Revista Iberoamericana de Neuropsicología, Vol. 8, No. 1: 73-88, enero-junio, 2025.

Exploring the Relationship between Attention, Working Memory, and Academic Achievement among Puerto Rican Adolescents Exposed to Adverse Events

Rosanna Rodríguez, PhD.[1*], Geraldine M. Méndez-González, MA, MS.[2], Kiara M. Vega-Tirado, MA, MS.[2], Mario E. Bermonti-Pérez, PhD.[2], Giselle Cordero-Arroyo, PhD.[2], Norka Polanco-Frontera, PhD.[2]

ABSTRACT

Objective: *To examine the relationship between attention (ATT), working memory (WM), and academic achievement (APROV) in Puerto Rican adolescents exposed to adverse events.*

Method: *Participants were 24 Puerto Rican adolescents (aged 12-17), with an average age of 14 years (M = 14; F = 10) who had been exposed to at least one adverse event. A within-subjects cross-sectional design was used. ATT and WM were measured using the Cognitive Assessment System-2: Spanish (CAS2:ES), and APROV was assessed across reading, mathematics, writing, and fluency using the Woodcock-Muñoz IV (Battery-IV: APROV).*

Results: *Linear regression analysis revealed that ATT accounted for 51.2% of the variance in APROV, while WM explained 42.9%. Both ATT ($b = 0.587$, $\beta = 0.716$, $t(22) = 4.804$, $SE = 0.139$, $p < .004$, 95% CI [0.334, 0.840]) and WM ($b = 0.431$, $\beta = 0.655$, $t(22) = 4.066$, $SE = 0.106$, $p < .002$, 95% CI [0.211, 0.651]) showed significant relationships with APROV.*

Conclusion: *The findings suggest that both ATT and WM are important predictors of academic success in this population, with ATT having a slightly stronger association. These results highlight the need to improve cognitive functions, such as ATT and WM, to support academic outcomes for Puerto Rican adolescents exposed to adverse events. Further research with a larger sample size is needed, as well as the development of targeted psychoeducational interventions aimed to enhance ATT and WM skills to help reduce the impact of adverse events on academic achievement.*

Keywords:

Academic Achievement, Attention, Working Memory, Adverse events, Adolescents, Cognitive Functioning

***Corresponding author:**

Correspondence concerning this article should be addressed to: Dr. Rosanna Rodriguez, Primary Investigator. Pompano Beach, Florida 33069.
E-mail: rosanna.rodriguez.phd@gmail.com

[1] Independent Researcher. This work was supported by School of Behavioral and Brain Sciences (SBBS) at Ponce Health Sciences University (PHSU).
[2] School of Behavior and Brain Sciences, Ponce Health Sciences University, Ponce, Puerto Rico.

INTRODUCTION

Academic achievement (APROV) encompasses students' performance in core subjects like reading, mathematics, and writing, shaped by such as cognitive abilities, personal habits, teaching methods, environmental influences, and socio-economic conditions. In this context, attention (ATT) and working memory (WM) play essential roles, as these cognitive functions directly support the processes that underlie learning and academic performance. Attention (ATT), as defined by the PASS Neurocognitive Theory (Naglieri & Otero, 2024)[1], is the ability to focus on specific stimuli while resisting distractions, while working memory (WM), as described by Georgiou et al. (2008)[2], involves temporarily storing, recalling, and manipulating information. These cognitive functions are critical to academic success, as attention supports sustained engagement with academic content, and working memory enables the retention and manipulation of information necessary for problem-solving and learning new material[3-4]. However, exposure to adverse events such as trauma, chronic stress, or neglect can disrupt these cognitive processes by affecting the brain's regulatory systems, ultimately hindering both attention and working memory, which negatively impacts academic performance[5]. Despite the recognized importance of attention and working memory in academic achievement, there is still limited understanding of how these cognitive functions interact with one another to influence academic outcomes. Additionally, the precise mechanisms through which adverse experiences disrupt these processes and further affect academic performance remain unclear. Understanding the relationship between these cognitive functions and academic achievement is essential, particularly for Puerto Rican adolescents exposed to adverse events. In Puerto Rico, factors such as high rates of socio-economic challenges, trauma, and the aftermath of natural disasters such as hurricanes can exacerbate cognitive impairments in attention and working memory. These disruptions are more pronounced in vulnerable populations, potentially leading to sustained academic underachievement. Addressing these issues is crucial to improving educational outcomes and supporting the cognitive development of adolescents in this context.

While academic achievement (APROV) encompasses various domains, including reading, mathematics, written language, and overall achievement skills, its relationship to cognitive functions such as attention and working memory remains underexplored, particularly for Puerto Rican adolescents exposed to trauma or chronic stress[6]. APROV describes the academic accomplishments that students have achieved in their short-term and long-term learning goals. However, academic performance is often assessed through standardized exams or ongoing evaluations that may not fully capture the intricate cognitive processes at play[6]. Recent studies suggest that APROV is influenced by neurocognitive functions, social-economic status, and parents' education levels[7]. While it is known that socio-family risk factors, such as lower socio-economic status and limited parental education, can negatively impact academic performance, exposure to trauma or adverse events—such as chronic stress, neglect, or family instability—can further exacerbate these effects by disrupting neurobiological processes implicated in the development of executive function (EF) skills (e.g., planning, organizing, decision-making, attention and working memory). These disruptions may contribute to persistent academic underachievement, but the specific ways in which trauma interacts with these risk factors to influence academic outcomes are still not fully understood, particularly in vulnerable populations. However, evidence is lacking on how these factors uniquely affect Puerto Rican adolescents, specifically those exposed to adverse events, whose cognitive abilities may be further compromised. In Puerto Rico, the aftermath of natural disasters, such as hurricanes, coupled with high rates of poverty, political instability, and the ongoing challenges of migration, have placed many adolescents in environments of chronic stress and trauma. These conditions can hinder the development of cognitive functions crucial for academic achievement, such as attention and working memory, ultimately affecting their academic performance and long-term educational outcomes[4,5,8,9].

