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Association between resilience and neurocognitive performance

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Association between resilience and neurocognitive performance

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An abstract of
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Abstract

Association between resilience and neurocognitive performance

By Aliza P. Wingo

Background: Whether psychological resilience correlates with neurocognitive performance is largely unknown. Therefore, we assessed association between neurocognitive performance and resilience in individuals with a history of childhood abuse or trauma exposure.

Methods: In this cross-sectional study of 226 highly traumatized civilians, we assessed neurocognitive performance, history of childhood abuse and other trauma exposure, and current depressive and PTSD symptoms. Resilience was defined as having ≥ 1 trauma and no current depressive or PTSD symptoms; non-resilience as having ≥ 1 trauma and current moderate/severe depressive or PTSD symptoms.

Results: The nonresilient group had a higher percentage of unemployment ($p = 0.002$) and previous suicide attempts ($p < 0.0001$) than the resilient group. Both groups had comparable education and performance on verbal reasoning, nonverbal reasoning, and verbal memory. However, the resilient group performed better on nonverbal memory ($p=0.016$) with an effect size of 0.35. Additionally, more severe childhood abuse or other trauma exposure was significantly associated with non-resilience. Better nonverbal memory was significantly associated with resilience even after adjusting for severity of childhood abuse, other trauma exposure, sex, and race using multiple logistic regression (adjusted OR=3.21; $p=0.01$).

Conclusions: We examined resilience as absence of psychopathology despite trauma exposure in a highly traumatized, low socioeconomic, urban population. Resilience was significantly associated with better nonverbal memory, a measure of ability to code, store, and visually recognize concrete and abstract pictorial stimuli. Nonverbal memory may be a proxy for emotional learning, which is often dysregulated in stress-related psychopathology, and may contribute to our understanding of resilience.

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INTRODUCTION

Neuropsychological resilience is a dynamic process encompassing a relative resistance to environmental risk experiences such as stress, adversity, or trauma (1, 2). Implicit within the notion of resilience are two critical conditions: exposure to significant threat or severe adversity and achievement of positive adaptation despite these experiences (1, 2). Emerging evidence from recent studies suggest potential neurobiological mechanisms underpinning resilience (3, 4). In peripubertal monkeys, the process of coping with mild early life stress in developing resilience was found to correlate with increased white matter myelination of the ventromedial prefrontal cortex (4). In humans neurocognitive development in children and adolescents involves ongoing myelination of the prefrontal circuitry and synaptic proliferation and pruning (5). Taken together, white matter myelination of the prefrontal cortex appears to underly the processes of resilience and neurocognitive development. Given the overlapping neurobiological mechanism, we hypothesized that resilience and neurocognitive performance are correlated, with resilience being associated with better performance. Our null hypothesis is that there is no association between resilience and neurocognitive performance. In this study, we compared neurocognitive performance between resilient and nonresilient individuals and examined association between neurocognitive performance and resilience, controlling for severity of trauma exposure, sex, and race.

BACKGROUND

Exposure to traumatic events such as childhood sexual, physical, or emotional abuse, or military combat, natural disaster, serious transportation accidents, physical or sexual assaults has been known to substantially increase risk for major depression and/or posttraumatic stress disorder (6-14). Interestingly, there are individuals who cope successfully and report little or no adverse mental health consequences after being exposed to traumatic events, underscoring the importance of resilience (15, 16). Understanding resilience is essential in achieving a comprehensive understanding of human responses to stress and trauma. Progress in this area can inform efforts in finding novel methods for preventing and treating depression and PTSD.

