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Working Memory in Children: Effects of Anxiety and Depression

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Abstract

The study analyzed archival data of 38 elementary and middle school students from special education records. Scale scores from the Behavioral Assessment System for Children-Second Edition-Teacher Rating Scale (BASC-2-TRS), were used to measure anxiety, depression, attentional and learning problems. These scale scores were used as predictor variables for working memory and full-scale IQ scores on the Wechsler intelligence scale for children-fourth edition. It was hypothesized that BASC-2-TRS scores would be negatively correlated with working memory scores, but not IQ scores. Results showed that the inverse relationship between learning problems and working memory scores was found to be significant.

Keywords: Working memory; Anxiety; Depression; BASC-2-TRS

Introduction

Intelligence assessment has been a primary tool used within school psychology to assess a student's level of cognitive abilities in determining need for special education services and predominantly as a tool to assist with the identification of Specific Learning Disabilities (SLD). There are currently 13 eligibility categories for special education under the Individuals with Disabilities Education Act (IDEA) with SLD being one that is difficult to define as there are varying characteristics of SLDs (e.g. comprehension, fluency, etc.) and SLDs can pertain to several academic areas (e.g. reading, writing, mathematics), yet nearly half of all students who qualify for special education do so under the SLD category [1].

Specific learning disability

The process for determining eligibility in the specific learning disability category has traditionally been through use of a discrepancy model. This model, though a federally legitimized method for determining eligibility, is becoming less widely accepted by school psychologists as a valid system for determining SLD. Research has identified more comprehensive methods, such as response-to-intervention model, which is promoted as a better practice for determining SLD [2]. In the state of Washington, a qualifying criterion for SLD is that a student's intellectual functioning is discrepant with his or her academic achievement, usually examined by standardized testing and using discrepancy tables published by the Office of Superintendent of Public Instruction [3]. However, it has been suggested that this is not an ideal method for determining SLDs because the use of the term "discrepancy" in the SLD definition is not operationally defined, and the discrepancy methods used to determine SLDs are variable [4].

The current discrepancy model uses a Full-Scale IQ (FSIQ) score from an intellectual assessment and determines if a student's academic achievement is discrepant with their cognitive abilities. In this case, discrepancy is determined by a difference in scores, the achievement score being "significantly" lower than the FSIQ, according to a state's individual standard. From this evaluation it can be inferred that because a student's achievement is disproportionate to his cognitive abilities as assessed by these two test scores, and other constraints (i.e. emotional disturbance, economic disadvantage, medical condition, etc.) have been ruled out, that the student is likely to have a specific learning disability. However, it has been proposed that learning disabilities should be assessed using batteries (e.g., Cross-battery assessment) that measure abilities directly related to the academic area of struggle.

Cattell-Horn-Carroll Theory

Cross-battery assessment uses a framework aligned with Cattell-Horn-Carroll theory, which has outlined broad and narrow cognitive ability categories, to more comprehensively evaluate a student's abilities by using multiple standardized assessments to thoroughly measure all cognitive abilities outlined in the theory which no one standardized test does independently [5]. This method can also flush out inconstancies in testing, such that if a student performed low on a measure due to being tired or inattentive, additional batteries can give more information about functioning in that particular area. Using this method, practitioners can identify which cognitive abilities are associated with reading (or other academic areas) and use measures that test these specific abilities to validly assess reading ability. This process can help pinpoint which cognitive abilities are strengths and weaknesses for a student as it pertains to the specific content area.

Learning difficulties

In order to further understand what contributes to learning difficulties in children, researchers have studied IQ [6,7] and working memory [8,9] as predictive factors of academic achievement. For instance, a longitudinal study by Alloway [10] showed that working memory capacity is a better predictor of learning abilities than is IQ. The researcher assessed achievement, intelligence, and working memory in students determined to have learning disabilities as currently outlined in IDEA. After an interval of two years, the students were reassessed with the same standardized batteries. Results indicated that IQ is not a significant predictor of academic success, but rather content knowledge and working memory span contribute significantly toward performance outcomes. In fact, working memory was shown to be a predictor of reading and math skills. An examination of the relationship between IQ and academic achievement has revealed that IQ may, in fact, not be the best predictor of academic achievement in children.