Exposure to adverse events has been consistently linked to increased risks of mental health disorders, learning difficulties, and academic

underachievement, particularly among Latino populations[10]. Adverse events, including physical assault, emotional abuse, natural disasters, and violence, can have profound psychological effects, especially on vulnerable populations such as adolescents exposed to these traumatic experiences[11,12]. Adolescents who experience adverse events may exhibit symptoms such as depression, anxiety, post-traumatic stress disorder (PTSD), delinquency, and substance abuse[13-16], all of which negatively impact academic performance[10]. Moreover, chronic trauma exposure during adolescence has been tentatively linked to heightened vulnerability for mental health issues, which can further hinder academic achievement[17]. While literature on adolescents with attention deficit hyperactivity disorder (ADHD) demonstrates a significant risk for reading problems[18] mediated by working memory[19], research specifically focusing on Puerto Rican adolescents and how attention and working memory influence their academic outcomes in the context of adverse events remains limited. Existing studies have also found a medium effect size for the relationship between exposure to familial trauma and poorer executive function (EF) performance, including attention and working memory[20]. However, the intersection of cognitive mechanisms of attention and working memory with academic achievement in Puerto Rican adolescents exposed to adverse events remains insufficiently explored[21].

Das, Naglieri, and Kirby's (2014)[1] Planning, Attention-Arousal, Simultaneous, and Successive (P.A.S.S.) theory of intelligence, grounded in Luria's neuropsychological framework, provides a detailed model for understanding cognitive processes such as attention and working memory, which are critical for learning and academic achievement. Attention, is central to the theory, encompassing the ability to focus on relevant stimuli while resisting distractions[2]. The P.A.S.S. theory divides Luria's second cognitive unit into simultaneous and successive processing, with a particular focus on how working memory—defined as the temporary storage, manipulation, and recall of information—relates to these cognitive processes[1]. The P.A.S.S. framework is particularly useful for understanding how cognitive functions, such as attention and working memory, affect academic performance, which can be significantly impacted by exposure to adverse experiences[1]. This framework is especially relevant for adolescents from communities exposed to trauma and stress, as such experiences can disrupt their cognitive abilities and hinder academic success. The Cognitive Assessment System, Second Edition (CAS2), which is based on the P.A.S.S. theory, provides a comprehensive tool for assessing these neurocognitive processes, offering a more targeted approach than broader models such as the Cattell-Horn-Carroll (CHC) theory[22,23-24]. The CHC theory, distinguishes between crystallized abilities, which rely on accumulated knowledge and past learning, and fluid abilities, which involve problem-solving and learning in novel situations. Crystallized abilities tend to remain stable throughout adulthood, while fluid abilities are more sensitive to aging and neurological changes[25]. This theoretical framework underpins tools like the Woodcock-Muñoz IV standardized academic achievement battery (Batería-IV: APROV), used to measure constructs academic achievement (e.g., reading, mathematics, and writing) and their correlations with neurodevelopmental trajectories and academic outcomes. As part of the conceptual theoretical framework, focusing on the CHC model alongside the P.A.S.S. theory ensures a more comprehensive understanding of the neurocognitive processes and underlying abilities, such as attention and working memory, that influence academic achievement in this developmental population[19,21, 26].

The relationship between attention (ATT), working memory (WM), and academic achievement (APROV) remains poorly understood in several key areas. While attention and working memory are known to support academic performance, the specific ways in which these cognitive functions interact to influence academic outcomes are unclear. Additionally, although adverse experiences such as trauma and stress can disrupt both attention and working memory, the mechanisms through which these disruptions affect academic achievement are not well-defined. Furthermore, the interplay between cognitive functions and socio-economic or familial risk factors, such as low socio-economic

status or parental education, in shaping academic outcomes in adolescents—particularly in Puerto Rican adolescents exposed to trauma—has yet to be fully explored. These gaps in understanding hinder efforts to address academic underachievement in vulnerable populations.

Understanding the complex interaction between cognitive functions, specifically attention and working memory, and academic achievement is essential for informing effective interventions, including the use of the *Batería IV* and other assessment tools within the Puerto Rican community, particularly among adolescents exposed to adverse events[6,17]. This study examines the relationship between attention composite index scores (ATT) and broad academic achievement (APPROV) among Puerto Rican adolescents who have reported exposure to adverse events. It also explores the relationship between working memory composite index scores (WM) and broad academic achievement (APPROV) in the same group. It is hypothesized that (1) higher levels of attention composite index scores are associated with better broad academic achievement scores in Puerto Rican adolescents exposed to adverse events, and (2) higher levels of working memory composite index scores are associated with better broad academic achievement scores in this population. Exposure was not used as a measurement variable in this study; rather, it is considered a defining characteristic of the sample. The findings are important because they highlight how attention and working memory, key cognitive functions, affect academic achievement, especially for adolescents who have faced such challenges. The data can guide the development of targeted interventions to improve these cognitive skills, potentially addressing academic underachievement and supporting better outcomes for students affected by trauma or stress. The implications of this research extend to both educational strategies and psychological support systems.

METHOD

We employed a quantitative approach with a within-subjects cross-sectional design. We used a combined non-probabilistic sampling technique of snowball and convenience sample. The originally planned sample size was calculated using G*Power for 30 participants, with an effect size of 0.95. This effect size is classified as large. However, participants were recruited during the global COVID-19 pandemic, which impacted resources for recruitment. We were able to recruit 46 participants, with only 24 who met and qualified for our eligibility criteria.

Table 1. Frequencies of Demographic Variables

Demographic variables	Frequency	Percent
Assign at birth sex		
Male	14	58.3%
Female	10	41.7%
School		
Public	12	50.0%
Private	11	45.8%
Homeschool	1	4.2%
Grade level		
6th Grade	1	4.2%
7th Grade	4	16.7%
8th Grade	3	12.5%
9th Grade	6	25.0%
10th Grade	2	8.3%
11th Grade	5	20.8%
12th Grade	3	12.5%

Table 1. Frequencies of Demographic Variables (Continuation)

Demographic variables	Frequency	Percent
GPA (*N* = 23)		
3.6 - 4.0	12	50.0%
2.6 - 3.5	9	37.5%
1.5 - 2.5	2	8.3%
Academic Problems		
Yes	9	37.5%
No	15	62.5%
Type of Academic Problem		
Mathematic	8	33.3%
Orthography	6	25.0%
Reading	3	12.5%
Writing	3	12.5%
Level of Education		
Mother		
High school or less	5	20.8%
Bachelor's degree	12	50.0%
Master›s degree	2	8.3%
Other	5	20.8%
Father		
High school or less	8	33.3%
Bachelor's degree	6	25.0%
Master's degree	5	20.8%
Other	5	20.8%
Participants		
Middle School	8	33.3%
High School	15	62.5%
Homeschool	1	4.2%
Participants' Income		
< 15,000	5	20.8%
15,000-24,999	6	25.0%
25,000-34,999	4	16.7%
35,000-49,999	1	4.2%
50,000-74,999	5	20.8%
> 75,000	3	12.5%

Note. *N* = 24.