Studies of resilience have defined this construct in various ways, including positive affect despite chronic exposure to stressful life events (17), absence of lifetime psychiatric disorders following exposure to traumatic events (15, 16), absence of PTSD following combat exposure (18), no time loss to illness following psychological stress exposure (19), and a high score on the Connor-Davidson Resilience Scale (20-22). In this study, we operationally defined resilience as having at least one previous trauma (childhood abuse, combat exposure, natural disaster, serious transportation accidents, sexual assault, physical assault, sudden death of a loved one, etc.) and no or very mild depressive or PTSD symptoms. We defined nonresilience as having at least one previous trauma and current moderate-to-severe depressive symptoms or moderate-to-severe PTSD symptoms. Our definition of resilience includes the absence of both depression and PTSD, the two psychiatric disorders most commonly associated with stress and trauma exposure (7-10).

METHODS

This is a cross-sectional study, in which all the included participants were exposed to at least one prior significant trauma per definition of resilience. Thus the data were analyzed as those of a cohort study. Our null hypothesis is that there is no association between resilience and neurocognitive performance.

Sample, recruitment, and procedure

This cross-sectional study was part of a larger study investigating genetic and environmental risk factors for PTSD and depression in a population of urban, low-income, highly traumatized, predominantly African American men and women (23, 24). Inclusion criteria included 18 to 75 years of age, English speaking, and able to give informed consent. Exclusion criterion included mental retardation, reflected by an IQ < 70, measured by the abbreviated Reynolds Intellectual Assessment Scales, further described below (25). The participants who did not meet criteria for either resilience or nonresilience were excluded from the analysis. The study was in compliance with the Code of Ethics of the World Medical Association and approved by the institutional review boards of Emory University School of Medicine and Grady Memorial Hospital.

Members of the research team approached adult patients waiting for their appointments at the primary care, obstetrical-gynecological clinics, and pharmacy waiting areas of Grady Memorial Hospital in Atlanta, GA, to solicit for study participation. Approximately 58% of those approached agreed to participate. Participants gave informed consent and completed a battery of self-report measures. Due to variation between subjects with respect to literacy, all self-report measures were obtained verbally.

Measures

Childhood abuse was assessed retrospectively with the psychometrically validated, 28-item Childhood Trauma Questionnaire (CTQ) (26, 27). Scores were extracted for the categories of emotional, physical, and sexual abuse. Following Bernstein and Fink's score ranges for none, mild, moderate, and severe levels of abuse, we classified participants into 2 groups: a) none/mild range, and b) moderate/severe range for each of the aforementioned type of abuse (26). We then divided the participants into 3 categories based on the number of types of abuse and severity of abuse they had: a) no abuse in the moderate/severe range, b) 1 type of abuse in the moderate/severe range, and c) ≥ 2 types of abuse in the moderate/severe range.

Trauma exposure was assessed using the Traumatic Events Inventory (28, 29). This instrument measures life-time exposure to 15 different categories of trauma, including natural disaster, serious accident or injury, sudden life-threatening illness, military combat, being attacked with a weapon, witnessing a family member or friend being attacked with a weapon, being attacked without a weapon, witnessing a family member or friend being attacked without a weapon, witnessing the murder of a friend or family member, and sexual assault. For each category of the instrument, having had the exposure was scored "1" and no exposure "0". The childhood trauma items in this inventory were excluded to avoid overlap with the information collected with the CTQ. Score can range from 0 – 15, with higher scores reflecting exposure to more types of trauma.

Depressive symptoms were measured with the psychometrically validated, 21-item Beck Depression Inventory (BDI), which has demonstrated good reliability (Pearson correlation coefficient r = 0.93) and validity (30). The items are rated on a likert scale of 0 – 3; total score ranges from 0 – 63, with higher scores reflecting higher levels of depression. Specifically, levels of depression severity are suggested by the following

score ranges: BDI ≤ 10 no depression, 10 < BDI ≤ 18 mild depression, and BDI ≥ 19 moderate to severe depression (30).

PTSD symptoms were measured with the modified PTSD Symptom Scale (PSS), a psychometrically valid, 17-item, self-report scale assessing PTSD symptoms based on DSM-IV criteria, over the prior 2 weeks (31, 32). A PSS score ≤ 10 reflects none or very mild level of PTSD symptoms (33, 34). We categorized participants as having or not having PTSD based on the DSM-IV criteria for PTSD, using the PSS scale. Moderate-to-severe PTSD symptoms for this study was defined by having PSS >26, as 26 was the median score for individuals who met DSM-IV defined PTSD criteria in this sample.