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Because of the large numbers of children identified as having a reading disability, much research is focused on the relationship between various executive functions and reading development. Christopher et al. [11] conducted a study to determine which processes of executive functioning (i.e. working memory, inhibition, processing speed and rapid naming) are independently significant predictors of reading outcomes. They did find that FSIQ's were predictive of reading comprehension and word reading but noted that it was significantly more predictive of reading comprehension than of word reading. They inferred from this that general intelligence may not be fully explanatory of individual abilities or of one's abilities alone. This means that while a higher IQ will likely increase one's ability to comprehend more complex text, the basic abilities needed to read the text, versus fully comprehend it, are mediated by other factors than IQ alone. For instance, they found that working memory was highly predictive of reading comprehension. They also found that it was highly predictive of word reading as was processing speed. The role of working memory in word reading is most likely associated with the task of learning symbol-sound naming. When learning to read, children must be able to associate what they see with what they hear and manipulate and store that information for later recall and then use that information to create and read novel words. These processes are taking place within the working memory model.

Following the research examining working memory and reading, Jerman et al. [12] expanded on the literature by assessing working memory growth as it relates to reading growth in students with and without reading disabilities and their progress in reading over time. Specifically, they wanted to know if growth in working memory correlates with growth in reading skills and if working memory deficits limit growth in reading and math. They divided the experimental groups into readers with poor comprehension skills, poor decoding skills, and average readers, as assessed by valid and reliable academic achievement measures. This study assessed students over a three-year period and the results showed that growth rates were similar across groups. The authors acknowledge that their findings are dissimilar with prior research and attribute it to methodological differences or the fact that they only examined one working memory task, sentence span. However, they did find that rate of growth was significantly correlated with age, in that younger children had higher growth rates in working memory span than did the older children. This was in line with other research, and the authors suggested that this demonstrates a ceiling effect of working memory growth, which may contribute to constraints in learning in other areas. Further investigation showed that working memory growth was significantly correlated with reading and math growth across all three years. These findings support that working memory performance is related to reading and math attainment.

Because of the evidence that shows working memory to be significantly related to academic performance and reading skills, it is important to look at factors that impair working memory capacity and contribute to deficits in performance. There has been much research done to investigate the impact of emotion on cognition [13,14]. The following sections will first explore how internalizing symptoms of emotions (anxiety and depression) impact cognitive functioning, and then examine the relationship of working memory to anxiety, depression, and learning outcomes.

Effects of Internalizing Disorders on Intellectual Abilities

Anxiety

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition [15] lists a variety of anxiety disorders. Certain anxiety disorders are related to specific stimuli (e.g. phobias) whereas some, like social anxiety disorder, affect a person's functioning in nearly all environments where social interactions are expected. Anxiety is an inappropriate response to stimuli (e.g. irrational fears) or inappropriate reactions in the absence of stimuli (i.e. excessive thoughts of worry), often accompanied by physiological symptoms such as elevated heart rate, muscle tension, or increased breathing [15]. Because of the impairment in functioning that is associated with anxiety disorders, it is essential to understand how these symptoms impact processes that are related to academic achievement. Research interest in the cognitive functioning of children with anxiety has yielded interesting results that show significant differences in cognitive functioning relative to their non-anxious counterparts. For example, Dalgleish et al. [16] sought to investigate the impact on various cognitive processes in children with varying emotional disorders. To determine whether children with depression, anxiety, and post-traumatic stress differed in their processing they used a series of tests, which assessed attentional and stimulus bias. The results showed that anxious children independently pay significantly more attention to threat-related stimuli, which is consistent with research about anxiety in adults [17]. Another study examining cognitive processing in anxious children used an ambiguous situations paradigm to see if anxious children are more likely to interpret situations of uncertainty as threatening and respond with plans that avoid the situation more than their non-anxious peers [18]. The results found that anxious children had a significantly greater tendency to avoid ambiguous situations and to interpret them as threatening. This is important because novel learning situations or complex material may heighten these avoidance tendencies in anxious children, therefore impacting their ability to learn the new information.

