three classes with ODD/CD and anxiety disorders, it cannot be assumed that the findings were not confounded by multiple comorbidities in the sample. Fourth, our findings are based on only one measure for each WM construct. It is possible that other WM tasks may show different findings. Furthermore, WM difficulties were examined using laboratory measures, which are generally considered to be less sensitive to the types of daily executive dysfunction prevalent in ADHD. Thus, the applicability of the findings in the current study to the daily functioning of children with ADHD has its limitations. Clearly more studies are needed, using the LPA procedure used in the current study, and taking into consideration the limitations mentioned.

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Table 1

Fit Statistics of the Latent Profile Analysis Models

Model	<i>BIC</i>	<i>Adjusted BIC</i>	<i>LRT p</i> value	<i>Adjusted LRT p</i> value	<i>Entropy</i>
1-class	12295.706	12276.655	-	-	-
2-class	12091.774	12060.022	0.0000	0.0000	0.665
3-class	12071.435	12026.983	0.0001	0.0001	0.744
4-class	12077.373	12020.219	0.0317	0.0364	0.644
5-class	12093.638	12023.784	0.3443	0.3568	0.666

Note. BIC = Bayesian information criterion; LRT = Lo-Mendel Rubin likelihood ratio

test.

Table 2

*Mean (and Standard Deviation) Scores and Comparisons of the Working Memory**Measures in Three Classes and the Clinical Comparison Group*

	Class 1 <i>N</i> = 196	Class 2 <i>N</i> = 394	Class 3 <i>N</i> = 111	Control (C) <i>N</i> = 59	<i>F</i> (<i>df</i> = 3, 756)	Δ Groups
WM measures used in the LPA						
Spatial span	3.45 (0.67)	5.40 (0.64)	7.42 (0.95)	7.73 (0.70)	1030.12***	1<2<3=C
SWM-error	61.67 (14.08)	44.18 (17.56)	24.43 (14.31)	33.39 (22.76)	134.64***	1>2>3=C
Digit span	8.37 (2.68)	9.08 (2.88)	9.58 (3.09)	10.00 (2.61)	8.11**	1<2<3=C
WM measures not used in the LPA						
SWM -strategy	38.00 (4.23)	36.52 (4.06)	34.91 (4.77)	34.71 (4.67)	45.61***	1>2>3=C
DMtS	59.83 (15.13)	74.58 (13.08)	84.84 (10.48)	85.25 (13.82)	110.82***	1<2<3=C

Note. SWM=error = spatial working memory, scores are between search errors in 6- and 8-box problems (higher scores reflect poorer functioning). SWM-strategy = spatial working memory number of search sequences starting with a novel box in both 6- and 8-box problems; DMtS = Delayed Matching to Sample percentage of correct responses in the simultaneous condition.

** $p < .01$, *** $p < .001$.

Table 3

Effect Sizes for Significant Comparisons of the Working Memory Measures in Three Classes and the Clinical Comparison Group

	H v M	H V A	H v C	M v A	M v C
WM measures used in the LPA					
Spatial span	3.16	5.10	6.36	2.82	3.60
SWM-error	1.06	2.64	1.72	1.17	.59
Digit span	<u>.25</u>	.47	.61	<u>.17</u>	<u>.32</u>
WM measures not used in the LPA					
SWM -strategy	<u>0.36</u>	0.70	0.74	0.37	0.45
DMtS	1.07	1.83	1.71	0.79	0.81

Note. H = high deficit group, M = moderate deficit group, A = average group.

Figures for *d* effect sizes in bold = large, italic = moderate, and underline = small, based on Cohen's (1992) guidelines for interpreting *d* effect sizes (small $\leq .20$, medium $> .50$, and large $> .80$).

Table 4

Mean (and Standard Deviation) Scores and Comparisons of CBCL and TRF Attention

Problems and Total Scores in Three Classes and the Clinical Comparison Group

	High <i>N</i> = 196	Moderate <i>N</i> = 394	Average <i>N</i> = 111	Control <i>N</i> = 59	<i>F</i> (<i>df</i> = 3, 756)	Δ Groups
CBCL Attention	72.49	72.83	70.67	55.26	48.57***	H=M=A>C
Problems	(10.58)	(10.97)	(10.20)	(5.02)		
TRF Attention	67.28	65.22	66.68	58.06	10.02***	H=M=A>C
Problems	(10.29)	(9.70)	(9.67)	(7.33)		
CBCL Total Score	71.80	72.57	71.12	52.21	116.52***	H=M=A>C
	(7.52)	(7.24)	(8.01)	(11.38)		
TRF Total Score	68.13	66.75	68.35	57.97	10.02***	H=M=A>C
	(9.72)	(10.58)	(8.45)	(9.43)		

Note. H = high deficit group, M = moderate deficit group, A = average group.