Neurocognitive performance was assessed using the Reynolds Intellectual Assessment Scales (RIAS) (25), including the *Guess What*, *Odd-Item Out*, verbal memory, and nonverbal memory subtests. The *Guess-What* subtest measures verbal reasoning in combination with vocabulary, language development, and overall fund of knowledge. *Odd-Item Out* measures nonverbal reasoning skills and visuo-spatial ability. The verbal memory subtest assesses ability to encode, briefly store, and recall verbal material. The nonverbal memory subtest measures ability to encode, briefly store, and recognize concrete and abstract pictoral stimuli. The RIAS has a high internal consistency (Cronbach's alpha coefficients range 0.90 – 0.95 for these subtests), test-retest reliability (r = 0.69 – 0.88), and excellent validity (25). The *Guess-What* and *Odd-Item Out* subtests can be used in combination to obtain an estimate of general intelligence; this index has a correlation of 0.67 with the full-scale IQ of the Wechsler Adult Intelligence Test-III (35), and 0.83 with the full-scale IQ of the Wechsler Intelligence Scale for Children, 3rd edition(36) (25). Participants with estimated IQ < 70 were excluded from the analysis. Raw scores were converted to the age-adjusted t scores using RIAS normative data (25).

Resilience

Resilience was defined, a priori, as having at least 1 previous trauma and none or only very mild current depressive (BDI ≤10) or PTSD symptoms (DSM-IV PTSD criteria not met and PSS ≤10); nonresilience as having at least 1 previous trauma and current moderate/severe depressive (BDI ≥19) or PTSD symptoms (PSS > median PSS scores among those with PTSD in the sample). PSS median score was 26 for individuals with PTSD in this sample. Information from the CTQ and TEI were used to ensure that each participant had been exposed to at least one trauma. For instance, a participant with no childhood abuse in the moderate/severe range on the CTQ must have at least a score of 1 on the TEI. On the other hand, a participant with a score of zero on the TEI scale must have at least 1 type of childhood abuse in the moderate/severe range. Some participants had a history of both childhood abuse and other trauma exposures. As mentioned above, trauma includes childhood emotional, sexual or physical abuse, or experiencing a natural disaster, serious accident or injury, sudden life-threatening illness, or being in military combat or war zone, or being attacked with or without a weapon, or having a close friend or family member being attacked or murdered, or sexual assault.

Statistical analyses

Analyses were performed using SAS Software (version 9.2© of 2008; SAS Institute, Cary, NC). Demographic and clinical variables were characterized with descriptive statistics. Data are shown as means and standard deviation (SD). Chi-square was used to compare proportions. Two-sample *t*-test was used to compare group means of normally distributed continuous variables, and Wilcoxon rank-sum test to compare group means of non-normally distributed continuous variables. Standardized mean-difference effect size (ES) was computed for each neurocognitive domain (37). Multiple logistic regression was performed to examine association between neurocognitive performance

and resilience, controlling for severity of childhood abuse, other trauma exposure, sex, and race. The independent variables consisted of nonverbal memory (continuous), childhood abuse (categorical), other non-child-abuse traumas (continuous), race (categorical), and sex (categorical). The assumption of linearity in the logit was checked for the two continuous variables, nonverbal memory and other non-child-abuse traumas. Non-child-abuse trauma met the linearity assumption and was kept as a continuous variable. Nonverbal memory did not meet the linearity assumption and was treated as a categorical variable with three categories: a) performing at $\leq 25^{th}$ percentile in the sample; b) performing between 25^{th} and 75^{th} percentile; and c) performing at $\geq 75^{th}$ percentile in the sample. Statistical significance required a two-sided *p*-value of <0.05.