Depression

Like anxiety, depression in children has also been found to affect multiple cognitive processes in children including processing speed, learning, and memory and attention [19,20]. Brooks et al. [21] examined five domains of cognitive processing, including memory, psychomotor speed, reaction time, cognitive flexibility, and complex attention, in depressed children. The results indicated significantly impaired processing speed and verbal memory, as well as reduced inhibition while measuring executive functioning. Similarly, other research by Doumas et al. [22] showed that working memory accuracy is also significantly lower in individuals with major depressive disorder and that as task difficulty increases, working memory accuracy decreases. Although this design has not been replicated in children, it is still worth noting the effects of depression on working memory performance in children. Given the cognitive processes that are impacted by these internalizing symptoms, it is possible that overall working memory functioning of children dealing with these symptoms would be adversely impacted.

Working memory

Working memory can be defined as a central executive system for temporarily storing and managing information currently being processed by an individual. The current widely accepted working memory model was first established by the seminal work of Baddeley and Hitch [23]. This model proposed working memory to be composed of several components that include the central executive (i.e. attentional control system), an episodic buffer, the phonological loop and the visuospatial sketchpad [23]. These systems hold and manipulate information, with the phonological loop being associated with speech-based information and the visuospatial sketchpad being associated

with visual and spatial information. There has been a bulk of research indicating that working memory task performance is correlated to academic and cognitive abilities [6-10].

The effects of anxiety on working memory functioning can be further understood by Eysenck and Calvo's processing efficiency theory [24] which explains that cognitive resources are likely to be drained due to high levels of worry related to negative evaluation, and attentional control theory [25] to understand the parts of the central executive (attentional control system of working memory) being impacted, specifically the functions of inhibition, switching, and updating. Theoretically, the attentional bias that stems from anxiety will prevent the anxious individual (i.e. working while ignoring the worrisome thoughts) from completing the task as effectively as someone who does not have worrisome thoughts while working. The anxious individual will make far more errors trying to complete the task in the same amount of time, thereby performing less accurately. This effect was shown when Ashcraft and Kirk [26] studied the performance of students with math anxiety, hypothesizing that there would be a trade-off in computation accuracy and fluency. The results showed that when individuals with high math anxiety are asked to perform addition problems that involved carrying, their performance significantly declined while also performing a heavy working memory load task.

Within the PET and ACT theories, the effect of anxiety on academic performance can be potentially explained by working memory as a mediating mechanism. Aronen, et al. [27] examined the associations between working memory, anxiety and depressive symptoms, and academic performance. What they found was that anxiety and depressive symptoms are associated with poor academic achievement and suggest that this effect is mediated by working memory. To expand on this theoretical framework, Owens et al. [9] formally tested a mediational hypothesis between trait anxiety and academic performance, with working memory being the mediating mechanism involved. After administering the state trait anxiety inventory for children as a measure of anxiety, the participants were tested with working memory and academic tasks. The results show that working memory and academic performance are positively related and that anxiety is negatively related with academic performance. More importantly, working memory was a mediator between anxiety and academic performance. These results support that anxiety negatively impacts working memory thereby reducing task performance.

Overall, research literature suggests that working memory has a strong relationship with academic performance and that internalizing symptoms may have their effect on academic performance via their effect on working memory. Therefore, it is possible that this relationship can be found in data taken from school psychology assessments that measure internalizing symptoms and working memory. However, in order to study that impact, it would be important to also examine the possible effects of mediating or confounding variables. Sometimes the effect of a predictor variable on a dependent variable is due to the effect of the predictor variable on an intermediary third variable, which can be mediating or confounding [28]. In order to determine whether any impact of internalizing disorders on working memory is direct or mediated, attention should be included because it is a necessary function for information intake which is required for working memory performance. Because of the relationship between learning difficulties and working memory and IQ as found in prior research [6-10], learning difficulties are also important to look at as possibly mediating or confounding any relationship between internalizing symptoms and working memory and IQ.

