



Comparing Working Memory Deficits Across ADHD and Anxiety in Youth : A Preliminary Meta-Analysis

Minkyu (Michael) Koo*

Chadwick International School, 45, Art center-daero 97 beon-gil, Yeonsu-gu, Incheon, 22002, South Korea

* Corresponding author email: michaelmkkoo@gmail.com

Abstract

Although attention-deficit/hyperactivity disorder (ADHD) and anxiety disorders are conventionally treated as distinct diagnostic categories, both have been linked to working memory (WM) impairment in children and adolescents, prompting an inquiry into whether the magnitude of WM impairment may be comparable across the two conditions. This preliminary meta-analysis pooled the Hedges' g effect sizes across six studies (four ADHD studies, two anxiety studies), comparing WM performance in youth with ADHD, clinically diagnosed anxiety, or elevated trait anxiety against comparison groups. A random effects model calculated effect for ADHD ($g = 1.12$, 95% CI [0.46, 1.78], $p < .001$) and for anxiety ($g = 0.69$, 95% CI [0.34, 1.05], $p < .001$); heterogeneity was high for ADHD ($I^2 = 91.0\%$) and low for anxiety ($I^2 = 26.5\%$). A leave-one-out sensitivity analysis identified one ADHD study (Cockcroft, 2011) as the leading factor, as its exclusion lowered the ADHD estimate to $g = 0.80$ (95% CI [0.30, 1.29]), a value that converges closer with the anxiety estimate. The results provide support that WM impairment across ADHD and anxiety may reach a comparable magnitude; however, because the anxiety estimate rests on only two studies and the ADHD subgroup shows heterogeneity, the present analysis cannot determine whether these deficits arise from a shared processing mechanism. Future research should prioritize additional pediatric WM-anxiety studies and longitudinal designs.

Keywords

working memory; ADHD; anxiety; meta-analysis

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a neurodevelopmental disorder marked by persistent inattention and/or hyperactivity-impulsivity (American Psychiatric Association [APA], 2013). It affects an estimated 3.4% of children and adolescents worldwide (Polanczyk et al., 2015), and the symptoms and impairments often persist into adulthood (Sibley et al., 2017). Alongside ADHD, anxiety disorders represent another major source of impairment among adolescents. These disorders involve excessive fear or anxiety that disrupts daily functioning (APA, 2013). They affect 6.5% of children and adolescents worldwide (95% CI [4.7, 9.1]), making them the most common youth mental disorder (Polanczyk et al., 2015). They often impair school attendance and academic performance (Finning et al., 2019; Mazzone et al., 2007).

Both disorders implicate working memory (WM), a limited-capacity system that temporarily stores and manipulates information during complex activities (Baddeley, 2000). Baddeley's working memory model represents short-term memory as consisting of four interacting systems: the phonological loop (PL) which retains verbal-acoustic information; the visuospatial sketchpad, which processes visual and spatial material; the episodic buffer, which integrates information across modalities into a unified representation; and the central executive (CE), which controls attention and coordinates the subordinate systems (Baddeley, 2011). Because WM supports reading comprehension, mathematical problem-solving, following instructions, and learning, deficits can produce substantial academic and everyday impairment (Alloway & Alloway, 2010; Gathercole et al., 2003).

Evidence links WM impairment to both conditions, although potentially through different processes. Children with ADHD show large deficits in tasks requiring storage and manipulation, particularly when CE demands increase (Kasper et al., 2012); simple PL storage appears relatively spared, since forward



digit span does not reliably distinguish children with ADHD, while backward digit span, which additionally recruits the CE, does (Cockcroft, 2011). On the other hand, anxiety may consume attentional resources through worry and threat monitoring, weakening goal-directed processing and reducing WM efficiency (Eysenck et al., 2007; Owens et al., 2008). Attentional Control Theory further predicts that anxiety's effect on WM should concentrate on verbal processing specifically, because ruminative worry itself relies on inner verbal activity, therefore interfering with PL function (Eysenck et al., 2007). These deficits raise the possibility that ADHD and anxiety produce overlapping patterns of impaired information processing.