Participants

Eligible participants were adolescents between 12-17 years of age who self-reported exposure to one or more adverse events, without significant physical, mental, motor, or neurodevelopmental conditions that would impede their ability to complete paper-and-pencil tasks or provide verbal responses for academic purposes. Our participants had an average age of 14 years (M = 14; F = 10); 78% received outpatient clinical services and 17.4% were recruited from secondary education schools in the eastern and southern regions of Puerto Rico (see table 1 for additional demographic information). All participants were fluent in both verbal and written Spanish. They resided in Puerto Rico,

had internet access, and had been exposed to at least one adverse event. Exclusion criteria included a reported history of substance use, traumatic brain injury (TBI), or any serious mental health or neurodevelopmental conditions that could hinder participants' ability to respond to the questionnaire. Additionally, participants were excluded if they indicated "no" regarding adverse events.

Participants experienced a mean of 2.75 adverse events (SD = 1.75; see figure 1). All 24 participants (100%) reported experiencing at least one adverse event, with the average number of adverse events ranging from two to three types (see figure 1). The reported events were: atmospheric (91.7%), accident or severe lesion (41.7%), victim of physical intrafamilial violence (12.5%), victim of physical interpersonal violence (20.8%), observed physical community violence (4.2%), sexual aggression (8.3%), sexual assault (4.2%), sudden death of someone close (29.2%), medical procedures (25.0%), and war (4.2%; see figure 2).

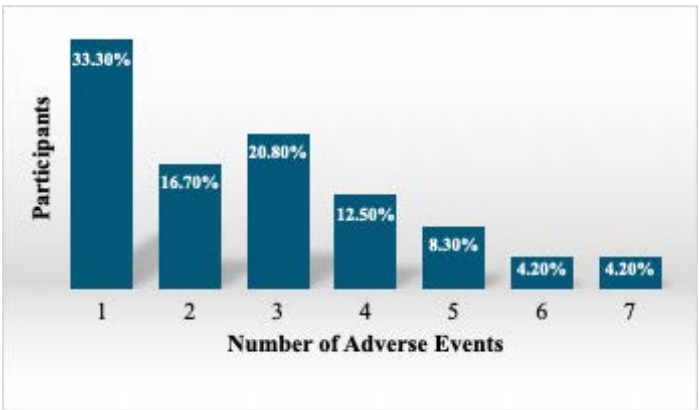

Figure 1. Number of adverse events experienced by participants, by percentage

Note. The mean number of adverse events experienced by participants was 2.75 (SD = 1.751), with all 24 participants reporting at least one adverse event. On average, participants experienced two types of adverse events (16.7%) to three types (20.8%).

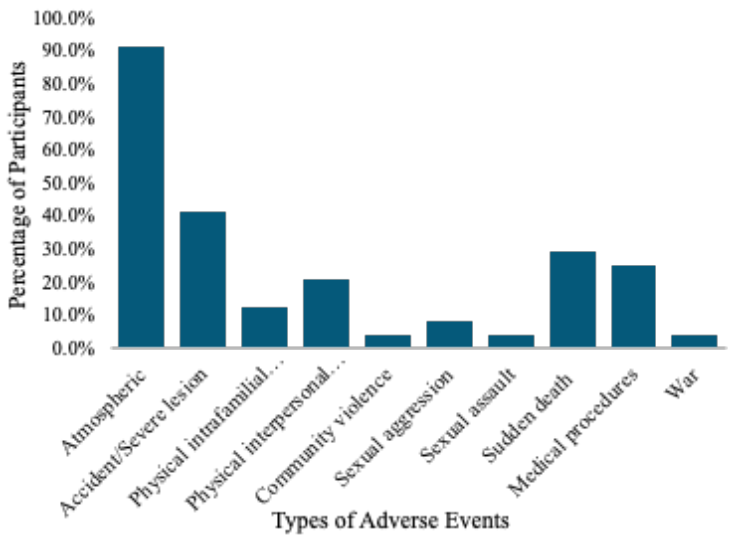

Figure 2. Types of adverse events experienced by participants, by percentage

Note. The types of adverse events experienced by participants, by percentage, are shown in this figure. Atmospheric events were experienced by 91.7% of participants, with accidents or severe lesions being the second most common, reported by 41.7% of participants.

Instruments

For this study, we used a sociodemographic questionnaire to explore participants' biopsychosocial history, including aspects such as age, gender, grade, school type, primary language, handedness, physical and mental health history, and potential academic challenges. This form, comprising of 80 items, was completed by parents/caregivers (e.g., 91.7% mothers, 4.2% father, and 4.2% aunts), and the administration of this questionnaire took about 30 minutes.

We used the Child and Adolescent Trauma Screen, Spanish Version (CATS[27]). This instrument was adapted for Puerto Rico in 2018 by the Support Project for Children and Adolescents at the Institute of Psychological Research, University of Puerto Rico, Río Piedras Campus. The adaptation is applicable to children and adolescents ages 7 to 17. This 15-item self-reported trauma screening employed a yes/no scale to explore childhood adverse events (i.e., natural disasters, man-made disasters, accidents, emotional and physical assault, maltreatment, violence, medical procedures), including significant functional impairment measured across five yes/no items such as getting along with others, hobbies/fun, school or work, family relationships, and general happiness. Overall, participants were required to have experienced at least one marked adverse event meeting criteria for inclusion. Completing the questionnaire by the participant typically took approximately 15 minutes.