Current Study

The current investigation was designed to assess whether data from standardized measures currently used in schools by school psychologists can predict a negative correlation between working memory performance and anxiety, depression, attention problems, and learning problems. The Behavior Assessment System for Children, Second Edition, Teacher Rating Scales [29] is a common assessment battery used in elementary and secondary education by school psychologists to screen for social, emotional, and behavioral problems. This study used scores from the BASC-2-TRS, specifically the scales for anxiety, depression, attention problems, and learning problems.

Working Memory (WM) scores from the Wechsler intelligence scale for children, Fourth Edition [30] were used to measure performance of WM, as it is a widely used IQ test by school psychologists. The full-scale IQ (FSIQ) score from the WISC-IV was also used to determine the relationship between FSIQ and anxiety, depression, attention problems, and learning problems.

Since working memory is a significant predictor of academic performance, and anxiety and depression in children have been shown to adversely impact working memory processing, the hypothesis of this study was that anxiety and depression scale scores on the BASC-2-TRS should be negatively correlated with WM scores on the WISC-IV. Archival data for both the WISC-IV and the BASC-2-TRS were used to predict working memory and FSIQ performance based on anxiety, depression, attention problems, and learning problems scores.

Materials and Methods

Participants

Archival data of the BASC-2-TRS and WISC-IV was obtained from a local School District in the region. All names were removed from the data, by the school psychologist, to ensure anonymity. Data was collected from 40 students in grades K-8. However, due to missing scores in the data, only 38 sets of student data were used in the analysis.

Inclusion and exclusion criteria

All students were assessed as a result of referral for special education by the district's school psychologist. Therefore, the sample pool constituted a special population and not a random sampling of the general student population. All data was used, regardless of qualification for special education, as this is not a factor in this analysis.

Measures

The BASC-2-TRS is a standardized measure of social, emotional, and behavioral functioning [29]. There are separate questionnaires for parents or teachers to complete, as well as a child self-report questionnaire. Questionnaires are completed by the individual based on his or her observations of a child's behavior in specific conditions. For the purposes of this study, only teacher ratings will be used. The BASC-2-TRS assesses multiple domains of functioning including externalizing problems, internalizing problems, school problems, and adaptive skills. Each domain gives a composite as well as a standard score for each subscale in the domain. Anxiety and depression as measured by the BASC-2-TRS have reliability coefficients ranging from 0.78-0.84 and 0.84-0.88, respectively. Coefficient ranges are by age and sex level [29]. For the purposes of this study the BASC-2-TRS forms will be used and only the subscales of anxiety, depression, attention problems, and learning problems, will be analyzed as predictor variables of working memory performance and FSIQ on the WISC-

IV. BASC-2-TRS subscales will be used as predictor variables in order to test whether these measures predict scores on working memory or FSIQ, presumably due to direct effects or effects of third variables. Research indicates that anxiety and depression may have a negative impact on working memory.

The WISC-IV is a standardized intelligence test [30] used in schools by school psychologists to assess students when referred for special education. The WISC-IV was standardized on 2,200 children, age 6:0 to 16:11, across sex, race/ethnicity, parent education level, and geographic region. The WISC-IV provides a FSIQ score that is comprised of four composite scores in the domains of verbal comprehension, perceptual reasoning, Working Memory (WM), and processing speed. For the purposes of this study, only the subscales of the WM composite will be analyzed as well as the FSIQ score. The subscales include Digit Span (DS) and Letter-Number Sequencing (LNS). Abilities and background factors for these subscales include attention, working memory, auditory acuity, auditory sequential processing, concentration, numeric ability, and short-term memory. Each subscale produces a standard score that represents a student's performance on the task, which can be compared to same-aged peers. The subscales have a mean of 10 and a standard deviation of 3. The composite scores for domains were normalized and have a mean of 100 and a standard deviation of 15. Reliability coefficients across ages for DS, LNS, WM, and FSIQ are 0.87, 0.90, 0.92, and 0.97 respectively. The WISC-IV has been established empirically as a valid measure of intelligence and is a standard measure used in schools for children ages 6:0-16:11 [30].