Although WM impairment does not uniquely distinguish ADHD and anxiety from other forms of psychopathology, these two conditions provide a particularly informative comparison because they frequently co-occur and can produce overlapping cognitive difficulties, making it difficult to determine how strongly observed WM deficits track diagnostic category rather than broader vulnerability (Manassis et al., 2007; Maric et al., 2018). Direct comparisons that separate ADHD-only, anxiety-only, and comorbid groups remain relatively limited, yet existing studies demonstrate that these groups can differ in WM (Manassis et al., 2007; Kofler et al., 2024). Taken together, these features render ADHD and anxiety a particularly useful comparison.

Although prior research links WM impairment to both conditions, whether there is a substantial difference in the magnitude of that between ADHD and anxiety in youth remains inconclusive. The present meta-analysis therefore compares WM deficits across the two literatures; comparable effect sizes would indicate similarity in the observed level of impairment and may motivate further investigation of overlapping processing constraints.

Methods

We searched PubMed on 14 July 2026 using two parallel search terms, both combining terms with ("working memory" OR "central executive" OR "verbal working memory" OR "visuospatial working memory") AND ("child" OR "adolescent" OR "youth" OR "pediatric"). The ADHD subgroup terms were ("ADHD" OR "attention deficit hyperactivity disorder" OR "attentiondeficit/hyperactivity disorder"); the anxiety subgroup terms were ("anxiety" OR "anxiety disorder" OR "generalized anxiety" OR "social anxiety" OR "separation anxiety"). The search was restricted to studies published after 2000 and to peer-reviewed journal articles. Because this study was designed as a preliminary review, the search was limited to PubMed; this restriction may have reduced retrieval breadth and is considered in the Limitations section.

Figure 1 summarizes the study selection process. The two PubMed searches identified 280 records in total, with 270 and 10 results for ADHD and anxiety, respectively. The disparity between the two yields previews the imbalance in pediatric anxiety-WM literature documented later on. Records were then screened by title and abstract, leaving ten articles for review. These were accessed and assessed against three criteria: (1) a sample of children or adolescents, age range 4-16 years; (2) a control group permitting estimation of WM differences between youth with ADHD or anxiety and typically developing peers; and (3) sufficiently reported statistics, namely averages and standard deviations to compute a standardized effect size. For the anxiety subgroup, eligible studies could define anxiety either through clinical diagnosis or elevated trait-anxiety grouping. These criteria excluded four further articles: one utilized a sample without a clinical ADHD diagnosis; one exclusively restricted its ADHD sample to the predominantly inattentive subtype and was therefore excluded in favor of samples representing a broader range of ADHD presentations; one did not report extractable means or standard deviations; and one was excluded due to concerns about measure comparability with the remaining pool. The remaining six met all the inclusion criteria and carried forward into the analysis. Ferrin and Vance (2014) was retained despite its primary focus on anxiety and depressive symptoms within ADHD because it reported an extractable ADHD-control WM comparison satisfying the same inclusion criteria as the other ADHD studies. All screening and data extraction were conducted by the author, and because there was no independent duplication through researcher triangulation, the possibility of selection error cannot be excluded.



With most of the studies reporting multiple WM outcomes, verbal WM was selected as the pooled measure for five of the six studies because it was the only construct reported comparably across them, and because attentional control theory predicts anxiety-related impairment concentrates in verbal rather than visuospatial function (Eysenck et al., 2007), consistent with Visu-Petra et al. (2011), who found a significant deficit on verbal WM tasks but not on visuospatial WM tasks within the same sample. Karaca Cengiz et al. (2025) contributed a CE composite (CNSVS) rather than a verbal measure, since no alternative WM-anxiety study meeting inclusion criteria was identified.