We assessed Attention (ATT) and Working Memory (WM) using standardized composite index scores from the Cognitive Assessment System-2: Spanish (CAS2:ES[28]). CAS2:ES is a norm-referenced test that evaluates neurocognitive abilities in children aged 5 to 18. ATT is operationally defined as the independent variable by the attention composite index, derived from the standard scores of three subtests in the CAS: ES2: *Expressive Attention*, which evaluates the ability to sustain focus and respond to a target stimulus while ignoring distractions such as reading words like "blue" and "yellow," identifying the colors of a series of rectangles, and identifying the color of the ink in which the word is printed, rather than reading the words themselves; *Number Detection*, which measures selective attention by identifying specific numbers or patterns in a random sequence where the examinee is tasked with underlining numbers on a page that match stimuli at the top of the page; and *Receptive Attention*, which assesses the ability to follow instructions and maintain attention while processing information, by finding and underlining pairs of identical images or letters. Together, these subtests provide a comprehensive measure of an individual's attentional control and processing abilities. WM is operationally defined as the dependent variable by the working memory composite index, calculated from the standard scores of two subtests in the CAS: ES2: *Verbal-Spatial Relations*, which assesses the ability to hold and manipulate both verbal and spatial information for problem-solving by selecting the correct image from multiple options in response to a question. The second subtest, *Sentence Questions*, evaluates the capacity to understand, retain, and retrieve verbal information from sentences or short stories, where each sentence contains color names in place of content words, requiring the examinee to answer a question based on the read text. Composite Index scores were considered very poor <70; poor 70-79; low average 80-89; average 90-109; high average 110-119; superior 120-129; and very superior >130. Internal consistency (reliability) for the PASS theory scales showed a Full-Scale alpha of .96.[29] While the Spanish version was not yet normalized in Puerto Rico, studies with bilingual children indicated a high correlation (.97) between the original English version and the Spanish edition[30]. Participant completion of this test typically ranged from 30 to 45 minutes.

We assessed Academic Achievement (APROV) using broad domains of reading, mathematics, writing, and fluency from the Woodcock-Muñoz IV standardized academic achievement battery (Batería-IV: APROV[31]). This comprehensive Spanish-language psychoeducational assessment system, designed for individuals aged 5 to 95, included a broad academic achievement battery. APROV is operationally defined as the dependent

variable by the broad academic achievement composite score derived from the standard scores of the core set of tests (e.g., Tests 1 through 6). Standard Scores were considered very inferior <69; inferior 70-79; low average 80-89; average 90-110; high average 111-120; superior 121-130; and very superior >131. These tests assessed *Lectura* con fluidez (Reading fluency), *Matemáticas con fluidez* (Mathematics fluency), *Lenguaje escrito con fluidez* (Written Language fluency), *Destrezas académicas* (Academic Skills), *Aplicaciones académicas* (Academic Applications), and *Aprovechamiento breve* (Brief Achievement). Internal consistency for core tests 1 through 6 demonstrated median reliability alpha between .89 to .92 in the 5 to 19 age range[6]. Participant completion of this test typically ranged from 60 to 90 minutes.

Procedure

Once authorized and approved by the Institutional Review Board (IRB) at Ponce Health Sciences University (IRB protocol # 1907018739A009), recruitment efforts targeted clinics and schools along the Southern and Northeastern coasts of Puerto Rico (details omitted for double-blind reviewing). Electronic and physical flyer advertisements were used, as well as oral announcements by clinical supervisors, practicum doctoral students, and school personnel who received training and instructions by the research team prior to the recruitment and data collection process.

Data collection occurred over three phases across three days: a 30-minute teleconsultation on day one, followed by one hour of virtual interaction on day two, and concluding with a two-hour in-person session on day three. During phase one, trained graduate students from the research team provided recruitment orientations, and parents/caregivers completed an online sociodemographic questionnaire via REDCap software upon expressing interest. Phase two involved orientation with the participants, obtaining online assent forms, and informing both parents and participants about the study's purpose before electronically signing consent and assent forms. Remote screening for adverse events was conducted using Teams, Google Meet, or Zoom by two trained graduate student assistants, with one evaluator and one clinical practicum advanced graduate student who also double checked the data collected.

A risk management protocol would be activated if high levels of risk to self or suicidal thoughts were reported verbally or indicated in item 9 of the Patient Health Questionnaire item 9 (PHQ-9). However, during the screening process, no protocol activation was necessary in any case. Additionally, participants were referred for mental health services if clinical symptoms were identified, and referrals were provided to those not currently receiving psychological services. Participants' meeting inclusion criteria proceeded to phase three, involving an in-person evaluation following COVID-19 safety protocols at the time, with audio recording utilized for certain tasks related to scoring purposes. Researchers shared written results and recommendations to parents/caregivers upon administration completion through March 2021 to November 2023.

Statistical Analysis

Trained research assistants and co-investigators scored self-reports and standardized tests. The research team entered data using the IBM SPSS Statistics 29.0 for analysis and double-checked the data once entered. A descriptive analysis was conducted using values of frequencies, means, confidence intervals, and standard deviation for each sociodemographic and obtained scores for attention, working memory, and academic achievement. We used visual tools, such as histograms and boxplot to observe the distribution, outliers, median, and central tendencies for each of our variables (ATT, WM, APROV). Since the scores seemed to move away from the normal distribution, and to generate a sampling distribution, including standard error to construct a confidence interval, we conducted our analysis using t-tests complemented by Bootstrap resampling method.

This approach enhanced the accuracy of our statistical inferences and accommodated variations in the data distribution. We observed

differences using the boot package of the SPSS Statistics program. The Pearson correlations and Linear regressions with confidence intervals were also carried out using Bootstrap to examine the relationship between the ATT measures and APROV measures. The confidence intervals for the t-tests and for the Pearson correlations are based on the normal distribution and were performed with 10,000 replications. The p-value, the slope of the beta (e.g., effect size – strength of the relationship), the standard error (the amount of error associated with that estimate), and the confidence interval were conducted for each analysis. Bivariate linear regression analysis (alpha = .05; two-tailed tests) was conducted to analyze the relationship between the predictor variables (i.e., ATT and WM) separately with the outcome variable (e.g., APROV). The composite index of attention and working memory functions and broad standardized academic achievement battery were coded as continuous variables.