RESULTS

Sociodemographic and clinical characteristics

There were 105 resilient and 121 non-resilient individuals in the sample. Their sociodemographic characteristics are presented in Table 1. Overall, this population of mostly African Americans was characterized by a high rate of trauma exposure and low socioeconomic status, reflected by low income and educational levels; only 9.6% of the participants had a monthly income ≥ 2000 while 68% had a monthly income < 999; only 9.8% of the sample was college graduates or attending graduate schools and 63.8% had a high school education or below. Both the resilient and nonresilient groups had comparable age, education, and relationship status (Table 1). There was a trend of more women ($p = 0.08$) and fewer African Americans ($p = 0.07$) in the nonresilient group (Table 1). Furthermore, the nonresilient group had a significantly higher percentage of unemployment ($p = 0.006$) and previous suicide attempts ($p < 0.0001$) compared to the resilient group (Table1). The resilient group had less severe childhood sexual, physical, or emotional abuse and fewer other trauma exposure than the nonresilient group ($p < 0.0001$) (Table 1).

Neurocognitive performance

Age-adjusted *t* scores for verbal reasoning, nonverbal reasoning, verbal memory, and nonverbal memory subtests for both the resilient and nonresilient groups are presented in Table 2. Both groups had comparable performance on the verbal reasoning, nonverbal reasoning, and verbal memory subtests (Table 2). However, the resilient group performed better than the nonresilient group on the nonverbal memory subtest ($p = 0.016$) with an effect size (ES) of 0.35 (Table 2). Estimated IQ of the resilient group had a mean and SD of 92.3 ± 10.9 and nonresilient group 92.5 ± 9.5. Hence, estimated IQ was comparable between the two groups ($t = 0.1$; $p = 0.92$).

To determine whether group difference in nonverbal memory was an artifact of depression or PTSD symptoms, Pearson correlation was performed to assess the relationship between nonverbal memory score and BDI or PSS score. In the resilient group, there was no significant correlation between nonverbal memory and BDI score (r = −0.015, p = 0.88) or PSS score (r = −0.060, p = 0.54). Likewise, within the nonresilient group, there was no significant correlation between nonverbal memory and BDI score (r = −0.017, p = 0.86) or PSS score (r = 0.03, p = 0.72). This suggests that group difference in nonverbal memory was not due to depressive or PTSD symptoms.

Multiple logistic regression models

The logistic regression model suggests that nonverbal memory was significantly associated with resilience, even after adjusting for severity of childhood abuse, other trauma exposure, sex, and race (Table 3). Specifically, performing at 75th percentile or above in nonverbal memory was associated with 3.21 higher odds of being resilient compared to performing at ≤25th percentile, given similar levels of childhood abuse, other trauma exposures, sex, and race (OR = 3.21; p = 0.01) (Table 3). This regression model also suggests that having 0 type of childhood abuse in the moderate/severe range was associated with 5.3 times higher odds of being resilient than having ≥ 2 types of childhood abuse in the moderate/severe range (OR [95%CI] = 5.34 [2.18 – 13.08], p = 0.0002) (Table 3). Likewise, having 1 type of childhood abuse in the moderate/severe range was associated with 2.5 times higher odds of being resilient compared to having ≥2 types of moderate/severe childhood abuse (OR = 2.51 [0.92 – 6.83], p = 0.07); however, this association was only a statistical trend (Table 3). Moreover, having one more type of non-child-abuse trauma exposure was associated with 20% lower odds of being resilient (OR = 0.8 [0.71 – 0.92], p = 0.001) (Table 3). Race and sex were not significantly associated with resilience (Table 3).

