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Exploring Hierarchical Structures of Cognitive Impairment in ADHD

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1 BACKGROUND

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder associated with a range of adverse outcomes including academic and occupational underachievement (Shaw et al., 2012). ADHD is linked to impairments in several cognitive functions including vigilance, inhibition, processing speed, and working memory (Guo et al., 2019). However, it's unclear how these functions may relate to each other.

We proposed that a cognitive hierarchy may be at play, such that impairments in core functions (vigilance, inhibition, and processing speed) may contribute to impairments in wider functions (working memory). This has implications for cognitive interventions to target memory impairments in ADHD. We used the Oregon ADHD-1000 dataset (ages 7 – 18yrs; Nigg et al., 2023) to investigate this.

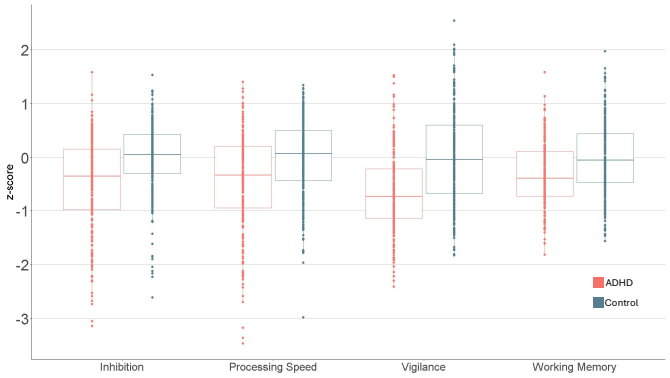
AIMS

1. Identify any group differences in cognitive ability
2. Investigate relationships between cognitive functions in ADHD
3. Determine whether impairments in working memory can be explained by deficits in core cognitive functions

2 GROUP COMPARISONS

We combined individual scores from various neuropsychological tests to form composite scores for each cognitive function. The ADHD group performed significantly worse on all individual measures and combined cognitive function scores. The composite score effect sizes ranged from low to medium, with vigilance showing a medium effect size (r = 0.365), followed by low effect sizes for inhibition (r = 0.286), processing speed (r = 0.250), and working memory (r = 0.244). All effect sizes were significant at p <.001.

Figure 1. Box plot showing standardised scores for all participants for each cognitive function

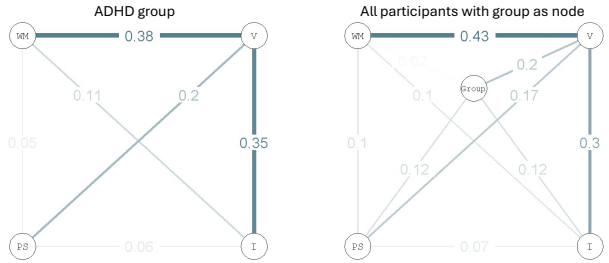


3 NETWORK ANALYSIS

Network analysis was conducted to illustrate relationships between the four cognitive functions. Edges represent partial correlations between cognitive functions, with the thickness of each line indicating the strength of the relationship. The ADHD network showed that the four cognitive functions are correlated to varying degrees, with the strongest relationships being between vigilance and working memory, and vigilance and inhibition.

When group status (ADHD vs controls) was included as a node, group status was correlated with all core functions but not working memory, suggesting that the core functions may mediate the relationship between group status and working memory.

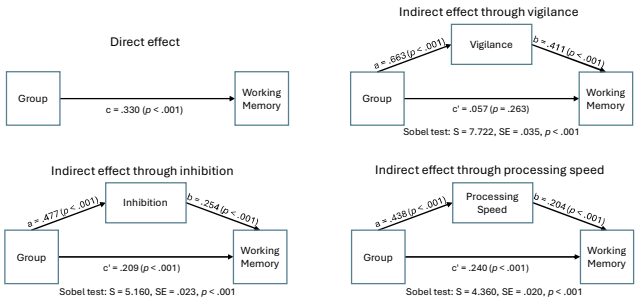
Figure 2. Network graphs for the ADHD group only and for all participants with group status included as a node



4 MEDIATION ANALYSIS

Mediation analysis was used to determine whether the core cognitive functions could explain the relationship between group status (ADHD vs control) and working memory. Baron and Kenny's (1986) method was used and found that all three core functions were significant mediators, with vigilance showing the strongest evidence for mediation.

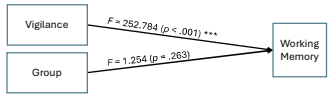
Figure 3. Mediation models showing regression coefficients and Sobel test results



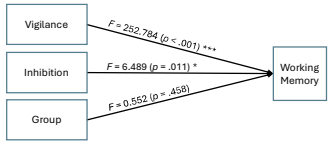
5 HIERARCHICAL ANALYSIS

Hierarchical regression analysis was used to test whether each core function was still significant when taking the others into account. Functions were added sequentially; the larger the F-value, the more the function improved the model. The best model to predict working memory included all three core functions, however, adding group status did not significantly improve the fit, suggesting that the three core functions can almost entirely explain the relationship between group status and working memory.

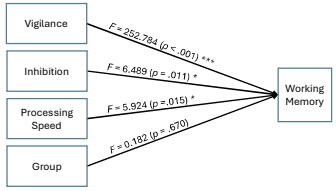
Figure 4. Hierarchical regression models showing change in model fit with the addition of each core function followed by group status (* = significant at 5% level, *** = significant at 0.1% level)



This model explained 32.3% of the variance in working memory, but group status did not significantly improve the fit.



This model explained 33.1%. Adding inhibition significantly improved the model fit, but adding group status did not.



This model explained 33.7%. Adding inhibition and processing speed both significantly improved the model fit, but adding group status did not.

6 CONCLUSION

1. Individuals with ADHD showed significant impairment in all cognitive functions tested.
2. Vigilance, inhibition, processing speed, and working memory were all correlated to varying degrees in ADHD. The strongest correlations were between vigilance and working memory, and vigilance and inhibition.
3. Vigilance, inhibition, and processing speed mediate the relationship between group status and working memory, together explaining 33.7% of the variance in working memory.

FUTURE WORK

We plan to replicate these analyses on a secondary data set to test the generalisability of our findings.

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