The analysis included 24 participants, and one participant was not included due to an administration error of the *Batería*-IV APROV. In addition, the sample size was calculated first by resources and feasibility of participants. Then, the statistical power was calculated via a Priori power analysis using G*Power[32,33], given the parameters of alpha level .05 and an estimation of 30 participants to obtain from a medium to large effect size. However, we achieved a smaller sample size and recalculated the G*power for each of the analyses. We conducted two post-hoc power analyses using G*Power 3.1, given the parameters obtained of beta level 0.587 and 24 participants. For ATT, our G*Power was 0.796, an effect size between medium and large. For WM, the G*Power was 0.988, considered a large effect size[33] (see table 2).

Table 2. Post-Hoc Power Analysis and Effect Sizes

Variable	Effect Size Classification*	Power
ATT	Medium-Large	0.796
WM	Large	0.988

Note. Corresponding post-hoc power analysis for the effect sizes for the objectives, given the parameters beta level 0.587 and 24 participants. Objectives: (1) to evaluate the relationship between ATT and APROV, and (2) to evaluate the relationships between WM and APROV in Puerto Rican adolescents exposed to adverse events.
*Cohen[33] defines the following conventional values for the effect size f^2: (a) small f^2 = 0.02; (b) medium f^2 =0.15, (c) large f^2 = 0.35.

RESULTS

Descriptive Analysis

The composite index of attention (*M* = 80.63, SD = 13.53, *N* = 24) consisted of three subtests: expressive attention (*M* = 9, SD = .623), number detection (*M* = 4.75, SD = .587), and receptive attention (*M* = 6.38, SD = .499). The composite index score of working memory (*M* = 96.88, SD = 16.87, *N* = 24) consisted of two subtests: verbal-spatial relations subtest (*M* = 8.83, SD = .616) and sentence question (*M* = 10.21, SD = .715; see table 3).

The standard score for broad academic achievement (*M* = 84.54, SD = 11.10, *N* = 24), consisted of reading (*M* = 88.75, SD = 11.72), mathematics (*M* = 75.54, SD = 15), and writing (*M* = 92.96, SD = 12.66; see table 3). The Cognitive Assessment System-2 (CAS2:ES), in Spanish, and the Woodcock-Muñoz IV standardized academic achievement battery (APROV) did not undergo validity or reliability procedures, as their purpose was to explore preliminary cognitive functions in APROV Puerto Rican adolescents exposed to adverse events.

Inferential Analysis

The first research question was to explore the relationship between higher levels of attention composite index scores with better levels of broad academic achievement scores in Puerto Rican adolescents exposed to adverse events. The results

Table 3. Descriptive Statistics: Predictor and Outcome Variables

Measure	N	M	SD	95% CI
Composite index score for the attention processing scale	24	80.6	14	85.9 - 75.6
Composite index score for the working memory scale	24	96.9	17	103.4 - 90.2
Standard score for broad academic achievement	24	84.5	11	89.3 - 80.6

Note. The predictor variables are the composite index scores of attention and working memory. Standard APA abbreviation are as follows: *N* = sample size, M = mean, SD = standard deviation, and CI = confidence interval.

indicated that attention accounted for 51.20% of the variance in academic achievement. A significant equation was found (F (1, 22) = 23.08, p < .001), with an R^2 of .512 (see figure 3). This suggests that attention is a statistically significant predictor for academic achievement (b = 0.587, β = 0.716, t (22) = 4.804, SE = 0.139, p < .004, 95% IC [0.334, 0.840]). The regression model suggests that per every standard score point in ATT, there is an .587 increase in standardized scores of APROV.

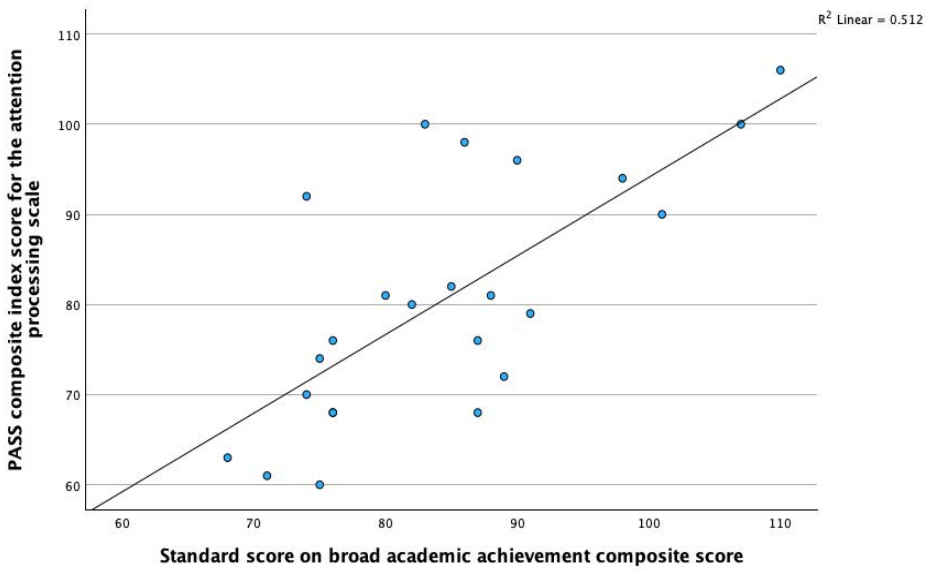

Figure 3. Scatterplot using Simple Linear Regression: Attention Composite Index
Note. The criteria variable is the standard score of broad academic achievement. The predictor variable is the composite index score of attention (P < .001).

The second research question was to explore the relationship between higher levels of working memory composite index scores and better levels of broad academic achievement scores in Puerto Rican adolescents exposed to adverse events. The results indicated that working memory accounted for 42.90% of the variance in academic achievement. A significant equation was found (F (1, 22) = 16.54, p < .001), with an R^2 of .429 (see figure 4). This suggests that WM is a statistically significant predictor for academic achievement (b = 0.431, β = 0.655, $t(22)$ = 4.066, SE = .106, p < .002, 95% IC [0.211, 0.651]). The regression model suggests that per every standard score point in WM, there is a .431 increase in standardized scores of APROV.