*** $p < .001$.

Table 5

Mean (and Standard Deviation) Scores and Comparisons of Age, IQ, and Academic

Ability in Three Classes and the Clinical Comparison Group

	High <i>N</i> = 196	Moderate <i>N</i> = 394	Average <i>N</i> = 111	Control <i>N</i> = 59	<i>F</i> (<i>df</i> = 3, 756)	Δ Groups
Age	10.81 (3.41)	11.39 (2.43)	10.52 (3.27)	11.07 (4.05)	2.53	H=M=A=C
Full Scale IQ (FSIQ)	86.39 (11.68)	91.14 (12.02)	97.08 (12.91)	98.24 (14.45)	24.94***	H<M<A=C
Verbal Comprehension Index (VCI)	88.62 (12.85)	92.57 (13.45)	95.77 (13.80)	96.09 (13.94)	9.03***	H<M<A=C
Perceptual Reasoning Index (PRI)	91.58 (14.08)	95.95 (12.54)	101.77 (12.23)	99.92 (13.12)	16.40***	H<M<A=C
Processing Speed Index (PSI)	88.10 (15.87)	88.88 (13.89)	94.10 (12.69)	93.36 (12.66)	6.13***	H=M<A=C
Working Memory Index (WMI)	87.92 (12.30)	93.53 (12.54)	97.76 (13.85)	99.19 (14.13)	19.91***	H<M<A=C
General Ability Index (GAI)	89.68 (12.32)	94.43 (12.20)	99.06 (13.23)	101.27 (15.00)	20.01***	H<M<A=C
Reading	91.19 (17.02)	95.60 (16.03)	96.59 (15.14)	98.06 (11.38)	5.05**	H<M,A,C; M=A; M<C; A=C
Arithmetic	81.55 (15.27)	84.02 (15.17)	86.61 (16.74)	90.43 (17.79)	5.87**	H=M<C; H<A=C; M=A

Note. H = high deficit group, M = moderate deficit group, A = average group, C = clinical comparison. *** $p < .001$.

Table 6

Estimate Marginal Mean (and Standard Deviation) Scores and Comparisons of the Working Memory Measures in Three Classes and the Clinical Comparison Group, Controlling for GAI, Reading Arithmetic and Depression

	High (H) <i>N</i> = 196	Moderate (M) <i>N</i> = 394	Average (A) <i>N</i> = 111	Control (C) <i>N</i> = 59	<i>F</i> (<i>df</i> = 6, 752)	Δ Groups
WM measures used in the LPA						
Spatial span	3.57 (0.77)	5.37 (0.67)	7.60 (0.73)	7.37 (0.71)	719.73***	H<M<A=C
SWM-error	55.25 (18.06)	45.22 (15.88)	30.50 (17.07)	32.98 (16.44)	49.55***	H>M>A=C
Digit span	7.86 (2.94)	8.98 (2.58)	9.90 (2.74)	9.84 (2.69)	31.61**	H<M<A=C
WM measures not used in the LPA						
SWM-strategy	37.68 (4.76)	36.66 (4.17)	34.04 (4.74)	35.47 (4.38)	14.29***	H>M>A=C
DMtS	64.27 (14.56)	73.77 (12.90)	80.63 (13.31)	83.78 (13.28)	40.77***	H<M<A=C

Note. Note. H = high deficit group, M = moderate deficit group, A = average group, C = clinical comparison. SWM-error = spatial working memory, scores are between search errors in 6- and 8-box problems (higher scores reflect poorer functioning). SWM-strategy = spatial working memory number of search sequences starting with a novel box in both

6- and 8-box problems; DMtS = Delayed Matching to Sample percentage of correct responses in the simultaneous condition.

$**p < .01$, $***p < .001$.

The Disclosure of Interest Form will be delivered offline very soon