To assess for interaction, association between nonverbal memory and resilience was stratified by sex, race, and childhood abuse (Table 4). For this purpose, childhood abuse was collapsed into two categories: a) 0 type of abuse in the moderate/severe range and b) ≥1 type of abuse in moderate/severe range. Likewise, nonverbal memory was collapsed into 2 categories: a) performing at ≥ 75th percentile, and b) performing at <75th percentile. Breslow-Day test was performed to assess for interaction. Statistically, no interaction was observed, as all the Breslow-Day p values were greater than 0.05 (Table 4). However, the magnitude of odds ratio of the two strata of race was substantially different (1.64 vs. 6.67), suggesting the presence of interaction. Hence, another logistic model, model B, was built to include the interaction term of race and nonverbal memory (Table 5). Model B suggests that the interaction term of race and nonverbal memory is significantly associated with resilience (p = 0.012) (Table 5). Among those who performed at ≥75th percentile on nonverbal memory, African American participants had 4.68 times higher odds of being resilient compared to participants of other races, given similar severity of childhood abuse and other trauma exposure and sex (Table 6). However, among those performing at ≤75th percentile on nonverbal memory, African American participants had a lower odds of being resilient compared to participants of other races (Table 6). This interaction between race and nonverbal memory with respect to resilience should be interpreted with caution due to the small sample size of participants of other races.

DISCUSSION

In this cross-sectional study of 105 resilient and 121 nonresilient individuals, we found that the resilient group performed significantly better than the nonresilient group on the nonverbal memory subtest, a measure of ability to encode, briefly store, and visually recall concrete objects or abstract concepts. Performing at ≥75th percentile in the sample on the nonverbal memory subtest was associated with 3.2 times higher odds of being resilient compared to performing at ≤25th percentile on nonverbal memory, given similar severity of childhood abuse and other trauma exposure, sex, and race. The two groups were comparable regarding their IQ and performance on the verbal reasoning, nonverbal reasoning, and verbal memory subtests. We also found that more severe childhood abuse or other trauma exposure was significantly associated with a lower probability of being resilient.

Association between full-scale IQ and resilience following family adversity has been examined in a longitudinal study by Fergusson et al (38). The authors followed children from age 8 to 16 and found that higher IQ, measured at 8 years of age, was associated with resilience (38). We did not find a difference in estimated IQ between the resilient and nonresilient groups as Fergusson and colleagues, potentially due to three reasons. First, our estimated IQ was only a rough estimate based on the two RIAS subtests, as described in Methods, and not a full intellectual assessment battery since our primary objective was assessing neurocognitive performance. Second, the nature of family adversity assessed in Fergusson study, including social and economic disadvantage, family dysfunction, marital conflict, and compromised parenting, was different from the nature of adversity measured in our study, including childhood sexual, physical, or emotional abuse or exposure to other traumatic events (38). Third, the nature of resilience defined by Fergusson and colleagues, absence of conduct problems,

delinquency, substance use, and school problems, is different from that of our definition of resilience, which is the absence of depressive and PTSD symptoms (38).

Association between full-scale IQ and risk of developing PTSD following exposure to traumatic events has also been reported in two other longitudinal studies (39, 40). The first, by Breslau et al (39), categorized IQ into 3 groups, IQ<100, IQ =101–115, and IQ>115, and found that the IQ >115 group had a significantly lower risk for developing PTSD compared to the IQ <100 group, and no significant difference in PTSD risk between the IQ<100 and IQ = 101–115 groups, after adjusting for the relevant risk factors in a logistic regression model. In our study, only 3 individuals in the resilient group and 1 in the nonresilient group had an IQ>115, while the rest of the participants had an IQ ≤115. Hence our observation of no difference in estimated IQ between the resilient and nonresilient groups is in line with the findings of Breslau study. The second study, by Koenen et al, followed children from age 5 to 32 to assess for PTSD at two time points, at age 26 and 32 (40). The authors found that lower IQ, measured with the Wechsler Intelligence Scale for Children, was associated with a higher risk for developing PTSD at age 26 (40). However, this association was no longer significant at age 32 (40). Since we assessed participants with an age range from 18 to 75, with a mean age of 44 – 45, it is possible that the wide range of age of our participants and their older average age may have affected our association between estimated IQ and PTSD manifestation.