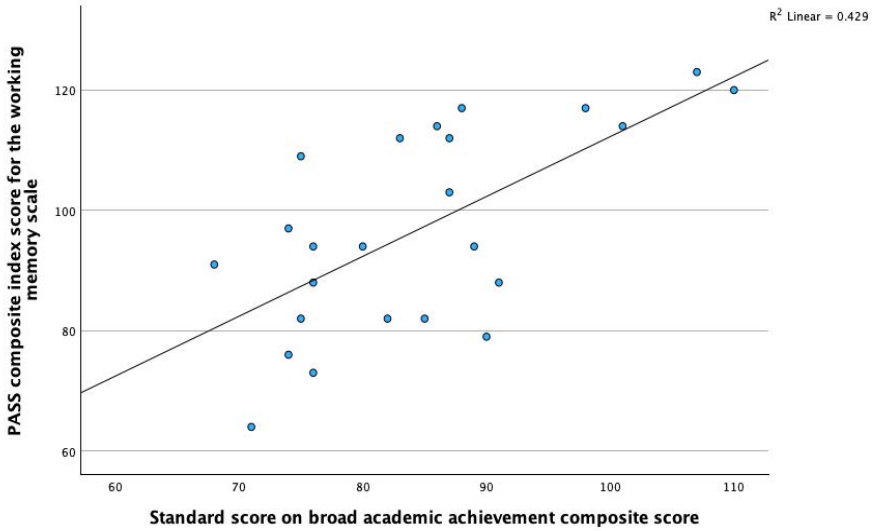

Figure 4. Scatterplot using Simple Linear Regression: Working Memory Composite Index
Note. The criteria variable is the standard score of broad academic achievement. The predictor variable is the composite index score of working memory (P < .001).

DISCUSSION

The primary aim of our study examines the relationship between attention composite index scores and broad academic achievement scores among Puerto Rican adolescents exposed to adverse events. Existing literature suggests a positive association between attention and academic achievement, with attention serving as a statistically significant predictor of academic success[18,19,25]. Our findings are consistent with this body of research, revealing a medium to large effect size. Specifically, our regression analysis showed a beta increase of 0.587 in academic achievement scores for each standard one-point increase in attention. However, due to the small sample size, these scores did not translate into significant changes in academic functioning.

Previous studies have also shown that students with better school performance tend to exhibit higher scores in selective attention, perform more proficiently in divided attention, and make fewer errors in attention-based tasks[25]. Although our study supports these findings, the limited sample size warrants caution in generalizing the results. These results highlight the importance of attention in the learning process and suggest that attention can significantly contribute to academic achievement. However, it is crucial to consider how the participants' exposure to traumatic experiences might influence both their attention and academic performance. While the studies we are comparing focus primarily on the role of attention in academic success, they may not fully account for how environmental stressors or past trauma could impact cognitive processes. The integration of attention and academic performance in this context provides valuable insights into the educational experiences of Puerto Rican adolescents exposed to adverse events. Attention is, therefore, a critical factor in facilitating the development of learning skills and promoting higher academic achievement, but understanding how trauma affects this relationship is key to fully interpreting the findings.

The secondary objective of this study examines the relationship between working memory composite index scores and broad academic achievement scores in the Puerto Rican adolescents exposed to adverse events. The results indicated a positive association between working memory and academic achievement, with an increase of 0.655 in academic achievement scores

for each one-point increase in the working memory composite index. This suggests that higher working memory capacity is linked to better academic performance in this population.

These findings are consistent with existing literature that highlights the importance of working memory in academic success. Previous studies have shown that working memory plays a critical role in facilitating the storage and processing of information, which is essential for tasks such as reading comprehension, problem-solving, and mathematical reasoning[7,8,19]. Our results align with these studies, reinforcing the notion that adolescents with stronger working memory capacity tend to perform better academically. Nonetheless, it is important to consider how the participants' experiences with traumatic events might interact with their working memory and academic performance. While the studies used for comparison primarily focus on working memory as a predictor of academic success, they may not fully account for how adverse experiences could influence cognitive functioning and learning outcomes. Future research should explore how trauma may affect working memory and its relationship to academic achievement in adolescents.

However, as with the findings related to attention, the improvements in academic achievement scores observed in our study may not necessarily translate into significant enhancements in daily functioning. This limitation may be attributed to the small sample size, which could affect the generalizability of the results. While working memory has been linked to academic success, its broader implications for everyday functioning may be influenced by other factors, such as environmental stressors, social support, and intervention programs[5]. It is important to consider how traumatic experiences, which may have affected the participants in our study, could play a significant role in shaping these outcomes. Thus, although our findings align with the existing literature on the relationship between working memory and academic achievement, further research with larger, more diverse samples is needed to explore the potential impact of working memory on daily functioning.

CONCLUSION

The primary objective of this study was to examine the relationship between attention, working memory, and academic achievement among Puerto Rican adolescents exposed to adverse events. Overall, our findings support existing literature, revealing significant positive associations between both attention and working memory with academic performance. Specifically, each one-point increase in the attention and working memory composite index scores was associated with increases of 0.587 and 0.655 points in academic achievement, respectively. These results highlight the importance of attention and working memory as predictors of academic achievement in this population.

However, despite the observed effect sizes, the small sample size limits the generalizability of these findings. While the improvements in academic achievement were statistically significant, they did not necessarily lead to substantial changes in everyday academic functioning. This suggests that other factors, such as environmental stressors, social support, and intervention programs, may also influence academic outcomes in adolescents exposed to adversity. Although our study highlights the crucial role of cognitive factors such as attention and working memory, it does not fully explore the adverse experiences that may shape these relationships. Future research should investigate the specific ways in which different types of adversity (e.g., trauma or socio-economic stress) may moderate or mediate the relationship between cognitive functioning and academic outcomes.

The implications of these findings are two-part. First, we suggest that interventions aimed at enhancing attention and working memory could improve academic performance in adolescents facing adversity. Second, we urge a more thorough understanding of how cognitive development impacts academic achievement in this population. By addressing these factors, educators and policymakers can better support the educational experiences of vulnerable populations, including Puerto Rican adolescents. Further research with

larger and more diverse samples is necessary to fully understand the complex interplay between cognitive factors, adversity, and academic success, as well as the broader implications for everyday functioning.

Limitations and Future Directions

Based on the results and limitations identified in this study, several recommendations for future research and clinical practice can be made. First, the sample size was limited due to the COVID-19 pandemic, which may have reduced the study's statistical power and its ability to draw robust conclusions. This limitation emphasizes the need for cautious interpretation of the results and highlights areas for future research to address methodological shortcomings and enhance the generalizability of findings.