Procedure

Permission was obtained from the school principal and special education director of Cle Elum-Roslyn School District to use student data previously gathered by the school psychologist. An exempt form for HSRC was submitted along with a letter of cooperation from the school administration. To ensure anonymity of participants, the school psychologist sorted through student files to remove any identifiable information from the student files, including names of students, parents, and teachers, addresses, phone numbers, and birthdates. A numerical code was assigned to each set of student data to ensure accuracy for comparing scores from the BASC-2-TRS and WISC-IV. There is no record of original student files matched with the numerical code. The purpose of the code is only to keep the data sets together. The data was analyzed to determine whether scale scores for anxiety, depression, attention problems, and learning problems on the BASC-2-TRS can predict WM and FSIQ scores on the WISC-IV.

Hypotheses

This study tested the hypothesis that select BASC-2-TRS scores would be negative predictors of working memory composite sores on the WISC-IV but not for FSIQ scores. The BASC-2-TRS scores used as predictor variables were anxiety, depression, attention problems, and learning problems subscales. It was hypothesized that each scale score would be a significant negative predictor of Working Memory composite scores.

This study also examined whether significant predictors of working memory scores would also emerge as significant predictors for the FSIQ score. The same four subscales were used to examine the relationship with IQ scores on the WISC-IV. It was hypothesized that any significant predictors of working memory scores would not emerge as significant predictors of FSIQ.

Results

Descriptive statistics

Standard deviations and means were calculated for all variables. The mean working memory score was 77.76 with a standard deviation of 12.94. The mean FSIQ score was 78.21 with a standard deviation of 15.62. The mean anxiety score was 50.03 with a standard deviation of 30.26. The mean depression score was 60.84 with a standard deviation of 13.30. The mean attention problems score was 62.55 with a standard deviation of 10.50. The mean learning problems score was 70.45 with a standard deviation of 9.43.

Correlation coefficients

Correlation coefficients were constructed for all variables using Pearson's r. As shown in Table 1, working memory and FSIQ were significantly positively correlated ($r=0.85$, $p \leq 0.001$). This result is expected given that working memory is one composite score that is factored into the FSIQ. Moreover, working memory was significantly negatively correlated with learning problems ($r=-0.33$, $p \leq 0.05$). Depression and attention problems were significantly positively correlated ($r=0.35$, $p \leq 0.05$), while attention problems were significantly positively correlated with learning problems ($r=0.57$, $p \leq 0.001$). No other correlations reached statistical significance (Table 1).

Working memory

A hierarchical linear regression was performed to evaluate the relationship between working memory scores as measured by the WISC-IV and 4 BASC-II sub-scale scores. Working memory scores were used as the dependent variable and the 4 BASC-II sub-scales were used as predictor variables. The predictor variables were tested in two models, with the first model including depression and anxiety sub-scales and the second model adding learning problems and attention problems.

As shown in Table 2, depression and anxiety sub-scales were not found to be significant predictors of working memory scores in either model. Similarly, attention problems sub-scale did not significantly predict working memory scores when added in model 2. However, learning problems sub-scale scores were a significant negative predictor of working memory scores in model 2 ($Beta=-0.410$, $p<0.05$). The first model predicted 1% of the variance (Model 1 R square=0.012). Model 2, which included learning problems and attention problems, predicted approximately 15% of the variance (Model 2 R square=0.145).

Full-Scale IQ

A hierarchical linear regression was performed to evaluate the relationship between FSIQ scores as measured by the WISC-IV and 4 BASC-II sub-scale scores. FSIQ scores were used as the dependent variable and the 4 BASC-II sub-scales were used as predictor variables. The predictor variables were tested in two models, with the first model including depression and anxiety sub-scales and the second model adding learning problems and attention problems.