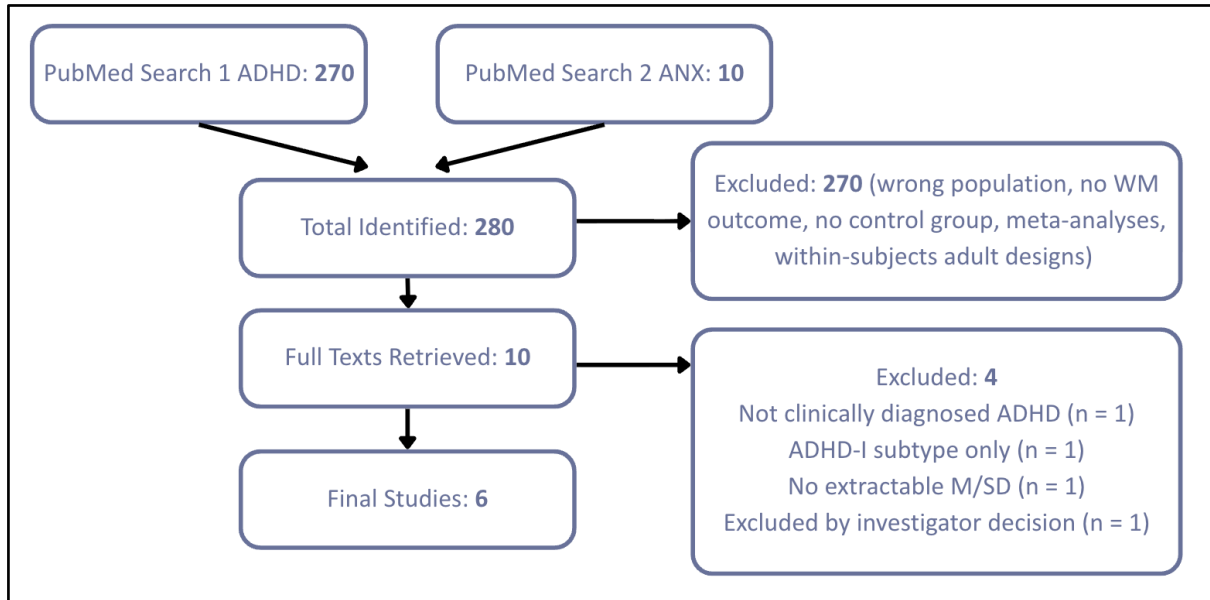


Figure 1. Study selection flow chart.

Hedges' g was calculated using Cambridge Insight Effect Size Calculator as the standardized mean difference in WM performance between clinical and comparison groups, divided by the standard deviation, with the bias-correction factor applied (Hedges & Olkin, 1985). Positive g values indicated poorer WM performance in the clinical group relative to controls. Pooled estimates were calculated using an inverse-variance random-effects model, with between-study variance estimated using the DerSimonian-Laird method. A leave-one-out analysis recomputed the ADHD pooled estimate with each study removed in turn, to check whether any single outlier was heavily affecting the result. A chi-square test comparing the two subgroups' pooled estimates was used to determine how the ADHD and anxiety effects differed.

Results and Discussion

Study and Sample Characteristics

The synthesis retained six studies, four contributing to the ADHD subgroup (total $N = 768$) and two to the anxiety subgroup (total $N = 177$). ADHD subgroup sample sizes ranged from 55 (Elosúa et al., 2017) to 508 (Ferrin & Vance, 2014); anxiety subgroup sample sizes ranged from 80 (Karaca Cengiz et al., 2025) to 97 (Visu-Petra et al., 2011). Participant ages spanned approximately 4 to 16 years across the studies. Grouping procedures also varied substantially across studies. ADHD samples generally relied on diagnostic of clinical classifications. For the anxiety subgroup, Karaca Cengiz et al. (2025) used a clinical social anxiety disorder diagnosis, whereas Visu-Petra et al. (2011) classified preschool children dimensionally according to trait-anxiety level without diagnosis.