Second, the majority of participants in this study were receiving psychological services; with 78% recruited from outpatient and community mental health clinics. This suggests that participants may have benefited from the psychological services they were receiving. The continuity of psychological services as an intervention for childhood exposure to adverse events is recommended, as it may mitigate the impact on executive function, including attention and working memory, as seen in the literature. However, this may have introduced a sampling bias, potentially affecting the generalizability of the findings to the broader Puerto Rican adolescent population. For example, participants may have had average performance in both cognitive abilities and academic achievement, which could limit the findings' applicability to other groups.

Finally, the confidence intervals for attention were lower than expected. This variability raises questions about the participants' clinical presentation or current diagnoses, particularly regarding ADHD as a confounding variable. Future studies should explore the mediator effects between academic achievement and cognitive functions such as attention and working memory. This includes examining factors such as adverse events, inattention, inhibition, and various cognitive abilities to clarify underlying mechanisms. Future research should focus on understanding how exposure to adverse events as a moderating variable affects cognitive functions and academic achievement of Puerto Rican adolescents. This study used a one-time assessment conducted more than one year after the exposure and involved a limited sample size. Longitudinal studies are necessary to examine the long-term effects of adverse events on cognitive development and academic outcomes. These studies should track the trajectory of cognitive skills, such as working memory, and their implications for academic success, particularly among adolescents with attention-related difficulties.

In recent years, psychoeducational interventions have gained recognition for their potential to improve and optimize learning outcomes for adolescents who have been exposed to adverse events. These interventions focus on addressing the unique challenges faced by such individuals by targeting various cognitive, emotional, and social domains. Research has identified several key areas for direct intervention, each aimed at enhancing the adolescent's ability to engage with and succeed in academic environments despite trauma-related barriers.

Psychoeducational intervention programs are suggested to improve and optimize learning processes of adolescent who are exposed to adverse events. For instance, the literature[34] identifies five areas for direct intervention: 1) the neuropsychological field to exercise the skills of inputting information to the brain through the senses, motor skills, laterality, and the spatiotemporal sense; 2) the cognitive field to train cognitive processes such as memory, different types of attention, thinking, and language; 3) the emotional sphere to develop interests and motivations, self-concept, emotional intelligence, and self-determination; 4) the academic field to provide resources and optimize the learning of curricular content; and lastly, 5) the social sphere including system of relationships established in groups, interpersonal intelligence, and social skills.

For the school neuropsychology intervention[34], it is important to know that the frontal lobe of the brain (right hemisphere) has been known to enhance attention and the limbic system, as that attention is closely linked to memory. These skills can be applied in the classroom setting where teachers can avoid long explanations and present different unusual tasks and exercises that stimulate curiosity. Furthermore, to ensure that students do not become blocked when faced with challenging tasks, the classroom climate should remain pleasant and supportive.

The application of these programs, along with future findings, will continue to provide training, support, and resources aimed at treatment, intervention development, program evaluation, system changes, and integration of trauma-informed approaches in schools. Trauma-informed approaches in schools can foster a deeper understanding of the widespread impact of trauma, provide pathways for recovery, help recognize signs and symptoms of trauma, and encourage practices, that resist retraumatization[35].

By addressing these recommendations, future research can contribute to a more comprehensive understanding of the complex relationship between cognitive processes and academic achievement in vulnerable populations, ultimately informing more effective interventions and support strategies[36].

Declaration of interests

The authors have no financial conflicts of interest to declare. This study was conducted with the mentorship of Dr. Mary Annette Moreno, who is one of the Principal Investigators of the original study. However, Dr. Moreno was not involved in the writing or consultation of this manuscript.

Financing

This work was supported by School of Behavioral and Brain Sciences (SBBS) at Ponce Health Sciences University (PHSU) under the support of the Educational Service Agreement assigned to the Ponce Research Institute (PRI) (SBBS pilot study award 2019-2020 grant; Rodríguez, Rosanna (PI)). We purchased the Cognitive Assessment the Cognitive Assessment System-2 and *Batería* IV Woodcock-Muñoz instruments for evaluation purposes.

Acknowledgments

I would like to express my deepest gratitude to the Puerto Rican community, including the parents, caregivers, participants, schools, and clinical centers, for their invaluable contribution to this study and their remarkable resilience in overcoming both historical and personal challenges. My heartfelt thanks also go to the dedicated members of the Research JET (*Jóvenes Expuestos a Trauma*) team for their tireless efforts in assessment training, recruitment, administration of measures, scoring, data entry, and summary report writing among other tasks. Your hard work and commitment have been instrumental to the success of this research.

REFERENCES

1. Naglieri, J. A., & Otero, T. M. (2024). PASS Theory of Intelligence and Its Measurement Using the Cognitive Assessment System. Journal of Intelligence, 12(8), 77.
2. Georgiou GK, Das JP, Hayward DV. Comparing the contribution of two tests of working memory to reading in relation to phonological awareness and rapid naming speed. Journal of Research in Reading. 2008 Aug;31(3):302-18.
3. Alloway, T. P., & Alloway, R. G. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. Journal of experimental child psychology, 106(1), 20-29.