As shown in Table 2, Depression and anxiety sub-scales were not found to be significant predictors of FSIQ scores in either model. Likewise, learning problems and attention problems were not found to be significant predictors of FSIQ when added in model 2. Models 1 and 2 did not predict a large percentage of the variance (Model 1 R square=0.017, model 2 R square=0.070).

Variables	Anxiety	Depression	Attention problems	Learning problems	Working memory
Depression	ns	--	--	--	--
Attention problems	ns	r=0.35*	--	--	--
Learning problems	ns	ns	r=0.57***	--	--
Working memory	ns	ns	ns	r=-0.33*	--
FSIQ	ns	ns	ns	ns	r=0.85***
Notes: Table displays Pearson's r-values. ns: not significant. *p<0.05. ***p<0.001.					

Table 1: Correlation matrix for all variables using Pearson's r.

Variables	Model 1	Model 2
Predictor variables	Anxiety	Anxiety
	Depression	Depression
		Attention problems
		Learning problems*
Criterion variables	Working memory	Working memory* (Beta=-0.410, p<0.05)
	FSIQ	FSIQ
Results	R square=0.012 (WM)	R square=0.145 (WM)*
	R square=0.017 (FSIQ)	R square=0.070 (FSIQ)
Notes: *p<0.05.		

Table 2: Results of the Hierarchical multiple linear regression-working memory and FSIQ.

Discussion and Conclusion

The purpose of this study was to examine the relationship of anxiety, depression, learning problems, and attention problems scale scores on the BASC-II-TRS with working memory and IQ scores on the WISC-IV. Specifically, it was predicted that all four BASC-II-TRS scale scores would have a negative relationship with working memory. The results of this study found that learning problems, but not anxiety, depression, or attention problems, were a significant predictor of working memory composite scores. As learning problems scores increased, working memory performance scores significantly decreased. It was also predicted that anxiety, depression, learning problems, and attention problems scale scores would not have a significant negative relationship with IQ. This was supported because none of the predictor variables emerged as a significant predictor of IQ.

Alternative explanations

There are several possible explanations for the finding that only the learning problems scale score was a significant predictor of working memory, while anxiety, depression, and attention problems were not. For instance, one potential issue is the sensitivity and subjective nature of the scales on the BASC-2-TRS for the domains of anxiety, depression, and attention problems. Learning problems can be assessed in more concrete forms, through data collection of academic performance by measuring growth in learning over time through academic work and curriculum-based measurement [1]. Therefore, teachers have more tangible evidence of a student's learning ability. However, the other domains tend to be more difficult to accurately assess from another's perspective. This is because anxiety, depression, and attention typically manifest with internalized symptoms (i.e. worrisome thoughts, inability to concentrate), which can be difficult to see, and therefore rate [31]. Moreover, a rater's bias can over- or underestimates a student's behavioral functioning [31]. The manifestation of anxiety is highly internalized compared to depression, which has more external cues. Because of this, it may not be as often recognized in students and not reported as an area of concern by teachers. For example, Cunningham and Suldo [32] found that teachers were able to accurately identify only 50% and 40.7% of elementary students with self-reported at-risk levels of depression and anxiety, respectively. Attention is also often hard to determine in students because it is a mental function that is frequently measured through bodily gestures such as a calm body and eyes attending to the instructor but may not necessarily indicate that a student is truly attending to the information. Therefore, based on the results of Cunningham and Suldo [32], it is theorized that the subjective nature of the measurement of the BASC-2-TRS scales may have underreported the true levels of anxiety, depression, and attention problems.

Another explanation for anxiety, depression, and attention problems not appearing as significant predictors of working memory composite scores could be the duration and coping strategies related to these domains. As measured by the BASC-2-TRS, length of time is not accounted for. While the respondent is instructed to report according to behavior exhibited in the past two months, it does not account for coping strategies that students may be using to manage any struggles if they have been experiencing any symptoms for a prolonged period of time. Coping strategies can be used to manage feelings and significantly reduce levels of anxiety and depression in children [33]. These strategies have been found to minimize negative effects on areas of life functioning, including learning, across the lifespan in students diagnosed with a learning disability [34]. If a student has developed effective emotional coping strategies, then it is less likely that anxiety or depression would negatively impact working memory performance, and therefore learning. Students who have difficulties with attention can also adopt effective coping strategies and teachers can implement interventions to minimize negative impacts on learning [35].