The four ADHD studies handled potential IQ differences between groups differently: Elosúa et al. (2017) matched groups on IQ directly, Ferrin & Vance (2014) instead entered IQ as a covariate, and Holmes et al. (2014) did not report controlling for a significant IQ gap between groups in comparison. Recruitment settings also varied: Cockcroft (2011) drew ADHD participants from special-education schools and controls from separate mainstream schools, and Karaca Cengiz et al. (2025) recruited controls from an outpatient counseling clinic instead of a general population. This difference may also



alter estimated effect sizes if comparison groups differ in cognitive or clinical characteristics unrelated to the two conditions, External validity was narrowed by control of comorbidities, ranging from tolerant (Cockcroft, 2011), which retained children with oppositional defiant disorder, conduct disorder, and learning disorders, to strict (Ferrin & Vance, 2014), which excluded conduct disorder, autism spectrum disorder, and eight further conditions, yielding a purer but perhaps less representative ADHD sample. A further complication concerns anxiety within the ADHD evidence base: Ferrin & Vance (2014) reported elevated anxiety within their ADHD sample, rendering comorbidity an alternative explanation for any apparent similarity.

Synthesis

The four ADHD subgroup studies produced a pooled Hedges' g of 1.12 (95% CI [0.47, 1.78], $z = 3.31$, $p < .001$), indicating a very large WM deficit in children and adolescents with ADHD relative to typically developing controls. Heterogeneity was high ($Q(3) = 33.42$, $p < .001$, $I^2 = 91.0\%$), reflecting a wide spread across the four estimates: Cockcroft (2011) produced by far the largest effect ($g = 2.19$, $N = 72$); and Ferrin & Vance (2014), by far the largest sample, produced the smallest effect ($g = 0.47$, $N = 508$).

The two anxiety-subgroup studies produced a pooled Hedges' g of 0.69 (95% CI [0.34, 1.04], $z = 3.85$, $p < .001$). Both contributing estimates were in the expected deficit direction: Visu-Petra et al. (2011; $g = 0.53$, 95% CI [0.13, 0.93], $N = 97$) and Karaca Cengiz et al. (2025; $g = 0.89$, 95% CI [0.44, 1.35], $N = 80$). With only two studies ($k = 2$), a heterogeneity statistic carries little information here ($Q(1) = 1.36$, $p = .243$, $I^2 = 26.5\%$) unlike the ADHD subgroup. The difference between the pooled ADHD and anxiety effects was not statistically significant, $Q(1) = 1.24$, $p = .265$.

Table 1. Study characteristics, methodological considerations, and effect sizes.

Author	Sub.	Age (years)	Recruitment (& Groups)	Subtype / Comorbidity	WM measure	IQ handling	Nclinical / Ncontrol	Sex Distribution	Hedges' g	95% CI
Cockcroft (2011)	ADHD	6.6-11.25	ADHD from 4 special education schools; controls from 3 schools (DSM-IV-TR + Conners ratings)	ADHD-I (n=27) and ADHD-HI (n=25); Anxiety/mood disorders excluded; ODD, CD, LD and DCD present	AWMA verbal WM composite	RCPM; IQ as covariate	52 / 20	ADHD 33M/19F, control 10M/10F	2.19	[1.56, 2.82]
Holmes et al. (2014)	ADHD	8-11	ADHD through pediatric psychiatrists; controls from 10 state primary schools	Combined-type ADHD; ASD excluded	AWMA verbal WM composite	WASI measured; groups not IQ-matched	83 / 50	ADHD 71M/12F, control 27M/23F	1.20	[0.82, 1.58]
Elosúa et al. (2017)	ADHD	9.24 (ADHD mean), 9.18 (control mean)	ADHD from psychiatry outpatient unit; controls from public school (DSM-IV-TR)	20 combined, 6 inattentive	Backward Digit Span	K-BIT; IQ ≥ 85	26 / 29	ADHD 17M/9F, control 13M/16F	0.76	[0.21, 1.30]
Ferrin & Vance (2014)	ADHD	6-16	Both ADHD and controls from 50 schools and assessed at 5 university clinics (DSM-IV & K-SADS-PL)	ADHD-CT (n=303) and ADHD-IA (n=77); anxiety/depression assessed; learning disorders, conduct disorder, psychosis and major medical/neurological conditions excluded	Digit Span verbal WM	WISC-III; controls had higher IQ; IQ as covariate	380 / 128	ADHD 314M/66F, control 98M/30F	0.47	[0.27, 0.67]