4. Swanson HL, Alloway TP. Working memory, learning, and academic achievement. In: Harris KR, Graham S, Urdan T, McCormick CB, Sinatra GM, Sweller J, editors. APA educational psychology handbook, Vol. 1. Theories, constructs, and critical issues. Washington (DC): American Psychological Association; 2012. p. 327–366. doi: 10.1037/13273-012.
5. Song H. Neuropsychological Perspectives on the Impact of Early Childhood Trauma on Cognitive Development. Journal of Social Science Humanities and Literature. 2024 Dec 24;7(6):46-50.
6. Wendling BJ, Mather N, & Schrank FA. Examiner's Manual. Batería IV Woodcock-Muñoz: Pruebas de aprovechamiento. Itasca, IL: Riverside Assessments, LLC; 2019.
7. Rodríguez Rodríguez D, & Guzmán Rosquete R. Rendimiento académico y factores sociofamiliares de riesgo: Variables personales que moderan su influencia. Perfiles Educativos. 2019; 41(164): 118–134.
8. Blasiman RN, Was CA. Why is working memory performance unstable? A review of 21 factors. Eur J Psychol. 2018;14(1):188-231.
9. Espinosa-Castro J, Hernández-Lalinde J, Rodrígue JE, Chacín M, & Bermúdez-Pirela V. Influencia del estrés sobre el rendimiento académico. Archivos Venezolanos de Farmacología y Terapéutica. 2020; 39(1): 63-69.
10. Porche MV, Fortuna LR, Lin J, Alegria M. Childhood Trauma and Psychiatric Disorders as Correlates of School Dropout in a National Sample of Young Adults. Child Development. 2011 Mar 9;82(3):982–98.
11. Feifer SG, Brooks RB, Barker L, & Douglas SF. The Neuropsychology of Stress & Trauma: How to Develop a Trauma Informed School. School Neuropsych Press, LLC; 2019.
12. Substance Abuse and Mental Health Services Administration. Trauma and violence [Internet]. Samhsa.gov. 2022. Available from: https://www.samhsa.gov/trauma-violence
13. Begle AM, Hanson RF, Danielson CK, McCart MR, Ruggiero KJ, Amstadter AB, et al. Longitudinal pathways of victimization, substance use, and delinquency: Findings from the National Survey of Adolescents. Addictive Behaviors. 2011 Jul;36(7):682–9.
14. Cisler JM, Begle AM, Amstadter AB, Resnick HS, Danielson CK, Saunders BE, et al. Exposure to interpersonal violence and risk for PTSD, depression, delinquency, and binge drinking among adolescents: Data from the NSA-R. Journal of Traumatic Stress. 2012 Feb;25(1):33–40.
15. López CM, Andrews AR, Chisolm AM, de Arellano MA, Saunders B, Kilpatrick DeanG. Racial/ethnic differences in trauma exposure and mental health disorders in adolescents. Cultural Diversity and Ethnic Minority Psychology. 2017 Jul;23(3):382-7.
16. Mills R, Scott J, Alati R, O'Callaghan M, Najman JM, Strathearn L. Child maltreatment and adolescent mental health problems in a large birth cohort. Child Abuse & Neglect. 2013 May;37(5):292–302.
17. Larson S, Chapman S, Spetz J, Brindis CD. Chronic Childhood Trauma, Mental Health, Academic Achievement, and School-Based Health Center Mental Health Services. Journal of School Health. 2017 Aug 1;87(9):675–86.
18. Kofler MJ, Spiegel JA, Soto EF, Irwin LN, Wells EL, Austin KE. Do working memory deficits underlie reading problems in attention-deficit/hyperactivity disorder (ADHD)? J Abnorm Child Psychol. 2019;47(3):433-46.
19. Rogers M, Hwang H, Toplak M, Weiss M, Tannock R. Inattention, working memory, and academic achievement in adolescents referred for attention deficit/hyperactivity disorder (ADHD). Child Neuropsychology. 2011 Sep;17(5):444–58.
20. Stewart-Tufescu A, Struck S, Taillieu T, Salmon S, Fortier J, Brownell M, Chartier M, Yakubovich AR, Afifi TO. Adverse childhood experiences and education outcomes among adolescents: linking survey and administrative data. International journal of environmental research and public health. 2022 Sep 14;19(18):11564.
21. González Nieves S, Morales F, Humberto F, Duarte JE. Memoria de trabajo y aprendizaje: Implicaciones para la educación. Saber, ciencia y libertad. 2016;11(2):161-76.
22. Taub GE, McGrew KS. The Woodcock–Johnson Tests of Cognitive Abilities III's cognitive performance model: Empirical support for intermediate factors within CHC theory. Journal of Psychoeducational Assessment. 2014 Jun;32(3):187-201.

23. Schneider WJ, McGrew KS. The Cattell-Horn-Carroll theory of cognitive abilities. Contemporary intellectual assessment: Theories, tests, and issues. 2018 Sep 17:73-163.
24. McGrew KS. CHC theory and the human cognitive abilities project: Standing on the shoulders of the giants of psychometric intelligence research. Intelligence. 2009 Jan 1;37(1):1-0.
25. Ramírez-Benítez Y, Torres-Diaz R, Amor-Diaz V. Contribución única de la inteligencia fluida y cristalizada en el rendimiento académico. Revista Chilena de Neuropsicología. 2016;11(2):1-5.
26. Resett S. Relación entre la atención y el rendimiento escolar en niños y adolescentes. Rev Costarric Psicol. 2021;40(1):3-22.
27. Sachser C, Berliner L, Holt T, Jensen TK, Jungbluth N, Risch E, Rosner R, Goldbeck L. International development and psychometric properties of the Child and Adolescent Trauma Screen (CATS). Journal of affective disorders. 2017 Mar 1; 210:189-95.
28. Naglieri JA, Moreno M, Otero T. Cognitive Assessment System 2: Español. PRO-ED Inc. 2017.
29. Naglieri JA, Rojahn J. Construct validity of the pass theory and cas: correlations with achievement. Journal of Educational Psychology. 2004 Mar;96(1):174.
30. Otero TM, Gonzales L, Naglieri JA. The neurocognitive assessment of Hispanic English-language learners with reading failure. Applied Neuropsychology: Child. 2013 Jan 1;2(1):24-32.
31. Woodcock RW, Alvarado CG, Schrank FA, Mather N, McGrew KS, Muñoz-Sandoval AF. Batería IV Woodcock-Muñoz: Pruebas de aprovechamiento. Itasca, IL: Riverside Assessment, LLC; 2019.
32. Faul F, Erdfelder E, Lang AG, Buchner A. G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior research methods. 2007 May;39(2):175-91.
33. Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2nd Edn. Hillsdale, NJ: Erlbaum.
34. Martín-Lobo P, Rodríguez Fernández A. La intervención desde la base neuropsicológica y metodologías que favorecen el rendimiento escolar. Procesos y programas de neuropsicología educativa. 2015:14-33.
35. Maynard BR, Farina A, Dell NA, Kelly MS. Effects of trauma-informed approaches in schools: A systematic review. Campbell Systematic Reviews [Internet]. 2019 Jul 17;15(1-2). Available from: https://schoolsocialwork.net/wp-content/uploads/2019/07/Campbell-Maynard_et_al-2019-Campbell_Systematic_Reviews.pdf
36. OpenAI. (2023). ChatGPT-4 [Large language model]. OpenAI. https://openai.com/chatgpt