Another study examining neuropsychological function in female victims of intimate partner violence with and without PTSD found no significant difference in attention, working memory, visuoconstruction, learning and memory, and executive functioning between 22 without lifetime PTSD and 17 with current PTSD subjects(41). The results of this study should be interpreted in light of its limited sample size and thus insufficient power to detect a difference if one exists.

It is quite interesting that we find a deficit in nonverbal memory, but not verbal reasoning, nonverbal reasoning, or verbal memory, related to nonresilience. Consistent with our finding, nonverbal memory deficits have been reported in PTSD (42) and major depression (43) patients. It is notable that cognitive bias in processing emotional information, usually seen in mood and anxiety disorders, are more closely detected by the laboratory measures of nonverbal memory, such as visual working memory, than the more complex verbal memory and verbal reasoning tasks (44). Furthermore, recent data suggest that emotional learning of fear discrimination and inhibition is dependent on nonverbal cue contingency awareness (45). Together, these data suggest that nonverbal memory measures may serve as a proxy for emotional learning and emotional information processing. We propose that emotional learning may be critical for recovery from traumatic experiences and resilience to stress-related psychopathology (46).

Regarding power analysis, 105 subjects per group would provide 80% power to detect a difference in neurocognitive performance between 2 groups with an effect size (ES) of 0.39, if one exists, at 2-sided alpha of 0.05. Our sample of 105 resilient and 121 nonresilient participants did not have enough power to detect a difference in neurocognitive performance with an ES <0.39 if one exists.

Our results should be interpreted in light of its limitations, including its cross-sectional nature, potential recall biases on the retrospective measures of Childhood Trauma Questionnaire and Traumatic Events Inventory, and the relatively limited number of neurocognitive domains we assessed. Additionally, alcohol and substance use was not measured in this study and may be a notable confounding factor in neurocognitive performance. Lastly, the majority of our participants were unemployed or had low income, obtained twelve years or fewer of education, and had frequent

trauma exposure; thus the effects we observed may not be generalizable to individuals of different sociodemographic characteristics.

Neurocognitive profiles, particularly those related to nonverbal and emotional memory, which may be unique to resilience, may provide information towards our effort of discovering the neuro-circuitry underpinning resilience. For future studies, more extensive neurocognitive and neuropsychological tests, including more detailed nonverbal memory, executive functioning, and emotional information processing, and a longitudinal study design are recommended to have a more fine-grained assessment of correlation between resilience and neurocognitive profiles

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Table1: Sociodemographic characteristics of the resilient and nonresilient groups

Characteristics	**Resilience (n=105)**	**Nonresilience (n =121)**	**Statistic**	**p**
Age (mean ± SD[a])	44.0 ± 14.0	45.0 ± 10.1	WRS[b] =11945	0.870
Sex (female)	54 (52.4%)	76 (63.9%)	$\chi^2 = 3.0$	0.084
Race			$\chi^2 = 3.3$	0.071
African American	96 (91.4%)	100 (83.3%)		
Others	9 (8.6%)	20 (16.7%)		
Education			$\chi^2 = 2.2$	0.324
Highschool or below	68 (64.8%)	75 (63.0%)		
Some college or technical school	24 (22.9%)	35 (29.4%)		
College graduates or graduate school	13 (12.4%)	9 (7.6%)		
Employment			$\chi^2 = 7.7$	0.006
Employed	33 (31.4%)	19 (15.8%)		
Unemployed	72 (68.6%)	101 (84.2%)		