Visu-Petra et al. (2011)	ANX	4.6-7.4	Both from preschool (median split of Spence Preschool Anxiety Scale)	Dimensional trait anxiety; N/A	Backward Digit Recall	RCPM; IQ as covariate	48 / 49	53M/45F (total in full sample, task-specific not recorded)	0.53	[0.12, 0.93]
Karaca Cengiz et al. (2025)	ANX	12-16	SAD group from university child psychiatry service; controls from outpatient counseling clinic (K-SADS-PL-DSM-5)	Social anxiety disorder; N/A	CNSVS WM domain	WISC-IV FSIQ; IQ ≥ 80	40 / 40	anxiety 10M/30F, control 10M/30F	0.89	[0.43, 1.35]

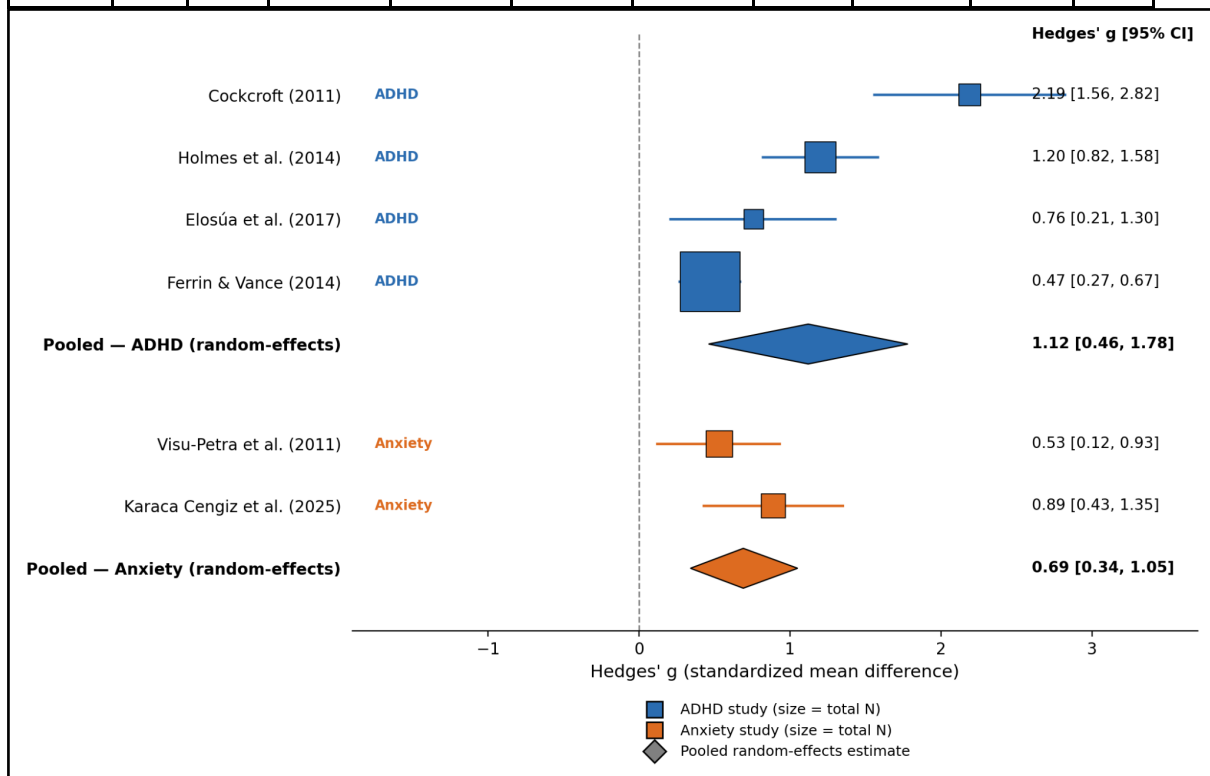


Figure 2. Forest plot of Hedges' g for ADHD (blue) and anxiety (orange) studies

Sensitivity Analysis

A leave-one-out analysis of the ADHD subgroup showed the pooled estimate was clearly sensitive to Cockcroft (2011): excluding it, the largest single effect, lowered the pooled estimate to $g = 0.80$ (95% CI [0.30, 1.29], $p = .002$), hereafter the adjusted ADHD estimate, and reduced heterogeneity to $I^2 = 82.5\%$. Excluding Holmes et al. (2014) yielded $g = 1.11$ (95% CI [0.17, 2.05], $p = .021$, $I^2 = 92.5\%$); excluding Elosúa et al. (2017) yielded $g = 1.25$ (95% CI [0.37, 2.12], $p = .005$, $I^2 = 94.0\%$); and excluding Ferrin & Vance (2014) yielded $g = 1.36$ (95% CI [0.65, 2.08], $p < .001$, $I^2 = 83.3\%$).

Findings

Although the full ADHD effect exceeded the anxiety effect, substantially greater heterogeneity within the ADHD subgroup complicates that apparent difference; excluding Cockcroft (2011), the two subgroup effects converged more closely. Furthermore, Ferrin & Vance (2014)'s 508 participant comparison produced an effect ($g = 0.47$) closest to the anxiety estimates. Across the studies examined, this pattern provides preliminary support that ADHD and anxiety can accompany WM impairment of comparable magnitude; however, it does not establish that the deficits originate from the same cognitive



process, especially since unmeasured or incompletely controlled comorbidity could partly account for the pattern.

Limitations

This review is limited in several respects. The anxiety subgroup rests on only two studies ($k = 2$), which limits how confidently its heterogeneity and precision can be determined. With only six studies overall, formal tests of publication bias would have limited power; small-study effects therefore cannot be ruled out, particularly because Cockcroft (2011) reported the largest ADHD effect size despite a relatively smaller sample. Two of the four ADHD studies (Holmes et al., 2014; Ferrin & Vance, 2014) did not match groups on IQ, leaving IQ as a possible confound in the reported WM deficits. Excluding an ADHD-I-only study also limits generalizability across ADHD subtypes and could affect the pooled estimate if WM impairment systematically differs across presentation.