For anxiety alone, there is possibly a third explanation for a lack of a significant negative relationship with working memory performance. The level of arousal caused by the experience of anxiety may not have been sufficient to make it maladaptive. That is, people with self-reported high levels of anxiety and stress have shown more variation in their cortisol levels compared to their low-anxiety and low-stress counterparts [36]. Stress is often measured physiologically by cortisol levels [37-41]. For instance, Vedhara et al. [36] found that high anxiety and high stress participants have higher levels of cortisol in the morning, and those levels would fall more quickly and remain lower than the low-anxiety and low-stress group for most of the day. However, by the end of day, the high-anxiety and high stress group

would reach higher levels of cortisol than the low-anxiety and low-stress group. These similar patterns of stress and anxiety and cortisol indicate that anxiety may be some form of perceived stressor that is evident in the cortisol levels. The study by Vedhara et al. [36] supports the finding that cortisol levels are more stable in people with low levels of anxiety and stress. A specific relationship pattern between working memory performance and cortisol levels was found by de Kloet et al. [42]. Their research revealed an inverted U-shaped dose response effect of cortisol on working memory performance. Low levels and high levels of cortisol each negatively impact working memory, however, within a certain normal range, cortisol supports or even possibly enhances working memory. Therefore, students with elevated anxiety levels may not have experienced sufficient levels to negatively impact working memory performance.

A final explanation for the lack of significant relationships between working memory and anxiety, depression, and attention problems may include the cognitive load of the specific subtests that create the working memory composite on the WISC-IV. For example, the digit-span subtest only requires the student to briefly hold a series of 2 to 7 numbers and repeat them back to the examiner in the same order. A separate portion of the same subtest requires a similar task, but asks the subject to repeat the numbers in reverse order. The other subtest that creates the working memory composite asks the subject to briefly hold a sequence of letters and numbers in working memory and repeat them back in order beginning with letters, then the numbers. While this portion of the test increases the cognitive load, the cognitive demands of the learning environment far exceed a simple repeat of a series of numbers as measured by the WISC-IV.

Future Research

Based on the literature and findings of the current study, there is a significant relationship between working memory and learning. Therefore, school psychologists should consider more of an emphasis on examining executive functions when accessing a student's level of cognitive abilities. Future research should use other working memory measures that include higher demand tasks that are more representative of the task demands related to learning. For instance, during learning instruction a student might have to hold and organize information while taking notes, and simultaneously attend to the incoming information. A battery that assesses the three main components of the working memory model (i.e. central executive, phonological loop, and visual spatial sketchpad) [23] would provide a more accurate measure of working memory functioning required to perform these tasks. Specifically, the working memory test battery for children, could provide a better assessment of working memory, because it includes 7 different subtests to validly and reliably assess the three components for an overall functional capacity score for working memory [43].

In addition, future studies should consider utilizing multi-reporter ratings, including self-reports, teacher reports, and parent reports, to get a more global view of the students' functioning in the domains of anxiety, depression, attention problems, and learning difficulties. This type of multi-dimensional approach could provide a more reliable way to get an accurate measure of these domains because of the subjective nature of any scale measuring internalizing symptoms. Acquiring only one person's perspective report on another's behavior can often be under or over reported due to biases [31]. Therefore, measures using three or more perspectives-that assess a student in multiple environments (i.e. parent assessing home environment, teacher assessing school environment) may minimize the impact of bias reporting.

In conclusion, the current study supports the hypothesis that working memory can be a more predictive measure of academic achievement than the full-scale IQ. Specifically, the current study showed that learning problems were a significant predictor of working memory composite scores and that IQ is not significantly related to learning ability. Moreover, the results of this study are in agreement with previous research which showed that working memory is more predictive of academic achievement [7,8] and learning abilities [10] over IQ.

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