Income per month 0 – 249 250 – 999 1000 – 1999 ≥ 2000	 20 (19.4%) 37 (35.9%) 35 (34.0%) 11 (10.7%)	 44 (37.9%) 48 (41.4%) 14 (12.1%) 10 (8.6%)	$\chi^2 = 18.8$	0.0003
Relationship status Married Others (single, divorced, widowed)	 15 (14.3%) 90 (85.7%)	 13 (10.9%) 106 (89.1%)	$\chi^2 = 0.6$	0.448
Childhood abuse 0 type in mod/sev range 1 type in mod/sev range ≥ 2 types in mod/sev range	 71 (69.6%) 20 (19.6%) 11 (10.8%)	 37 (34.9%) 27 (25.5%) 42 (39.6%)	$\chi^2 = 29.8$	<0.0001
Other types of trauma (mean ± SD[a])	4.0 ± 2.5	5.9 ± 3.0	WRS[a] = 8997	<0.0001
Having past suicide attempts	6 (5.8%)	40 (33.9%)	$\chi^2 = 26.3$	<0.0001

a. SD: standard deviation

b. WRS: Wilcoxon Rank Sum test

Table 2: Neurocognitive performance (t scores) among resilient versus nonresilient individuals

Neurocognitive domain	**Resilience** (n = 105)	**Nonresilience** (n = 121)	**Statistic**[a]	**p**	**ES**[b]
Verbal reasoning	41.6 ± 8.6	40.8 ± 7.2	t = -0.78	0.438	0.10
Nonverbal reasoning	46.3 ± 8.6	47.5 ± 9.3	WRS[c] = 11319	0.375	-0.13
Verbal memory	46.8 ± 10.0	46.4 ± 10.3	WRS[c] = 11838	0.612	0.04
Nonverbal memory	47.7 ± 9.8	43.8 ± 12.1	WRS[c] = 12801	**0.016**	0.35

Data shown as mean ± SD

a. Statistic test to compare neurocognitive performance between resilience and nonresilience groups

b. ES = standardized mean difference effect size

c. Wilcoxon Rank Sum test for non-normally distributed continuous variables

Table 3: Multiple logistic regression model for resilience (model A)

Factors	**Adjusted OR**	**95% CI**	**p value**
Nonverbal memory			
≤25th percentile	1.00	-	-
Between 25th and 75th percentile	1.81	0.79 – 4.13	0.16
≥75th percentile	3.21	1.26 – 8.17	0.01
Childhood abuse:			
0 type in mod/sev range	5.34	2.18 – 13.08	0.0002
1 type in mod/sev range	2.51	0.92 – 6.83	0.07
≥2 types in mod/sev range	1.00	-	-
Other non-child-abuse traumas	0.80	0.71 – 0.92	0.001
Sex (male vs. female)	1.80	0.90 – 3.60	0.09
Race (African Americans vs. other races)	1.47	0.48 – 4.72	0.48

Hosmer and Lemenshow Goodness-of-Fit test: chi-square = 3.9; p = 0.86

Concordance c = 0.78

Table 4: Association between nonverbal memory and resilience, stratified by covariates

Covariate	Substratum specific OR		p (for interaction)†
	OR_1	**OR_2**	
Sex	2.84	1.23	0.19
Race	1.64	6.67	0.14
Childhood abuse	2.79	1.08	0.18

† Breslow-Day test, α=0.05

Childhood abuse: 2 categories (0 type of abuse in mod/sev range and ≥1 type of abuse in mod/sev range)

Nonverbal memory has 2 categories: performance at <75th percentile and at ≥75th percentile

Table 5: Multiple logistic regression model for resilience (model B)

Factors	**Estimated coefficient**	**SE**	**p**
Nonverbal memory (≥75th vs. <75th percentile)	3.75	1.26	0.0029
Childhood abuse (0 type in mod/sev range vs. ≥1 type in mod/sev range)	1.20	0.34	0.0004
Non-child-abuse trauma	-0.27	0.07	<0.0001
Sex (male vs. female)	0.69	0.36	0.052
Race (African Americans vs. other races)	1.77	0.87	0.044
Race*nonverbal memory	-3.31	1.31	0.012

Table 6: Odds ratio (OR) for resilience based on model B

	Nonverbal memory ≥75th percentile	**Nonverbal memory ≥75th percentile**
African Americans	4.68	0.17
Other races	1.0	1.0