Comorbidity remains a limitation because the included studies did not consistently measure both ADHD and anxiety symptoms within the same participants; the observed convergence may therefore partly reflect unmeasured cross-diagnostic symptoms. The six studies also used different WM tasks: for example, digit span versus a computerized composite score, which may explain some of the high heterogeneity ($I^2 = 91.0\%$). A longitudinal design would help clarify the specific mechanics between WM deficits and either condition, which the cross-sectional studies synthesized here cannot address. Given that anxiety disorders constitute the most prevalent youth mental health condition (Polanczyk et al., 2015), the shortage of comparable pediatric WM-anxiety studies represents a pressing gap for future research to close.

Conclusion

The present analysis provides preliminary evidence that WM impairment may reach a comparable magnitude across ADHD and anxiety in youth. Both pooled estimates share a direction, and the adjusted ADHD estimate ($g = 0.80$) and the anxiety estimate ($g = 0.69$) are of similar magnitude.

The anxiety finding, by contrast, is derived from only two studies; a subgroup built on two comparisons cannot be cross-checked as readily as a larger subgroup permits. In addition, the ADHD subgroup shows substantial heterogeneity; comparable effect sizes therefore provide preliminary evidence for similarity in observed level of impairment. Future research should enlarge the pediatric anxiety evidence base, apply comparable WM measures across diagnoses, and assess both symptom dimensions within the same participants to determine whether a common pathway actually accounts for this pattern.

This synthesis accordingly addresses the acquisition, rather than the treatment, of WM impairment alongside each diagnosis; because the included studies were cross-sectional, however, the findings cannot establish when, through what process, or whether any intervention could reduce the deficit.

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Authors

Michael Koo is a senior at Chadwick International School with research interests in psychology, cognitive science, and linguistics. He is particularly interested in exploring how these interconnected fields shape human understanding and behavior.